AUSTRALIA

Developing Long-term Strategies for Science and Technology in Australia - Findings of the Study: Matching Science and Technology to Future Needs 2010

1996

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Foreword

The links between science and research outcomes and socio-economic progress are complex and uncertain. However, science and technology (S&T) 'foresight' offers promise as a means to help ensure Australian science, technology and engineering contribute to national objectives, including through the identification of priority areas in research and development (R&D) for both economic and social benefit.

In this study, ASTEC has applied 'foresight' processes to evaluate the S&T needs of Australia to 2010. Foresight is an iterative learning process which, in ASTEC's view, should become an integral part of Australia's S&T planning. The output must be regarded as the first iteration – an exploration of 'foresight'.

Benefits from this study fall under two basic headings: *process*, from the testing of foresight in S&T planning in government and industry; and *product*, from a strategically based set of tactical S&T policy recommendations, primarily for the Commonwealth government.

The process revealed many strengths. Foresight is highly consultative and allows us to address many difficult issues Australia faces in keeping pace with change, particularly in fast growing and dynamic sectors of the economy. It can help us identify and consider issues such as fostering attitudinal change in Australian society and increasing industry's commitment to R&D as part of achieving competitiveness and prosperity.

It is useful to link the relatively new process of 'foresight' with the more familiar world of corporate strategic planning. A model of such an application is presented in Chapter 1. The comparison demonstrates for me the power of foresight as an effective aid to S&T strategic planning. It is a useful analogy, I believe, in aiding the comprehension of the outputs and the process of foresight as applied by ASTEC.

A product of the study has been a better appreciation of the interrelationships between science, technology and the economy in the Australian context. The reality is that Australia is a small player, that our contribution to pure science on a world scale is of the order of two per cent, and we need to comprehend the implications of this in optimising our S&T efforts and skills base with regard to overall national well being. There is no doubt that planning R&D is controversial; however, it is an issue that we must face.

We should not be surprised to note that the first round of this Australian foresight process reveals a different emphasis to that of many overseas studies. For example, while we stressed *Global Integration, Applying Information and Communications Technologies, Environmental Sustainability, and Advances in Biological Technologies*, which are reflected overseas, international studies also identify the critical future importance of manufacturing-related S&T. In particular, overseas studies have identified the high significance of precision and control in management, and new materials, which did not emerge from the ASTEC foresight study. It is possible that these omissions reflect some gaps in the ASTEC consultation process, or the high importance accorded to manufacturing in many other countries.

Foresight provides the opportunity for governments to adopt a catalytic role in working with industry to develop new competitive strengths. ASTEC identified many potential export opportunities for a variety of industry sectors in Australia. Capturing these opportunities will require a proactive approach, involving industry, to further examine opportunities and constraints in detail, including those arising outside the S&T system, such as access to capital.

It is also probably necessary to emphasise that the outputs of ASTEC's study should not be seen as prescriptive. We have not sought to identify specific scientific or technological developments for 2010. Rather, we have sought to emphasise the value of 'foresight' as a tool in managing change and to address broad issues of skills, culture, innovation and communications.

If I had to identify a single, critical priority to emerge from this approach, it is the need to develop Australia's technological literacy as part of the inculcation in the young of a spirit of enterprise. This must start at the primary education level and continue through all levels and forms of education and training. Initiatives in this regard should be at the top of the list for actions. ASTEC has proposed that S&T education in primary school be the subject of a flow-on study of great urgency.

In conclusion, I would like to thank all the people who have contributed so generously to this study. This includes the Reference Group, all those who provided input by way of responses to the call for submissions, the Key Issues Roundtable meeting participants and all those involved in the Partnerships. In particular, I would like to thank all my fellow Councillors who made many strong contributions. The overall responsibility of directing the study fell to Ron Johnston who, as Convenor, worked tirelessly and enthusiastically to structure and direct the study and to promote Australian participation in the foresight process, both nationally and internationally. The importance of the input of the ASTEC Secretariat, their enthusiasm, skills and effort cannot be overestimated.

This study is a first for Australia and has demonstrated the importance of foresight as a method for re-directing the mindset of this country, as it must be, and the paramount importance of S&T in securing the future well being of all Australians.

A strong science, technology and engineering system is essential to managing the uncertainties ahead. It is in this context that ASTEC considers foresight to be a useful tool for fine-tuning our S&T activities, to achieve better outcomes in the longer term.

D G Williams

DG WILLIAMS
Chairman of ASTEC

October 1996

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Terms of Reference

Given the Government's objective to improve Australia's long-term economic competitiveness and our social and environmental well-being, by maximising the contribution from science and technology; and, noting the importance of adopting a forward looking approach:

A. Examine possible national and global changes to the year 2010, specifically:

   i) Australia's key future needs and opportunities which rely on, or could be significantly affected by, scientific developments and the application of technology; and

   ii) potential mismatches in the supply of and demand for science and technology in Australia.

B. In addressing A:

   i) engage in an extensive consultative process in accord with international best practice in foresight designed to match science and technology to national objectives;

   ii) encourage the collective identification of important themes for future science and technology planning in both the public and private sectors; and

   iii) increase awareness and understanding of the value and methods of future-oriented analysis.

C. Provide an information base which can assist government and industry to make better informed decisions on the development and application of science and technology.

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Dr Doreen Clark: Key Issue Roundtable: The need to build a Forward Looking Science and Technology System

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Professor Don Nicklin: Partnership: Alternative futures for full service networks in Australia

Dr Jim Peacock: Partnership: Management of neurodegenerative disorders in older people

Mr John Vines: Partnership: Young people's dreams and expectations for Australia in 2010 and the role of science and technology

Dr Don Williams: Partnership: Science and Technology Directions in the Maritime Industry, Key Issue Roundtables: The need to Capture Opportunities from Globalisation Roundtable; and, The Need for Innovation and Entrepreneurship.

Executive Summary

This is the final report of the ASTEC study *Matching Science and Technology to Future Needs: 2010,* which brings together the main outcomes of a number of mini-studies, broad ranging consultations, extensive literature reviews and analysis of overseas foresight experiences. A summary version outlining the outcomes of the study was released in May 1996 (ASTEC 1996b).

A Reference Group of more than 30 eminent Australians assisted ASTEC to develop a set of six *Key Issues for Australia to 2010,* which then became the focus of our broader consultations. Detailed Partnership studies with major Australian organisations, Roundtables which discussed certain of the Key Issues and two major consultancies led us to identify four Key Forces for Change.

The study is one of the most ambitious and complex ASTEC has undertaken.

What Does the Future Hold?

If we knew the future we could minimise the risks of decisions we take today. There are many ideas about what might happen and many attempts by experts to develop predictions. These, often based on trend analysis, collectively form an 'expected scenario' for 2010, which underpins much current long-term strategic planning and decision-making. ASTEC's interpretation of the common elements of this expected 'global future' is shown in the box below.

The future will not unfold exactly like this. Unexpected events will emerge, changing the future in significant ways, although our values and preferences as a community will temper just how these events unfold. Plans which rely too heavily on an expected future risk failure.

To develop a more comprehensive picture of the future, built on combining perspectives of 'expected', 'preferred' and 'possible' alternative futures, we adopted the processes of 'foresight'. The objective of the approach was to enable us to manage the uncertainties ahead.

ASTEC's interpretation of the expected global future

In 2010, economies are expected to be market based. There will be a greater international focus, with stronger regional groupings and a widening gap between industrialised and developing countries. Even though there will be more global institutions, and greater agreement on many matters, there will also be an increased potential for more localised conflicts. Wealthy industrialised countries with aging conservative populations will be trying to protect their position, while poor countries with rapidly increasing numbers of young citizens try to survive. A small number of countries, particularly those in Asia, will have moved from developing to industrialised status, and their increased savings and national economic growth will make them, and the Asia-Pacific region, the main engine of growth in the global economy. International and intra-regional trade in goods and services will increase, with an emphasis on off-shore production and sophisticated high-technology. Resource distribution will be even more inequitable so that poorer countries do not have sufficient water, food or energy, and their problems are exacerbated by cycles of environmental destruction, resource depletion and increasing debt. While the environment of poorer countries is worsening, it will become a higher priority for rich countries and for the newly industrialising countries who want cleaner air and water as part of improved living standards.

Foresight processes were used to develop alternative perspectives on Australia's longer term requirements for science and technology (S&T), including engineering. ASTEC obtained a considered view about the direction and nature of change on the eve of the 21st Century, its implications and how we might better position ourselves to respond to the challenges of shaping our future.

ASTEC developed a distinctive approach to foresight – a 'demand-driven' view. This contrasts with the emphasis of many international foresight exercises, which primarily identify new developments in S&T. ASTEC believes Australia needs a broader view of possible futures which, from the outset, sees S&T as a tool to achieve economic, social and environmental goals.

Four Key Forces for Change to 2010

From analysis of the outcomes of our consultations and mini-studies, we have identified four key forces which are destined to affect our futures in many ways. We must prepare ourselves to manage and shape them to meet our needs into the 21st Century. While they will impact in various ways on industrial sectors and groups within our multicultural and diverse society, we must all understand the implications of these Key Forces for Change:

- *Global Integration;*
- *Applying Information and Communications Technologies;*
- *Environmental Sustainability; and*
- *Advances in Biological Technologies.*

These Key Forces, singly and combined, will change our lives over many years to come. They can significantly change the way people conceptualise the world around them and the way it operates. We are already experiencing changes due to globalisation, increased environmental awareness and the rapid developments in computers and telecommunications. These are expected to accelerate over the next 15 years. However, our capacity to respond to advances in genetic and biological technologies is still in its infancy. We are only beginning to understand their potential and deal with their wider implications.

ASTEC suggests that to assist us prepare for the challenges these Key Forces will bring, areas of action are to:

- *develop a set of strategic principles to guide Australia's proactive participation in a variety of international fora, and to encourage the demonstration and promotion of international bench-marking within Australian companies;*
- *ensure that information and communications technologies (I&CT) are integrated as a key component within all sectors and that all Australians are skilled to provide a flexible response to the challenge of these technologies;*
- *establish the broad parameters for a system of resource accounting in Australia and its scientific and technological requirements, and the development of infrastructure and strategic research in this area; and*
- *develop guidelines for ethical, environmental and equity issues arising from biotechnology developments, eg genetic treatment and testing of humans, and a suitable regulatory environment across all State and Territories.*

The importance of S&T will grow over the next 15 years as the world changes. People in all walks of life will be required to make decisions about scientific knowledge and technological applications in their everyday lives. S&T experts must be prepared to answer these community needs and adapt to working in new ways – increasingly through expanding multi-disciplinary networks.

The S&T system will be required to play an increasing role if we are to meet our national goals of a creative, productive, inclusive and ecologically sustainable Australia into the 21st Century.

Managing the Impacts of the Key Forces for Change

ASTEC expects the Key Forces for Change to have significant impacts on industry, government and the community.

For industry, the unfolding of a particular sector's future will depend on responses to a unique set of long-term issues, drivers and constraints. A long-term perspective indicates the value of adopting a sectoral industry-driven approach to innovation policy and the development of strategic perspectives on future competitiveness. ASTEC's Partnership studies demonstrated the value of taking a targeted approach.

Global markets will bring greater competition for Australian industry – we need to focus on our strengths and to develop and maintain competitive advantage. Enhancing economic growth through an increased research and development (R&D) growth could contribute an estimated $60 billion to national income over a 10 year period (Sheehan et al. 1995).

There is wide agreement that innovation will be critical to Australia's success in the 21st Century. A culture which adapts to change, uncertainty, newness, complexity and the novelty of different approaches is required for innovation to flourish. Foresight can assist the development of an innovative culture.

New opportunities for industry are emerging as a result of the Key Forces for Change. Success in such business will depend to a large extent on using these forces to advantage. This report suggests that future opportunities will require a stronger knowledge base, including a skilled workforce, a good R&D infrastructure and an enhanced capacity for technology transfer. Opportunities were identified for Australian businesses in developing information-based international services, applying sophisticated technology in new ways and integrating business systems into global networks.

Over the next 15 years, Australian governments are expected to face many challenges requiring them to re-assess their roles. They will need to prioritise the acquisition and use of S&T in new policy frameworks on a regional, national and international basis for issues varying from urban water, defence, I&CT, to aging populations. While many current initiatives are targeted in the areas of the Key Forces, ASTEC questions whether we are giving them a sufficient priority.

The last decades have brought immense and often unforeseen changes in the role played by S&T in our daily lives in areas ranging from sport to security, from shopping to employment. Some groups, especially young people, Aboriginal and Torres Strait Islander communities and communities in regional Australia, questioned whether S&T really meets community priorities. They have argued that S&T needs to change significantly if their needs and priorities over the next 15 years are to be met and Australia is to realise its goal of an inclusive society.

To ensure that we are prepared as a nation to face the challenges of the future, government must help Australians to understand the Forces for Change, to shape them for our longer term benefit and to benchmark the appropriateness of our plans for the future against them.

ASTEC identified areas for action to:

- *develop a targeted strategic approach to industry advice on innovation and, in partnership with industry, review the implications of foresight for competitiveness;*
- *collect and disseminate information on emerging characteristics of new businesses and industries, including information on the complex relationships between S&T and economic growth in specific sectors;*
- *examine the scope and adequacy of sources of information on relevant science, engineering and technology in Commonwealth Departments and Agencies and consider the identification or appointment of S&T advisers; and*
- *consult with Aboriginal and Torres Strait Islander communities, particularly in isolated regions, about their capacity to access infrastructure to develop, undertake and evaluate appropriate S&T; and to explore options for developing infrastructure programs.*

A Science and Technology System to Meet Broad Challenges Ahead

Two out of three young Australians believe S&T offers the best chance to meet the challenges ahead. The S&T system, both in industry and government, must be designed to do this effectively. Considerable change is needed and much of this must be motivated from within, as part of a re-think of the role of S&T into the 21st Century (ASTEC, 1996a).

The scale and complexity of the potential challenges ahead require a broad-based response. An essential part of the response must come from the S&T system. The requirement is a forward looking S&T system that is better integrated with socio-economic and environmental needs. This suggests an S&T community that is more aware of, and responsive to, broad community concerns. An S&T system that meets the broader community 'half-way' is likely to foster increased understanding of, and respect for, S&T.

An important aspect is a capacity to capture opportunities and competitive advantages from future technology. As part of our study, ASTEC considered six international generic priorities or 'critical technology' areas for the 21st Century:

- environment (including energy);
- transportation;
- information and communications technology and electronics;
- genetics and biotechnology;
- manufacturing and precision and control in management; and
- new materials.

Prospective technological developments in these areas are considered internationally to be particularly important to the achievement of national goals, eg wealth creation or community well-being. They have much in common with ASTEC's four Key Forces for Change.

ASTEC has assessed Australia's performance in these critical technology areas (Bourke and Butler, 1995). International comparisons reveal relative Australian strength in science related to biotechnology and genetics, and environment (including energy), but some concerns were expressed about our capacity to build commercial success from this expertise. Australia has niches of strength in I&CT and transport, but a weak position in precision and control in manufacturing and new materials (DIST 1996). ASTEC suggests that Australia's relatively weak position in the latter two areas might reflect the high importance accorded to manufacturing in many other countries. Means to develop Australian capability in these areas needs to be further investigated.

Many of the new technologies to 2010 are characterised by the convergence of a number of component technologies. This creates the need for networked international and multi-disciplinary effort. Many of the policy issues they raise, such as intellectual property and commercialisation of new ideas, require the development of effective links between S&T and the finance and legal systems. Developing such links is a critical long-term issue.

The global S&T system is becoming more integrated, raising questions about how we can best benefit from the changing situation. Australia is part of a dynamic region which is rapidly expanding its S&T effort. There are many complementarities between Australia's S&T system and the region as a whole. In particular, our strengths in biotechnology and environment could enhance Australia's long-term future through mutually beneficial collaborations with our Asian neighbours.

Foresight can identify critical skills for the future. Four areas of 'generic' skills required to better prepare the S&T system for the challenges ahead are: management, international relations, applying I&CT, and risk management. These are particularly important for enhancing the commercialisation of Australian ideas.

ASTEC suggests that areas for action are to:

- *promote an S&T system which is integrated into its social and industrial context and, while committed to excellence, is also open and responsive to social and ethical issues;*
- *conduct a review of Australia's relative strengths and weaknesses in emerging 'hot spots' in research and technology, and commercial prospects into the 21st Century, and of barriers to the development of inter- and multi-disciplinary research;*
- *review existing 'national benefit' criteria for Australian involvement in international science, engineering and technology activities, and evaluate Australia's ability to provide relevant and timely scientific and technological information to support Australia's strategic needs in international negotiations; and*
- *encourage organisations responsible for S&T (including industry, government and relevant academies and professional organisations) to review how well they are building generic skills for managing change into the 21st Century.*

Embedding Science and Technology in Australian Culture

The field of S&T will be increasingly important to Australia's ability to meet the challenges of the 21st Century. The level of understanding of S&T across the Australian community is an important factor in determining the extent to which Australia can use this powerful tool. As individuals, and as a community, we need to incorporate socio-economic, environmental and S&T factors into all decision-making. A much better level of knowledge, understanding and skills in S&T is needed for all Australians.

For many years, literacy and numeracy have been the cornerstones of western industrialised education. Yet many people have questioned its adequacy for a more technological age that requires new skills in technology and problem solving. ASTEC proposes the framework for considering this is 'technacy'. Technacy is a way of defining the meaning of 'technological literacy' that goes beyond competency in using technology. It refers to a holistic view of technology problem solving, communication and practice that includes consideration of social, ethical, technical and environmental resources and constraints.

ASTEC suggests that the Commonwealth Government support the development of improved S&T skills by integrating 'technacy' in all primary and secondary school curricula and teaching practices.

ASTEC has demonstrated that foresight is a useful tool in assisting us to meet our goals for the future. Determining research priorities and improving the capacity for long-term planning are only two of these. Overseas experience has proven that it can also build consensus, assist communication between different groups and act as a focus to developing a longer term commitment and vision of the future.

We have the capacity as a nation to meet the challenges ahead successfully. Australians are very interested in the future and want a national framework to build a longer term perspective. People are encouraged by the foresight process; through it, they can develop a confidence about their ability to manage the future. If we are to harness such enthusiasm for the future we need to build an ongoing national capacity for foresight.

ASTEC suggests that the Commonwealth Government encourage government, industry, research and educational organisations, professional societies, peak bodies and community groups to undertake, or be involved in, foresight exercises.

Foresight, which develops a rich context for S&T decision-making, allows us to anticipate potential consequences of current decisions. This can help us shape the present, to better meet our future needs.

Chapter 1. Introduction

1.1 Overview of the Study

This is the final report of the Australian Science and Technology Council's major study Matching Science and Technology to Future Needs: 2010. The study's two broad objectives were (i) to identify needs for Australia in 2010 and to assess longer term national requirements for science and technology (S&T), and (ii) to test the use of 'foresight' techniques. The Council used foresight processes throughout its study to develop alternative perspectives on Australia's longer term requirements for S&T.

This report brings together the many components of the study. The report is intended to provoke debate, and, by providing an information base on the future, to act as an input for organisations across Australia in government, industry and the community for their own long-term strategic planning activities.

The study, conducted in the period from September 1994 to December 1995, brought together the outcomes of thirteen separate mini-studies, a broad range of consultations, extensive literature reviews and analysis of overseas foresight experience. These numerous components are more fully explained below and in Appendix 2.

The primary advisers for the study were a Reference Group of over 30 eminent Australians, well known in industry, government and the broader community. We undertook extensive consultations, including several surveys of the community and S&T experts, including engineering, targeted industry interviews, sector and issue-based and regional consultations. The report builds on a broad base of information and opinions – tested and retested.

Based on an initial 'Overview', we established a set of six Key Issues for Australia to 2010, which then became the focus of our investigations. We initiated detailed studies in five Partnerships involving over 20 major Australian organisations; developed Roundtables to discuss certain of the Key Issues; and established two major consultancies on the contribution of S&T to economic growth and Australia's position in internationally identified critical technologies. The study was one of the most ambitious and complex ASTEC has undertaken.

Australians are increasingly aware that we can no longer rely on natural resources for wealth and long-term prosperity. Nor can prosperity any longer be guaranteed. We live in a complex world where technologies that did not exist a few decades ago are playing key roles in our social and economic life. We now understand that the development, acquisition and application of knowledge through science, technology and innovation can create new sources of wealth and improve the quality of our lives. Knowledge and skills have become key factors in developing and sustaining international competitiveness.

Mechanisms have been developed for systematically looking ahead. 'Technology foresight' or 'foresight' processes are well established overseas, notably in Japan and are under development in Europe and the United States of America. Foresight is being used to contribute to policy development and investment decisions in both the public and private sectors. Companies such as Shell, Philips and Hitachi focus on the long-term to achieve competitive advantage.

Many Australian institutions are casting their horizons further ahead. ASTEC decided that it was important for Australia to investigate how we can benefit from the application of foresight methods to S&T and as a result the use of foresight has been the focus of this study.

1.2 *What is 'Foresight'?*

The Macquarie Dictionary defines 'foresight' as: 1. care or provision for the future; 2. the act or power of foreseeing; and, 3. perception gained by or as by looking forward.

In this report, 'foresight' has an additional special meaning, referring to the growing field of S&T foresight. This field seeks to use various types of information about prospective scientific, technological and other developments as inputs to decisions on priorities and research directions.

Technology foresight exercises are generally viewed as systematic efforts to identify and promote emerging and generic technologies. This is illustrated by an OECD accepted working definition that foresight refers to:

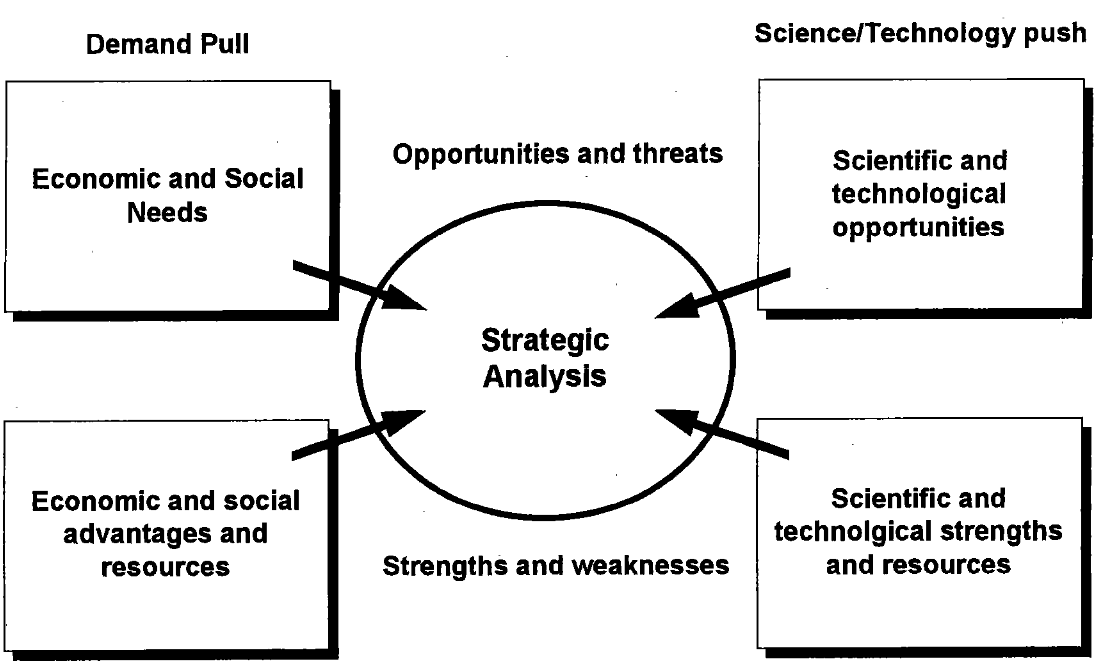
> *'systematic attempts to look into the longer term future of science, technology, economy and society with a view to identifying emerging generic technologies likely to yield the greatest economic and/or social benefits'.*
>
> (OECD 1996)

This definition provides a direct link between foresight and priority-setting through its identification of areas of strategic research likely to bring high-value future benefits.

The essential components of foresight are outlined in Box 1.1. Most prominent is that it develops strategic analysis, based on information which balances 'science-push' and 'demand-pull' factors that influence future developments, and which takes account of strengths and weaknesses and opportunities and threats.

The key aspect of foresight is its forward looking orientation. Foresight attempts to capture the dynamics of change by placing today's decisions into a context that includes the possible developments of tomorrow. It is not intended to replace more traditional methods of analysis. Rather it seeks to add a new dimension to our thinking.

Box 1.1. The Essential Features of Foresight



Source: Based on Martin and Irvine 1989

The process has a number of important characteristics. In particular, it is:

- a way of thinking about the longer term future and how it could differ from the present;
- a means for testing our current views and policy settings; and
- one way of overcoming the difficulties of a static or backward looking analysis.

Foresight acknowledges a range of possible futures. It provides a valuable opportunity to think seriously about significant technical trends and their relationship to socio-economic needs. Unlike 'forecasting', it does not attempt to estimate or predict what the future will be. Foresight implies an active approach to the future and reflects the belief that the future can be influenced through actions we choose to take today. Many decisions involving investment in S&T have long lead times, which makes it important to have an informed view about the future.

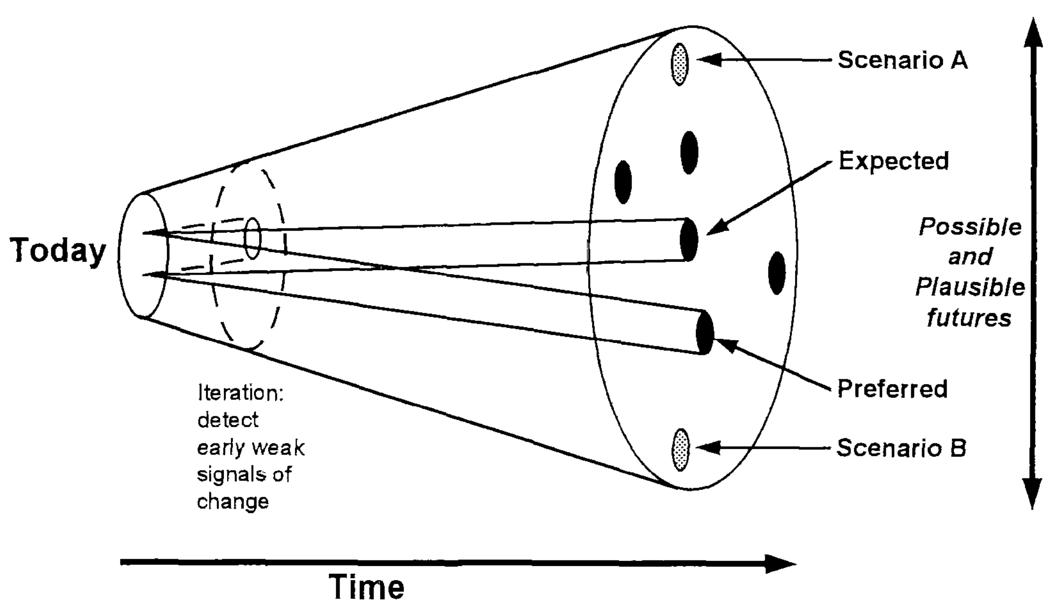
To develop its perspectives on the future, ASTEC combined information and opinion from across the study to build perspectives on expected futures, possible futures and preferred futures:

- *expected futures* are the analyses of experts based on current trends and extrapolations;
- *preferred futures* are those we as a community want to achieve – individual values, strategies of corporations and community organisations, and government policies; and
- *possible futures* provide a range of options for a world which might change significantly over time – focusing on critical uncertainties and trend breakers.

Box 1.2 illustrates these three essential concepts. As we look towards 2010 the future appears as a 'cone of uncertainty'. However, within it in we can distinguish a variety of futures, which are both plausible and possible.

A variety of strategic approaches to managing change is revealed by this view. One can look towards a preferred future as a means of developing, for example, notional targets or milestones, and to establish strategies to realise a Vision. Looking towards an expected future

Box 1.2. Looking to the Future



Source: modified from Bezold and Hancock, 1993.

can often provide a valuable starting point for a 'business as usual' strategy. Both these approaches can, however, be limited by their focus on just one future. The exploration of a number of alternative futures, or scenarios, allows the development of more 'robust' strategies that can be successful in a number of outcomes. ASTEC believes that it is necessary to consider information from these three concepts of the future to develop an adequate strategic position.

The assumptions which underpin foresight methodology are different from those of forecasting techniques. While foresight uses some of the same techniques, eg trend analysis, it provides a different context for understanding the findings. Rather than a primary emphasis on attempting to predict a single future, foresight acknowledges that addressing the future necessitates the management of uncertainty. Foresight involves a process by which a richer and well-informed context for current decisions is developed through a dialogue among relevant stakeholders; it is both active and responsive: an extension of human abilities of forethought, creativity, analysis and judgement, leading to action. Foresight provides a valuable opportunity for us to think seriously about significant technical trends and the relationship between these trends and socio-economic needs.

Foresight assumes that all our actions today, whether or not consciously taken with long-term perspectives in mind, will shape the future – doing nothing is equivalent to an action.

Using foresight, researchers and others can 'rehearse' their possible futures and look forward to potential impacts of new technology, emerging needs and the consequences of current actions. This develops new perspectives on current activities that can provide an input to strategy formulation and long-term planning. The reiteration of foresight exercises offers promise to help more readily identify early weak signals of changes with strategic importance.

It is now well accepted that the process of foresight requires consultation and interaction between scientific experts, research users, policy-makers and the wider community. That is, involving both users and producers of research. In this way, a broad range of perspectives can be explored – the wider the involvement, the more broadly the benefits will be felt. Through such means foresight is intended to overcome vested interests and expand the outlooks of participants.

It is also clear from overseas experience that foresight processes must be transparent. They must allow the underlying assumptions, analytical framework and data inputs to be subject to external scrutiny. Such openness also allows non-conformist views to be given equal weighting with conventional ones and allows the possibility of identifying emerging paradigms.

In conducting foresight it is necessary to maintain a balanced perspective between the supply and demand factors that influence future developments. In particular:

- supply factors include the creation of new technological or commercial opportunities by scientific research, and Australia's strength and resources to exploit them, eg our world class agricultural research; and
- developments in technology and production can create a use for existing and novel science through the mechanism of demand-pull – demand factors include the priorities and needs of the broader community eg the need to alleviate soil degradation.

It is through the interaction of these main elements that successful innovation occurs and the adoption and use of imported technology is mediated.

1.3 ASTEC's Approach

This complex study aimed to provide an information base to assist government and industry to make better informed longer term decisions on the development and application of science and technology (S&T). It examined possible national and global changes to 2010 and Australia's key future needs and opportunities that rely on, or could be significantly affected by, scientific developments and the application of technology.

There are many variations between foresight exercises undertaken around the world. These variations have been structured by a typology suggested by Martin and Irvine (1989), which identifies many dimensions upon which foresight exercises vary, eg from holistic national-level exercises to specific project-based exercises.

Using this typology the ASTEC exercise can be classed as a long-term holistic, national-level exercise with an emphasis on demand-pull, stressing the functions of direction setting, anticipatory intelligence and communication and education. Implementation is directed primarily towards Commonwealth government responsibilities.

ASTEC's study emphasised developing pictures of the context for S&T to 2010, and of Australia's broad future needs. ASTEC used the results of many international studies, including technology forecasts, to develop a view of Australia's S&T context and future globally-available technology to 2010.

This approach is built on the view that complex pictures of alternative futures will enable the assessment of how well our current S&T system is positioning itself to meet our future needs in a variety of external circumstances. From this assessment, critical 'levers' for change were identified. These are areas where actions taken today will place Australian S&T in a better position in the longer term.

The study involved many thousands of people, a series of separate consultancies and drew on international foresight studies, eg from the UK, US and Japan. It was based on an iterative process of identifying, testing and retesting ideas through extensive consultations with experts in S&T and other areas, often in partnership with other organisations. A feature of our study is its very broad base of information and opinions, including inputs from S&T users, providers and policy advisers in both the private and public sectors.

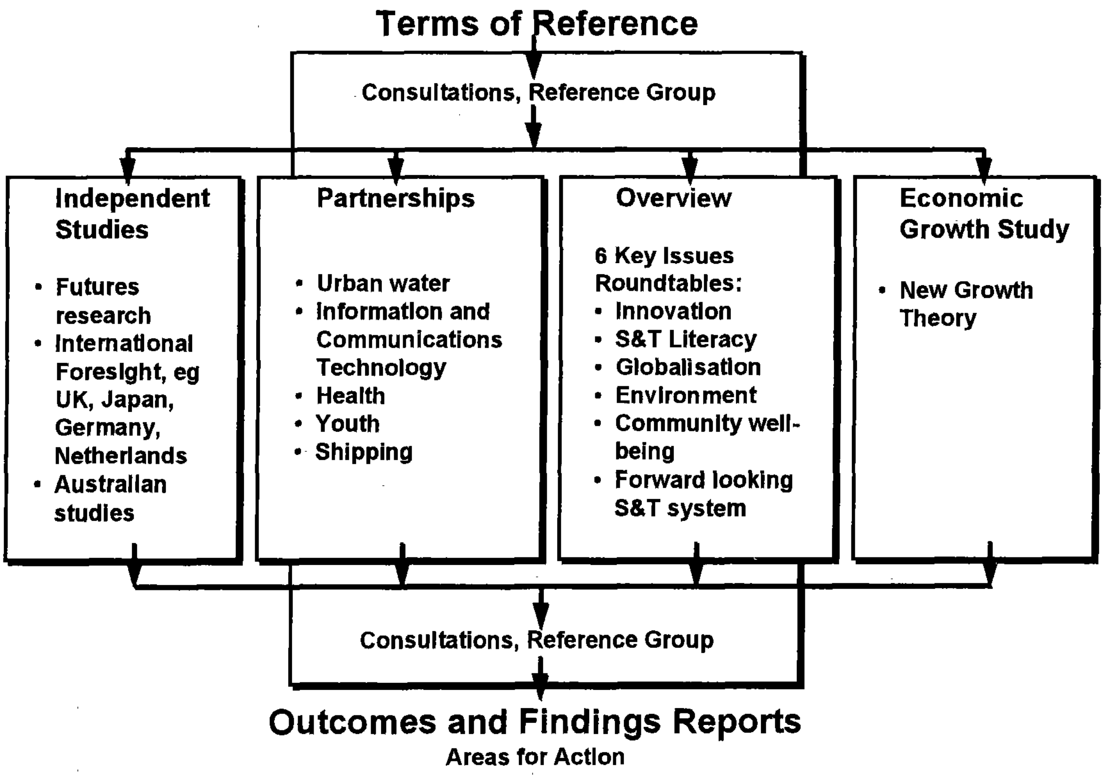
Special features of the ASTEC approach, developed to fit the Australian context, were:

- a catalytic role by ASTEC, with emphasis on process, consultation and involvement;
- a multi-stream approach, with selective studies complemented by a wide overview and the use of multiple methodologies;
- a demand rather than supply-driven approach, with emphasis on needs for S&T in achieving preferred futures; and
- a significant use of overseas studies to establish the general supply conditions for S&T.

Important elements of the study, which are frequently referred to in this report, are shown in Box 1.3. These are:

Reference Group – ASTEC established a Reference Group as the primary advisory body for this study and to ensure that the views of key groups were considered. The members are listed in Appendix 2. ASTEC also worked with the Prime Minister's Science and Engineering Council, and with the Coordination Committee on Science and Technology, to ensure that its work was widely known and understood within the Commonwealth science, engineering and technology advisory system.

Box 1.3. Elements of the Study



Source: ASTEC

Partnerships – in-depth, specific sector foresighting studies jointly conducted with other organisations. Separate reports are available for each Partnership. These used individually designed foresighting processes to identify S&T opportunities and requirements over the next 15 years and demonstrated that foresighting is useful to a wide range of groups in their long-term planning. They investigated how specific S&T capabilities will impact on the realisation of preferred futures and found that broad participation in foresighting results in cohesive sector strategic planning; foresight methodologies could be tailored to individual sector/area needs. Partnerships were in the areas of:

- urban water life cycles;
- information and communications technology;
- health, neurodegenerative diseases in older people;
- youth; and
- shipping.

Overview – This aspect took a broad approach to both supply and demand issues to 2010 and sought inputs from S&T users, providers and policy advisers in the private and public sectors. It was focused through the identification of key issues for Australia. Roundtables involving groups of up to 50 different experts discussed the following Key Issues for Australia to 2010:

- *the need for innovation and entrepreneurship;*
- *the need for a technologically literate society;*
- *the need to capture opportunities from globalisation;*
- *the need to sustain our natural environment;*

- *the need for continuous improvements in community well-being; and*
- *the need to build a forward-looking S&T system.*

Economic Growth Study – a major consultancy on the role of S&T in wealth creation and whether economic growth limits might be lifted through additional investment in research and development (R&D).

Independent Studies – ensured that the knowledge of other groups conducting their own future-oriented analysis will be taken into account. As part of this approach, ASTEC obtained information about the experience of other countries in technology foresight, particularly Japan, the United Kingdom, the United States, Germany and the Netherlands. ASTEC also provided support, through materials, advice and workshops, to organisations seeking assistance on foresight activities. In addition, ASTEC commissioned a review of international foresight and its implications for Australia.

Areas for Action – these are not traditional recommendations. They have been designed to highlight areas of action where governments and others can develop potentially powerful levers for responding to the issues identified. The design of specific actions and programs should rest with the relevant stakeholders. In a few selected cases where potential actions were clear, ASTEC has made recommendations for specific Commonwealth Government actions.

ASTEC believes that the application of foresight can be a practical and useful exercise for many organisations. In particular, foresight is readily adaptable to industry and can be used as part of corporate strategic planning processes. To illustrate this potential, Box 1.4 provides a comparison between the elements of a corporate strategic model and the process and the outputs of the ASTEC study. This reveals a strong correlation. Linkages between the elements of the model are illustrated in Box 1.5.

Box 1.4. ASTEC's Foresight Study Viewed from a Corporate Strategic Perspective

S&T foresight is often proposed only as an aid to strategic planning and in this role it is a powerful and practical tool. Managers need to be able to look ahead with confidence to make strategic choices and investments today, in anticipation of uncertain future returns. Foresight allows managers to consider strengths, weaknesses, opportunities and threats in a dynamic context provided by long-term perspectives. It brings together the consideration of many factors crucial to competitiveness and innovation, such as helping identify commercially valuable research areas and indicating emerging market needs.

Yet the processes of foresight can be viewed as linking even more closely with the techno-industrial planning model. Box 1.5 compares the process and the outputs of the ASTEC study with the elements of a more traditional corporate strategic model. The model is largely self explanatory; however a few words of explanation and a few caveats are appropriate.

The Vision and Objectives statements show both the ASTEC Vision and Objectives, as set out in the ASTEC Act, and the Vision and Objectives as set out in the Terms of Reference for this Study. The correlation between the two reinforces the basis and scope of the study. The Mission Statement makes the point that ASTEC's basic role is to furnish advice to government. While a very important output of this study is the impact of the foresight process on the S&T culture of Australia, the specific output, the Tactics, are advice to government.

A suggested set of Goals is shown in the model, but without quantification, which remains a task for the future. The goals deserve urgent evaluation as part of a framework for accelerating economic growth in Australia and the rate at which we become a more technologically literate society.

The strengths, weaknesses, opportunities and threats (SWOT) analysis lists the various parts of the foresight process employed by ASTEC. The Overview captured the general views of a broad cross section of the Australian community, the Partnerships were foresight exercises on some specific areas of S&T activity or community interest, the Independent Studies constituted a review of national and international foresight and foresight type studies, and the Economic Growth Consultancy was a first cut at applying new growth economic theory to evaluate the contribution of S&T to overall economic growth in Australia.

The first major output of the study was the set of Key Issues shown in the model. These emerged from the extensive consultation process of the Overview and were reinforced to varying degrees in the Partnerships and other consultations. ASTEC's consultations and the analysis of its inputs also identified a list of important export opportunities for Australia and provided the perspectives which were a major determinant of the strategic priorities.

The next two steps in the process distinguish this study. Analysis of the Key Issues and all the other vision and advice collected in the consultations led clearly to four Key Forces for Change. These in effect are the Strategies which will link the Objectives and Goals with the Key Issues. ASTEC acknowledges that second and later foresight iterations will lead to modifications to the list as the national and international priorities change.

As with the Key Issues the Key Forces for Change are not entirely novel, nor should they be expected to be. The difference is that they have emerged from a process of consultation and analysis and hence there is a basis, a logic in their prioritisation, to form the primary set of future drivers for Australia, as perceived by Australians in 1995.

The Study produced a database of ideas ranging from Key Issues through Key Forces for Change or Strategies, to more detailed tactical suggestions relating to how the particular concern might be addressed and the specific objective or goal achieved. These are captured under the heading of Tactics in the model. While these are primarily for government, which is the Mission of ASTEC, many of them have application more broadly, in industry, in the education arena and for the community at large.

Box 1.5. Diagrammatic Representation of Foresight Related to a Corporate Strategic Planning Model

VISION
ASTEC
- The furtherance of the national well-being through the advancement and application of scientific knowledge

STUDY
- To improve Australia's long-term economic competitiveness and our social and environmental well-being, by maximising the contribution from science and technology.

ASTEC MISSION
- To furnish advice to the Commonwealth Government in respect of matters relating to the contribution of science and technology (S&T) to the national well-being

OBJECTIVES
ASTEC
- to evaluate the adequacy, effectiveness and overall balance of S&T activities in Australia
- to identify and support new ideas in S&T likely to be of national importance
- to facilitate the practical development and application of scientific discoveries
- to foster S&T innovation in industry
- to determine means of improving efficiency in the use of resources by the application of S&T

STUDY
Terms of Reference

STUDY GOALS
increase in:
- community awareness of S&T
- investment in R&D by industry
- *investment in R&D by government*
- technology transfer
- economic growth

SWOT ANALYSIS
A SWOT Analysis was carried out through a process involving:
- Overview consultations
- Partnerships
- Independent studies
- Economic growth consultancy

KEY ISSUES
The SWOT Analysis identified as KEY ISSUES the need for:
- Innovation and entrepreneurship
- A technologically literate society
- Capturing the opportunities of globalisation
- Sustaining our natural environment
- Continuous improvements in community well-being
- Build a forward looking S&T system

STRATEGIES
An analysis of the outcomes led to the *Key Forces for Change* which become the STRATEGIES required to achieve ASTEC'S OBJECTIVES and GOALS.
- Global Integration
- Applying Information and Communication Technologies
- Environmental Sustainability
- Advances in Biological Technologies

TACTICS
The following *Areas for Action* are a set of TACTICAL policy initiatives designed to facilitate the STRATEGIES in fulfilment of ASTEC'S MISSION:
- **Global Integration** - develop a set of strategic principles to guide Australia's proactive participation in a variety of international fora, and to encourage the demonstration and promotion of sectoral benchmarking within Australian companies.
- **Environmental Sustainability** - establish the broad parameters for a system of resource accounting in Australia and its scientific and technological requirements, and the development of infrastructure and strategic research in this area.
- **Advances in Biological Technologies** - develop guidelines for ethical, environmental and equity issues arising from biotechnology developments, eg genetic treatment and testing of humans; and a suitable regulatory environment across all States and Territories.
- **Improving the input of S&T to Government Programs** - examine the scope and adequacy of sources of information on relevant science, engineering and technology in Commonwealth Departments and Agencies, and to consider the identification or appointment of science and technology advisers.
- **Developing technological literacy in Aboriginal and Torres Strait Islander Communities** - consult with Aboriginal and Torres Strait Islander communities, particularly in isolated regions, about their capacity to access infrastructure to develop, undertake and evaluate appropriate science and technology; and to explore options for developing infrastructure programs.
- **Enhancing the information base for research decisions** - review of Australia's relative strengths and weaknesses in emerging 'hot spots' in research and technology, and commercial prospects into the 21st century, and of barriers to the development of inter- and multi-disciplinary research.
- **An S&T system responding to globalisation** - review to assess existing 'national benefit' criteria for Australian involvement in international science, engineering and technology activities, and an evaluatio of Australia's ability to provide relevant and timely scientific and technological information to support Australia's strategic needs in international negotiations.
- **Improving S&T skills in the community** - incorporate 'technacy' (the technological equivalent of literacy and numeracy) in primary and secondary school curricula and teaching practice across Australia.

1.4 About this Report

This report brings together the many components of the study. The various parts of the report review important findings and their implications for Australia. Throughout the report, these implications focus on our S&T system, which includes the spectrum of S&T from pure basic research to applied research, engineering and commercial industrial technology development.

The report is divided into a number of parts:

- *Part A: Perspectives on 2010* sets the scene. Its one chapter looks at the background and perspectives that have been developed for 2010. Foresight combines information on predicted, possible and preferred futures to develop informed options. This chapter includes information on trends, scenarios, hopes, fears and national goals as background to ASTEC's analysis.
- *Part B: Key Issues and Key Forces for Change* explores the four forces of change ASTEC identified as 'key' for Australia over the next 15 years – global integration, environmental sustainability, applying information and communications technology and advances in biological technology. These will bring significant changes to all areas of Australian life and the way we think of ourselves. 'Key Forces for Change' are used as the organising device for gathering together the vast number of elements of probable, possible and preferred futures – each is explored in a separate chapter.
- *Part C: Impacts of the Key Forces for Change* explores some potential combined impacts of the Key Forces for Change on industry, government and the community. In a chapter on each sector, this section demonstrates how the impacts of each Key Force for Change will be compounded by other trends, and moderated by local forces and how the Key Force will interact with other changes.
- *Part D: Implications for the S&T System* examines some of the changes required in our S&T system to cope with the challenges of the next 15 years. An S&T system developed for the 20th Century may not be best suited for the next millennium.
- *Part E: A Culture to Manage Change into the 21st Century* concludes the report by examining how Australians can prepare for the future by rethinking their approach to S&T. It proposes a national S&T foresight program for Australia to ensure that our S&T system can better manage the changes of the future.

Part A
Perspectives on 2010

What will Australia be like in 2010? What will have changed and what will remain the same? Many features of our society, economy and environment are changing rapidly. Developments are occurring nationally and globally with seemingly overwhelming speed and complexity.

This study built pictures of 2010 as a broad context for identifying our future needs. It is only when we have built complex pictures of possible and plausible alternative futures that we will be able to assess how well our current science, engineering and technology system is positioning itself to meet our future needs.

Although the details of the future are unknowable, experts have made predictions, based on trend analysis, which collectively form an 'expected scenario for 2010'. This collective view underpins much current strategic planning and decision-making.

Unexpected possibilities will emerge to change this in significant ways. Our values and preferences as a community will also temper how some events will unfold. We must ensure that our preparations for the future are sufficiently flexible to manage the uncertainties ahead.

This Chapter briefly outlines our findings on expected, possible and preferred futures for Australia to 2010.

Chapter 2. Alternative Futures to 2010

The future is neither predetermined nor totally within our control. Small countries like Australia will not be able to impose their 'futures' on the world. However, using foresight we can try to understand the forces of change and, where possible, shape the future to better meet our needs.

Foresight is both active and responsive: an extension of human abilities of forethought, creativity, analysis and judgement, leading to action. It is explained more extensively in Appendix 1.

In this study, ASTEC built its perspectives on the future by combining information and opinion from across the study on expected futures, preferred futures and possible futures:

- *Expected futures* are based on the analyses of experts using current trends and extrapolations. They are very useful for elements in the environment that are determinable and somewhat predictable, eg large scale and long-term issues such as population or trends in resource use. They provide a useful starting point for analysis. However, they often reflect a 'business as usual' perspective and can be limited in their ability to take account of unforseen circumstances. For example, many perceived shortcomings or failures in 'futures' studies arise from a tendency to overemphasise predictions based on current trends or elaborate models (eg Schnaars, 1989).
- *Preferred futures* are those we as a community want to achieve. They encompass our individual values and aspirations, the strategies of our corporations and community organisations and the plans of our governments. They are important because they identify the values on which we will make future decisions. They include what we want and don't want in 2010, what we hope to give to our children and what we will work hard to achieve. Preferred futures are important indicators of what might happen, but do not necessarily take into account whether these futures are achievable. They are often used as a central reference point for goal-directed strategies and the setting of notional targets.
- *Possible futures* provide a range of options for a world which might change significantly over time. These possibilities are usually described through 'scenarios' and provide plausible alternative development paths for the future. However, they do not seek to quantify the likelihood of each of the various possibilities coming to fruition. ASTEC developed various scenarios and used those developed by others. For example, the scenarios of international trade developed by Shell (Shell, 1993) and three scenarios developed by Colin Benjamin for Australia to 2020 (EPAC 1995a and personal communication). Analysis of possible futures allows the development of 'robust' strategies that will remain useful in a variety of outcomes (eg Schwartz P, 1991).

2.1. Expected Futures

What do the experts expect? Whilst there is disagreement on the margins, ASTEC considers that Box 2.1 represents a reasonable interpretation of a 'global' expected future held collectively by many experts in this field around the world.

Box 2.1. ASTEC's Interpretation of an 'Expected Future'

In 2010, there is expected to be an even greater emphasis on market forces, a stronger international focus, a revival of nationalism and a wider gap between industrialised and developing countries. New global institutions and increased international agreement on many matters will not discourage an increase in localised conflicts. Three regional groupings of Europe, the Americas and the Asia-Pacific region will be increasingly important – with large amounts of intra-regional trade and increasing national powers being given to regional bodies.

Wealthy industrialised countries with declining populations of aging and conservative citizens will be trying to protect their position against developing countries experiencing rapid increases in their more youthful populations. A small number of countries, particularly from Asia, will have moved from developing to industrialised. Their increased savings and rapid economic growth will make the Asia-Pacific region the growth area of the global economy.

Trade growth will be concentrated particularly in the areas of high technology goods and services and with an emphasis on off-shore production. Global companies based in many countries will escape control by individual nations and the global financial markets will become more powerful, increasing their influence on the policies of national governments.

While theoretically the levels of global resources are sufficient for the increased population of 2010, inequalities in their distribution will mean that poorer countries will not have sufficient water, food or energy – problems exacerbated by cycles of environmental degradation, resource depletion and increasing debt. Declining living standards in heavily indebted countries may increase political violence and force concessions on debt payments. Conserving the environment will become an even higher priority for industrialised countries; and the emerging middle classes of the newly industrialised countries will demand cleaner air, land, water, etc. Set against this will be tensions arising from energy use and an enhanced greenhouse effect.

Source: ASTEC

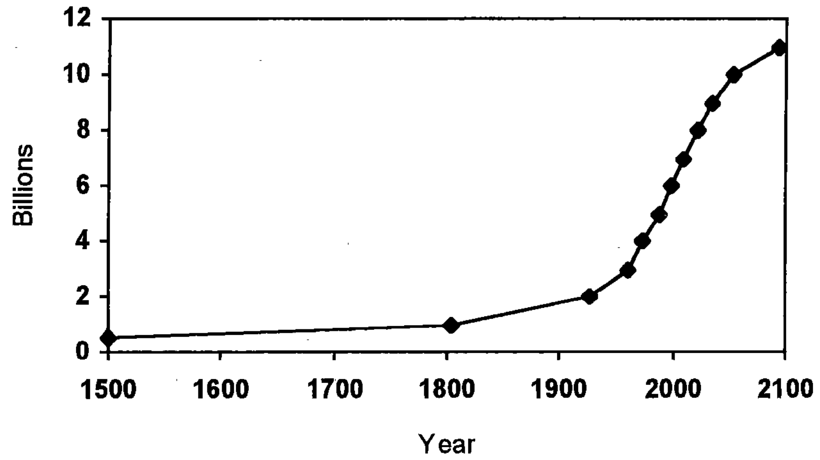
The remainder of this chapter examines some of the underlying features of this expected future to 2010. The intention of this examination is not to be comprehensive, rather it is to place science and technology (S&T) in the context of long-term trends in society, economy, politics and the environment. This section has a focus on demographic changes and the potential impacts of this on other areas, such as security or resources, and includes some features which are more speculative. The latter are secondary, yet add richness to the scenario and are intended to provoke a greater range of opinions, eg a country's response to increasing debt repayments.

Although a global catastrophe purely as a result of population pressure is unlikely by 2010, demography is considered a critical force of change over the next generation. Humans have existed for at least 2 million years and for most of that time our numbers increased very slowly. We are now in an exponential growth phase (see Box 2.2).

The United Nations estimates the world population will be 8.5 billion by 2025 and will stabilise at between 10 and 11 billion people by the second half of the 21st Century. Other estimates put this figure as high as 14.5 billion. These estimates are based on an anticipated decline in birth rate as living standards and education levels rise.

The future pattern of population growth will depend largely on how powerful the links between development, women's education and fertility rates turn out to be. This relationship will be particularly important in China, which has one fifth of the world's population and a birth rate which is more in line with a more developed economy. There has been a dramatic

Box 2.2. World Population Growth – 1500 to 2100



Source: United Nations (UN 1994b)

increase in the use of 'modern contraception'; in industrialised countries, for example, 75 per cent of couples use birth control. In the 1960s only 20 per cent of couples in developing countries used contraception, this has now risen to about 55 per cent with another 12 per cent wanting to use birth control (UN Population Fund, 1994b).

For several decades, poorer countries have accounted for a larger and larger share of humankind and world population growth is now concentrated almost entirely in the developing world. In 1950 nearly a third of humankind lived in the industrial world; now it is below one quarter. By 2020 it will be less than one fifth.

In most developed countries, birthrates have dropped below the average of 2.1 children for each woman of child-bearing age, needed to maintain present population levels. At the same time life expectancy has been increasing. These trends will see the Japanese population go from being the youngest of the main industrial nations to being the oldest within a generation. An older industrial world will inevitably be a slower-growing one, although that does not mean they will necessarily grow more slowly in terms of income per capita.

A reduction in the proportion of people of working age will require significant changes in the way the labour market of most industrial societies operates. Significant changes, some of which are already evident, could include: increases in retirement ages, greater female participation rates and more part-time working (including homeworking and work by university students). Efforts to ensure the unemployed are in work could increase with retraining, maybe several times in a career. It is also likely to be linked to a greater use of voluntary labour and more pressure on children to learn marketable skills.

Immigration is expected to be one of the key issues of the first part of the next century. There will inevitably be great pressure from people on the fringes of the rich world. The current problem of illegal immigration from Mexico to the United States may become one commonly faced by Europe, the richer parts of Asia and Australia. In Asia, migration within countries is expected to be more significant than migration between them. The most obvious example of this will be a movement within China to what are currently the new economic zones, but which appear to be rapidly developing into semi-autonomous states within a greater China.

There has been a ten-fold increase in refugees since the mid-1970s to 50 million displaced persons today (IFPRI, 1995). This number will only grow.

While migration will not be adequate to address the real need, it will lead to striking changes in the demographic balance of a number of countries. The impact of past and current migration in North America will see a relative decline of the 'white' population of North America to 53 per cent by 2050: a trend expected to be well on the way by 2010.

The threat of emerging infections is seen by some as significant, with new or previously rare diseases likely to reach vast numbers of people. High population density and large population movements could allow both new and old diseases to spread rapidly once they have gained a foothold. An infection may come to light anywhere in the world and span continents within days or weeks. Changes in disease distribution may also be influenced in the longer term by climate change.

As the number of humans increases, so does our pressure on natural resources. The world's food and basic natural resources are estimated to be adequate to support increased population levels to 2010 and even provide an increasing number of people, from newly industrialising countries, with modestly comfortable lifestyles. However, the distribution of these resources is likely to leave many peoples in developing countries without adequate food, water or energy – resulting in tensions that could lead to conflict.

In the longer term, population growth is predicted to outstrip increases in food supplies over the next 40 years, leading to massive grain deficits in China, India and Africa, and sending food prices soaring all over the world. The Worldwatch Institute argues that the amount of grain produced per person each year has already peaked. World carryover stocks of grain for 1996 are projected to drop to 229 million tons, down from 296 million tons in 1995. This decline will reduce stocks to only 48 days of world consumption, the lowest level on record (Worldwatch Institute, 1996). Also, the absolute size of seafood catches reached a peak in 1990 at 100 million tonnes and many fisheries are now in decline. The world is reaching the limit of water available for production; the amount of land being farmed is shrinking as more countries industrialise; and fertilisers are now so widely used that simply adding more will not bring the dramatic gains in productivity seen in the past (Brown, 1995).

A shortage of fresh water is predicted to be the most serious resource problem the world will face to 2010 and beyond and has been identified as 'the battleground of the 21st Century' (IFPRI, 1995). Once again the problem is not one of global shortage, but uneven distribution – three-quarters of the fresh water on the planet is held in the polar icecaps and glaciers. Four countries in particular face serious problems: India, China, Pakistan and Egypt. Factors that are expected to contribute to water shortages include:

- further increases in irrigated land – vital for the world's food production;
- the growth in the urban population of the developing world – requiring a large increase in water supplies;
- the normal method of increasing available supplies – building more dams – has been identified as having grave environmental consequences, as most of the world's best dam sites have already been taken; and
- where rivers cross national borders – countries may grab what they can at their neighbours' expense.

Cities and their demands will grow. In 1950 there were two urban agglomerations with more than 10 million people. The United Nations estimates that by the year 2000 there will be at least 25 cities with populations of more than 11 million, of which only five will be in the industrial world. By 2015, the Asian region alone is expected to house 20 such mega-cities. In practice many of the people in these agglomerations simply will not have access to clean water for residential use or for industrial development.

The population of the Asian region, which includes 49 countries from Iran to Australia, is expected to double to 3.3 billion by 2040 (UN, 1994). This astronomical increase will lead to increases in the need for water and sanitation (four-fold), energy and manufactured goods (five-fold) and to a ten-fold increase in air and water pollution. Even with the world's fastest rate of economic growth, three quarters of the world's poor will live in this region.

With no pollution controls in most countries, ten major cities have serious air pollution problems. Currently twenty per cent of greenhouse gases come from the region, but by 2000 emissions are expected to surpass those of Europe and the United States. A one metre rise in sea level, which is predicted by some climate change models, would inundate 23,000 sq kms of Bangladesh and 126,000 sq kms of China. Acute water shortages are increasing, Singapore is already 'water scarce' (measured at less than 1000 cu metres per person per year), while Iran, India and China face similar problems. The region has the world's fastest rate of species extinction and deforestation, with 3.9 million hectares or 1.2 per cent of forests wiped out each year, and more than 70 per cent of sewage dumped in the Pacific is not treated.

Tourism is a further factor impacting on the expected future. As an added environmental pressure, tourism is the fastest growing sector of the Asia-Pacific economy with tourist arrivals expected to reach 107 million by 2000 and 200 million by 2010.

There is predicted to be ample energy to support economic growth beyond the end of the next century. Coal, in particular, and natural gas are in plentiful supply. At present consumption rates there is enough coal to last the world for more than 200 years and enough natural gas for some 60 years. Oil supplies are even tighter. However, the history of resource production shows that stocks continue to grow as more effort is put into exploration.

The bulk of the world's energy is expected to come from fossil fuels at least until 2010 despite increasing concerns about an enhanced greenhouse effect. At the moment they supply 75–80 per cent of the world's total energy needs. The most important renewable energy is wood, which is the main source of energy for half the world's population. But while wood is considered a renewable resource, its collection is leading to grave environmental degradation in many parts of the world. Compared with firewood, the other sources of renewable energy are tiny, due in large measure to low prices for conventional energy.

Even if the industrial world pares back its energy use slightly over the next twenty-five years, there will be increased demand for energy from the newly industrialised countries and in particular from China. In the developing world the number of vehicles is certain to rise in places like India and Latin America, while air travel seems set to continue growing all round the world. Even with a strong conservation policy in the industrial world global energy usage will increase to 2010 and that additional energy is predicted to come in the main from fossil fuels.

During the last decade there has been a genuine shift in perceptions of global environmental problems. Constant step by step degradation of environmental systems is no longer perceived as tolerable and concern about environmental issues is expected to increase over the next 15 years. Current trends suggest that the advanced industrial world will apply increasing resources to achieve higher environmental standards both domestically and to problems likely to impinge on the global environment.

Emerging middle-classes, in the present generation of newly industrialised countries, are also likely to demand much higher standards in air and water quality and waste disposal. In these countries rapid environmental improvements may be possible by the use of new technologies developed in the rich countries under the influence of tough environmental controls.

But other countries (or regions) at the earliest stages of industrialisation will be struggling with even more serious problems than they do at present. Environmental degradation will escalate cycles of poverty and increase the need for high levels of on-going international aid.

Demographic changes will also impact on international relations. In the last quarter of the 20th Century, international relations have been dominated by several emerging inter-related political trends: the collapse of communism; revival of nationalism; growth of regionalism and greater emphasis on the value of market forces. The world is currently going through a period of transition from a relatively balanced 'Cold War' situation to one that is more complex and less predictable. Currently the United States remains the only superpower and by 2010 its chief rival for dominance will probably be China. As the United States' dominance declines, other developed nations must decide whether and how they should take greater responsibility for world stability. The diverse nations of western Europe have to decide whether they can achieve a sufficient level of agreement to act together as a force in world politics. Japan will have to decide whether it wishes to have a greater political and military voice in its region.

Global organisations, generally under the umbrella of the United Nations, are becoming increasingly important. They are increasingly fulfilling some of the functions previously the preserve of national governments: eg providing health and education. This expansion of international organisations in response to an increasing range of regional and global threats is leading to a strengthening of the UN system. The move to global institutions is expected to be through a stage of regionalisation. Certainly there is a rapid acceleration in the establishment of regional economies and trading blocs.

The European Community has developed to the point where the aim of establishing a single European market without barriers to the movement of goods, people and capital between member states is virtually a reality. Equally important is the North American Free Trade Agreement between the United States, Canada and Mexico. In our own region, the internationalisation process continues with the formation of the wider Asia Pacific Economic Cooperation forum. At the same time there has been a marked increase in local conflicts eg the rise of hostility towards ethnic and religious minorities in many countries. For example, the break-up of the Soviet empire, conflict in the former Yugoslavia and tensions in central and eastern Europe. These have led to large flows of cross-border migration which may encourage the spread of 'ethnic cleansing' to other parts of Europe. Other flash points are southern Africa and parts of Asia which have scope for inter-racial conflicts.

In 1991, total external debt for the developing world reached 32.4 per cent of aggregate gross domestic product and 126.5 per cent of its total exports of goods and services. Many debtor countries have fallen into the deepest economic crisis in their histories so that between 1981 and 1988 real per capita income declined in absolute terms in almost every country in South America. The debt crisis has a self-reinforcing dynamic fuelling the fire of poverty over the next 15 years.

The decline in living standards in the heavily indebted countries leads to an increased potential for political violence. Political instability may make it more difficult for democratic regimes to survive, leading to the establishment of authoritarian regimes, or spilling over into international security issues. Debtor governments find themselves forced to demand certain concessions on debt repayment in order to maintain their legitimacy.

Increasingly, large companies will be major players in international relations. Owned by investors scattered around the world, they will have the freedom to base themselves wherever they want. The growing freedom of financial markets limits the ability of governments to set trade controls, controls on capital movements, or on the assets that companies will increasingly hold in many different countries.

The aging population of industrialised countries will be more traditional and conservative in outlook. The influence of these values could lead to a preference for low inflation, low unemployment, low crime, low tolerance for disorder and unconventional behaviour and a greater acceptance of authority. Another important social trend is the slow decline in gender inequality in both developed and developing countries, although its progress will be uneven between and within countries.

This is a global scenario of the 'expected future to 2010' developed by experts. How will Australia be influenced by these trends? Certainly some outsiders expect that there may be global catastrophe by 2010, into which Australia will be drawn. However most experts think on balance Australia will be relatively isolated from many of these changes by its place in the fast growing economic region of the Asia-Pacific.

Certainly Australia's demographic situation is different to that of both developing and developed countries and it is unlikely to be as important an issue for Australia as it will be for the world in general. In contrast to most developed countries, where aging will dominate their demographic changes over the next 15 years, rates of migration will determine the size of the increase in Australia's population, estimated at 21 million by 2010 (ABS, 1994).

The current wave of immigration is characterised by a progressive increase in the importance of the Asia-Pacific region as a source of immigrants, which, over time, will cause significant changes to the make-up of the Australian population. By 2030 it is estimated that at least one in every eight Australians will be Asian immigrants or first generation Australians of Asian descent (AURDR, 1995). Another group expected to grow proportionately faster than the rest of the Australian population are Aboriginal and Torres Strait Islander peoples.

From 2000, the dependency ratio will increase as Australians age. By 2010 it is expected that 2.89 million Australians will be aged 65 years and over (ABS, 1994). While some areas in Australia – for example the health sector – will be significantly impacted on by aging, it is not as large an issue for Australia as for most other developed countries.

Migration inside Australia is predicted to continue towards the north and the west. Queensland is likely to continue to attract high net migration from other states. South Australia and Tasmania are expected to have the lowest rates of growth, with Tasmania's population possibly even falling. Within the States, it is forecast that most immigrants will settle in the capital cities and there will be continued drift away from inland centres. Sydney is expected to remain Australia's largest city with a population of 4.3 million in 2011 – almost one million more than Melbourne – the next biggest city (AURDR, 1995).

We could as a nation choose to radically alter this situation. In response to concerns about the sustainability of the fragile Australian environment, we could reduce immigration and set a population target considerably lower than current levels. Or, in response to large numbers of global refugees, and as part of the price of belonging in Asia, we could open our northern borders to intensive development.

However, the outlook for Australia to 2010 cannot be predicted by simply looking at global or national trends. We must develop a view of the future that incorporates our values and concerns.

2.2. *Preferred Futures*

The values and aspirations of Australians will influence the realisation of prospective futures. People will attempt to shape the future in ways consistent with their values and aspirations. People often use preferred futures to set goals and notional targets to guide their plans. While the links between individual values and national behaviours may often appear tenuous, many changes in society result from changes in community attitudes, eg the revaluation of ecological resources or China's population policy.

This section outlines the views of thousands of people from across Australia from different occupations, regions and sectors on their preferred futures for Australia. This information was gathered from across the study – broad community input, views of the Reference Group, young Australians attitudes and national goals and plans.

a) Community Views

To find out the priorities of Australia's citizens, ASTEC began its broad consultation program with calls for community views on key issues to 2010 (ASTEC 1994b). Analysis of the community responses highlighted three broad themes addressed below.

The environment was nominated by over fifty per cent of people from both urban and rural areas, unions, community groups, academics, business people, government and consultants. These people argued that industry and economic activity must be radically reshaped by 2010 in order to deal with environmental problems ranging from the Greenhouse effect, marine and air pollution and land degradation to conservation of our natural environment, retention of biodiversity and protection of forests and rangelands. Population, water quality and particularly energy options were also constant themes. The people we consulted believe that Australia must respond to these challenges. This high level of concern for the environment is consistent with, for example, a 1993 Australian National Opinion Poll which found environment to be the most important issue on the nation's long-term agenda. The public perceived an excellent opportunity for Australian S&T in developing new environmentally friendly technologies – waste munchers, water purifiers and solar power.

A growing concern about *Australia's place in a changing world* was the second theme to emerge. Australians no longer see themselves as separate and geographically isolated from the rest of the world. We have come to realise that we must find a place in a global community, with Asia on our doorstep. Will we be the poor relation in Asia? The dynamic economies of Taiwan, Thailand, Indonesia, Singapore and China are accruing significant influence on international economic affairs. Economic growth rates of between five and ten per cent and large projected increases in population (and consumption) make these countries very attractive new markets. More broadly, some forecasts have the share of world trade of the Asia Pacific Economic Cooperation (APEC) forum countries growing to almost 50 per cent in 2000 and even higher by 2010. Optimists see only opportunities for Australia, where others question Australia's capacity to 'play the Asia game to our advantage'.

The third theme which dominated our responses related more specifically to *core S&T issues* (including engineering). Concerns were about the need for S&T in small and medium-sized enterprises, developing a more technologically literate society, valuing our scientists and engineers, technological innovation and sovereignty, the need to be a clever country and the commercialisation of new technology. Some of these issues are obviously from an S&T community that feels itself undervalued. But others identified a wariness in the general community of a future dominated by technology. The community remains concerned that technology may be part of the problem, not just the solution. This is reflected in calls by some for scientists to adopt the precautionary principle on environmental matters and consider the ethical implications of new developments, such as the use of aborted foetuses in clinical tests.

Other themes also emerged from public comments, such as the search for an 'Australian identity', the importance of health and education, the challenge of changing information and communication regimes, our economic stability, youth unemployment and maintaining our standard of living to 2010.

b) Reference Group

ASTEC's prime advisers for this study have been a Reference Group – a representative group of about thirty eminent Australians. This included individuals from industry, government, S&T organisations and community groups (see Appendix 2 for a list of members). The

Reference Group endorsed the community's emphasis on ecologically sustainable development, Australia's role in a borderless world and the potentially critical role of S&T. They added concerns about the changing role of work, an aging society and health care and the importance of the information society.

Some members of the group raised issues of economic sovereignty and the capacity to maintain our standard of living in a growing Asian economy. But they also pointed to the need for social cohesion and focusing national priorities. As individuals they painted a fascinating picture of:

- an Australia with no effective borders, as new global information and communications technologies combine with the abolition of passports;
- significant changes to the way we view ourselves as workers if the number of jobs is reduced, Australians move towards self employment, the link between income and work is further weakened and the gap between 'haves' and 'have-nots' widens;
- Australia's place as the only European-style nation of Asia – a region destined to become the dynamic centre of a global economy;
- an economic system forced to reflect growing environmental concerns and the need for ecologically sustainable development; and
- an aging society, where individuals may be required to address problems in their genetic make-up and the cost of health care limits access to the affluent, who face increasing disabilities as they live longer.

c) Young Australians' Views of Preferred and Expected Futures

Young Australians are divided in their expectations about the world in the 21st Century. As part of the ASTEC Youth Partnership over 800 young Australians were asked in a national opinion poll to choose which of two statements more closely reflected their view of the world in the 21st Century. More than half (55 per cent) chose: 'More people, environmental destruction, new diseases and ethnic and regional conflict mean the world is heading for a bad time of crisis and trouble'. Unsurprisingly only four in ten (41 per cent) chose: 'By continuing on its current path of economic and technological development, humanity will overcome the obstacles it faces and enter a new age of peace and prosperity'. Only 4 per cent were unable or unwilling to answer the question.

Two different scenarios for Australia in 2010 were presented to determine the expectations and preferences of young Australians. In essence these scenarios described an internationally competitive Australia focusing on economic growth and efficiency (the 'growth' scenario) and a greener Australia focusing on environment and building better communities (the 'green' scenario).

- 'Growth' scenario: A fast-paced, internationally competitive society, with the emphasis on the individual, wealth generation and 'enjoying the good life'. Power has shifted to international organisations and business corporations. Technologically advanced, with the focus on economic growth and efficiency and the development of new consumer products.
- 'Green' scenario: A 'greener', more stable society, where the emphasis is on cooperation, community and family, more equal distribution of wealth and greater economic self-sufficiency. An international outlook, but strong national and local orientation and control. Technologically advanced, with the focus on building communities living in harmony with the environment, including greater use of alternative and renewable resources.

Young people expect that Australia will be closer to the 'growth' scenario (63 per cent) than the 'green' scenario (35 per cent). However, more than 8 out of 10 young Australians would prefer Australia to be closer to the 'green' scenario (81 per cent) than the 'growth' scenario (16 per cent). As young people become adults in influential positions will they make decisions which try to achieve their vision of a 'Green' Australia?

d) National Goals and Plans

Another indication of preferred futures is provided by exercises leading to 'National Plans' in a number of countries, eg the 'Singapore Unlimited' plan for national information infrastructure, or 'Malaysia Vision 2020'. The past decade has seen the release of many new and increasingly sophisticated national strategy statements, perhaps in response to the pace of change and the growing complexity of national and international economies.

Strategy documents have been produced by administrations in Washington, the European Commission, the Netherlands Central Planning Bureau, Norway, Finland and Sweden, Canada, New Zealand, Japan, and the developing east Asian economies of Singapore, Korea, Taiwan, Hong Kong, Malaysia and Thailand.

National strategy statements can provide focus, clarification, understanding of options and provide coherence to efforts, which may become a powerful force for motivation, informed choice and evaluation of achievement (EPAC, 1994a). The aspiration behind many strategy statements is for better informed and more cooperative and purposive behaviour. Singapore's plan identifies a series of clusters or sectors as major opportunities and develops action plans for each of them.

Generally national strategies are designed for the country where they originate and are not directly transferable. However, we can learn much by comparing the attitudes of different countries to areas of economic and social policy and their strategic directions.

In its consultations ASTEC found that many Australians believe there is value in adopting a national strategic approach. However, policy makers in Australia were sceptical of the applicability of approaches taken by dynamic Asian economies to our pluralist system. Indeed, in Australia, organisations have been increasingly interested in producing sector-specific national strategy documents. Major interest groups have also called for, and often provided, strategy statements. The Economic Planning Advisory Commission (EPAC) recently compiled an analysis of these various strategies, noting that many are produced in response to an often expressed desire for a keener sense of strategic vision.

Box 2.3. Business Council of Australia: Australia 2010: Creating the Future Australia

An illustration of a preferred future is provided by the BCA 'Australia 2010' study, which presents a clear view of a preferred future for Australia and outlines strategic directions to achieve it. The study aimed to give Australians a new sense of national purpose and direction and set an over-arching objective to return Australia to the ranks of the world's ten most affluent countries. Specifically, the program identifies six national objectives:

- being in the top ten countries as defined by per capita income;
- achieving the lowest possible rate of unemployment (not higher than 5 per cent);
- containing net foreign debt at about 50 per cent of GDP;
- achieving a strong and sustainable level of private investment to provide high economic and employment growth;
- maintaining an independent, democratic and cohesive society; and
- maintaining maximum capacity to defend our territorial integrity.

Source: Business Council of Australia, 1993.

Australian strategy statements are most developed in the case of business organisations and state governments. Business groups such as the Business Council of Australia and the Committee for Economic Development of Australia have both provided statements (eg see Box 2.3).

Strategy statements for other groups have tended to focus on particular issues, eg the unemployment problem of the early 1990s. These responses have frequently gone well beyond the immediate issue and increasingly chosen to explore the broader context of national strategies and directions including matters of internationalisation, micro-economic reform, and infrastructure provision. A recent development was the formation of a 'New Visions Coalition' by a wide range of community organisations, which accepted a set of basic principles outlined in Box 2.4.

Box 2.4. New Visions Coalition: Our Shared Vision

We believe that in the future Australia must become a society where employment opportunities exist for all Australians and of consistently improving life opportunities and quality of life for all Australians, based on economic and ecological sustainability and democratic values and social justice.

Our vision is of a society which is pluralist yet united, celebrates our cultural, ethnic and racial diversity and recognises the dispossession faced by Aboriginal and Torres Strait Islander people.

In our current and future Australian society we must respect and promote the human rights of all in Australia and globally, regardless of gender, ethnicity, disability, age or religion. We must 'think globally and act locally' to protect, rehabilitate and preserve our natural Australian environment; and the governments and all other sectors of our Australian community, must accept a common responsibility to foster democracy, social participation and justice.

We seek a society which is free from violence, recognises freedom of speech and the right of citizens to demonstrate, organise, speak out and voice their concerns without fear, promotes and protects democracy, human rights and justice as the governing principles of civil society throughout the world and recognises the interdependence of people.

We seek a society which encourages the right to work in permanent part-time and full-time jobs according to an individual's choice, encourages equal opportunities for all and supports and gives more recognition to the wide variety of unpaid and caring activities which are essential to social and human development in our society.

We seek a society which closes the gap between the 'haves' and the 'have-nots', between the rich and the poor, and between men and women, recognises the special rights and needs of children, and recognises the rights of those with special needs and enables people with disabilities to have a fulfilling social and working lives.

Organisations included in the New Visions Coalition are the Australian Consumers' Association, Australian Council for Overseas Aid, Australian Council of Social Service, Australian Council of Trade Unions, Evatt Foundation, Federation of Ethnic Communities Councils of Australia, National Council of Aboriginal Organisations, National Women's Consultative Council.

Source: New Visions Coalition, 1995.

EPAC suggested that the agenda for Australia's future is one that is increasingly held in common, with strategic elements also agreed in ways unthinkable in Australia a decade ago.

The 1994 EPAC National Strategy Conference, 'Shaping our Future' helped to define national ambitions and future opportunities for Australia and to consider long-term strategies to assist the achievement of national goals. A basic vision for Australia that emerged was of a country that is:

- creative;
- productive;
- inclusive; and
- ecologically sustainable.

There was broad agreement on these as national goals and they were endorsed by the then Commonwealth Government. These are consistent with ASTEC's own consultations.

According to EPAC, key future priorities for the achievement of these goals are (EPAC 1995):

- consolidation and enhancement of Australia's emergence as a global nation;
- further development of Australia's capacities as an innovative nation in each of the economic, social and environmental spheres;
- reinvigoration of the commitment to sustainable Australia through ecologically sensitive activities and policy development; and
- redefinition of a social charter to provide for social security, personal and community development and civic engagement.

These perspectives, especially the four national goals for Australia, must be integrated into our scenarios or possible futures for 2010, as they identify values associated with areas of potential change. We will strive to shape the future to achieve our goals and tensions will arise if the future diverges too far from our preferred outcomes. For example, the 'expected global scenario for 2010', based on competition and freer markets, may in some circumstances be inconsistent with the goal of 'inclusiveness' and/or 'ecological sustainability' and is likely to be tempered by our preferences.

2.3. Possible Futures

An over-emphasis on expectations and preferences can lock people into a 'business as usual' mindset. However, it is not always the most obvious trends or our wishes that will determine the future. The most important challenges might arise from unexpected changes, or small initial variations that can lead to sudden and significant transformations in the future.

Looking to the future there are two important dimensions of risk – probability and importance. The process of developing an 'expected' future gives greater emphasis to the consideration of probability, whereas 'possible' future scenarios weigh importance more highly.

A useful way of addressing this is to consider a number of possible futures through a set of scenarios, which are coherent, alternative stories about the unfolding of the future along important dimensions. While there are no limits to the changes which might be considered, it is important that they are both plausible and internally consistent.

The scenario method has its origins with Herman Kahn in the 1960s as a tool for the military. Pierre Wack, a planner for the Royal/Dutch Shell group, further developed it. Wack suggested that planners need to recognise and make visible the 'hidden' forces present and acting in the world as a means to 'reperceive' the future. Through scenarios one can 'effectively organise a variety of seemingly unrelated economic, technological, competitive, political and societal information and translate it into a framework for judgement – in a way that no model could do' (Wack, 1985).

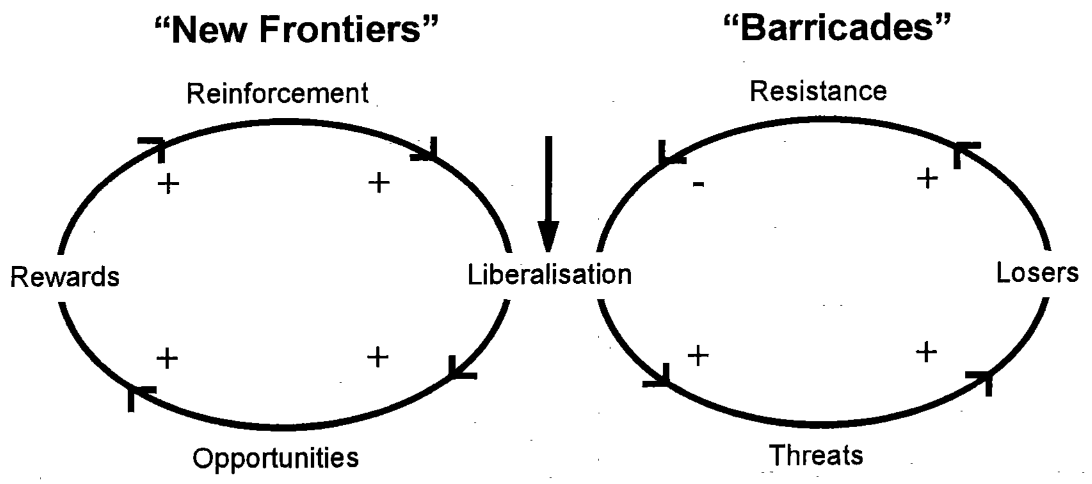
A set of scenarios must focus on the futures and forces which are meaningful to decision-makers, they need to present logical sequences of events in an organisation's environment to show how future states might evolve from the present. They do not predict. Rather, scenario building establishes several plausible and internally consistent stories of the future. These explore critical uncertainties (both highly important and highly uncertain) and possible developments in key variables. Scenarios help to identify key branching points and choices and serve to enrich the mental maps of the participants and managers.

One set of scenarios ASTEC found useful in illustrating the principles of foresight was that developed by Shell (Box 2.5). Shell has put considerable effort into the development of global scenarios over the last 15 years. In its 1992 exercise Shell developed two alternative global future scenarios for the period 1992–2020 based on possible divergent responses to particular events in the 1980s and 1990s. These events included the collapse of the former Soviet Union, the reunification of Germany and the change from a bipolar world order. These scenarios demonstrate that the same motivation or force of change, eg global political and economic liberalisation, might produce two entirely different sequences of events (Shell International Petroleum, 1993).

The two divergent scenarios can be characterised as:

- 'New Frontiers' or continued liberalisation and freer trade and investment flows. This is a story of growth turbulence and change characterised by free interchange of ideas, investment and trade with new business opportunities in many countries. Economic growth in developing countries would be dramatic. It would be a very demanding competitive world for companies to operate in and one in which they would be expected to be good corporate citizens; and
- 'Barricades' which arises from resistance to liberalisation and increased regulation. In this world rich and poor countries continue to conduct their affairs defensively and on a national basis. 'Political' systems would continue to emphasise ethnic differences and regional or national boundaries and development would be much more inward oriented, discouraging international trade and investment.

Box 2.5. Shell's Global Scenarios 1992–2020



Source: Blyth M and Young R, 1994.

These two scenarios have very different implications and together span the breadth of possible scenarios. From them, Shell developed robust strategies which enabled it to succeed regardless of what might happen, in the knowledge that reality is likely to be somewhere between the two. An important purpose of such methods is to sensitise the organisation to recognise signals of possible changes in the world and to enable quick and appropriate responses.

Alternative scenarios demonstrate the important requirement of foresight to consider a range of possible futures – not just one.

Another example of the use of multiple scenarios is provided by the set of scenarios for Australia developed by Colin Benjamin, an Australian corporate strategist and member of the Reference Group for this study. Benjamin developed three alternative futures for Australia in '2025' (as shown in Box 2.6), which can be used to help people cast themselves forward into alternative Australian futures. ASTEC used them extensively in its consultations as a means of extending mind-sets to consider new possibilities over the study's long-term time horizon.

Each of Benjamin's scenarios gives priority to one of economic development, social issues, or the environment.

Yet there is considerable overlap when discussing technology options. They all emphasise information technology, value-adding in primary products, new services and environmental sustainability, but see this as being achieved through different ways and used to achieve different goals.

1. *Regulated equity scenario* is a managed future, with stable social democratic government and a relatively high standard of living. There is moderate Government intervention in planning, market place and workplace conditions and significant 'knowledge based' industry sectors have developed. It places Australia as the 'fourth node' in the global communications multi-media networks with an enviable world class reputation in energy and conservation. While natural based products remain important most are now elaborately manufactured to achieve higher returns for value added services.
2. *Deregulated equity scenario* is a 'market' future that has produced a small, non-interventionist government largely right of centre. There is little regulation of business activity, including shopping hours, and working conditions are generally negotiated at the enterprise level. The economy and service delivery are driven by consumer power and there is significant inequity in the Australian community although the nation overall is prosperous. It views Australia with sophisticated value adding industries based on indigenous intellectual property and is also a major exporter of health and education services. Sophisticated information switching and video-text technologies link major centres around the coast of the nation.
3. *Ecologically sustainable deferred development scenario* suggests a 'Green' approach which has led to a lower standard of living and a move to voluntary 'simple' lifestyles in the interests of long-term economical sustainability. In response to international limits on the emission of greenhouse gases, freeways and fossil fuel powered vehicles are banned and we have made large investments in rail infrastructure and alternative fuel vehicles. Environmentally unfriendly, mainly resource based, industries such as wool scouring, paper pulp production and aluminium production have been abandoned. 'Brain based' industries, particularly in the environmental management area, are insufficient to replace the income lost. There is a high premium on skills and competencies to repair, restore and renew the infrastructure of the old cities.

The market-oriented future (scenario 2) is perhaps the closest to what the experts have predicted for global future in 2010, the more managed future (scenario 1) strongly emphasises Australia's goal of an inclusive society. Some aspects of the 'Green' future (scenario 3) give high priority to ecological sustainability and reflect the preferred future of many young Australians.

Box 2.6. Colin Benjamin: Three macro scenarios for Australia in 2025

1. Regulated equity scenario

Australia in the year 2025 is a product of a long period of dominance by social democratic Governments. These have committed themselves to a mixed economic system and moderate Government intervention in planning and in the market place. Business operations and workplace conditions are still significantly influenced by Government intervention.

Australia is an independent, middle size, Pacific Rim power, with a relatively high standard of living. Governments have retained the responsibility for providing most major services, including education, health, transport, housing and community services. Governments remain major players in the delivery of social justice and equity. Considerable equity has been achieved, but at a price of keeping a significant proportion of unmotivated people dependent on social services. Australians coexist by and large on an equal footing in a clean and sensibly managed environment with a stable and healthy economy.

It has developed a significant 'knowledge based' industry sector, with a world class record in environmental management and conservation. Governments play a major role in industrial restructuring and in the promotion of innovation. While natural resource based products remain important, most are transformed to high value products and services by Australian industry, using largely Australian intellectual property.

Governments promote comprehensive, multi-functional real time information systems covering all forms of travel, with equitable access and integrated across a range of functions, not all directly related to travel.

There are a few major inter-ethnic divisions by world standards and Australia has achieved a complex multi cultural society which now exports products and services in multi cultural management to a world in which many countries have become multi cultural. Its culture has been significantly Asianised and because of this is now able to play a major bridge role between the Asia-Pacific region, of which it is an integrated part and a united Europe extending from the Atlantic Ocean to the Urals.

After many years of struggle Australia's Aboriginal people have achieved a significantly improved status and much greater recognition in a society which respects the culture and lifestyle of Aboriginal people.

Australia's people have achieved considerable security. Security now embraces not only military and physical security, but also financial security. Australia has a system which provides a guaranteed minimum income and national superannuation. In addition, the concept of security now extends to food security, (food is ample and free of contamination) and environmental security (protection from environmental contamination).

Australia's population is 25 million. Because significant investment in large scale decentralisation commenced in the 1990s, Australia now has six cities with a population between 100,000 and 1 million. As a result, Sydney and Melbourne's populations have been contained at 4 million. This has enabled serious urban problems facing Australia's larger cities related to air and water quality, transport, open space and housing crisis to be addressed.

2. *Deregulated equity scenario*

In Australia in 2025, Governments for the previous 15 years have been largely right of centre. The Government sector has become much smaller and much less interventionist. Australia's structure and function has largely been influenced by consumer power. 'Market forces' are now delivering much more acceptable outcomes in terms of quality of life than they did in the second half of the 20th. Century. Environmentally conscious consumers in the 1990s demanded clean and uncontaminated food and environmental beneficial and neutral products and services. As a result, a clean environment has been delivered more by 'enlightened' consumer power than by Government regulation. Its society is culturally and materially sustaining and encourages mutual support and self help.

While it still depended significantly on its natural resource based industry, it has diversified its economy by the addition of sophisticated value adding industries based on indigenous intellectual property and is also a major exporter of health and education services. It has also significantly developed products and services based on biotechnology, advanced materials and information services. Australia's Aboriginal people generally still lack equal socioeconomic status with non-Aboriginal people. Some Aborigines, however, have become particularly successful business people, creating and marketing many products and services based on Aboriginal culture, which are greatly sought after throughout the world.

The relatively high cost of transportation within Australia will start to fall, in direct response to sophisticated information switching and video-text technologies linking major capitals and provincial centres throughout Australia. Geographic proximity to clients and colleagues will become less important over time. While road transportation will continue to be necessary, particularly for the transport of goods and for tourism purposes, increasing reliance will be placed on more efficient and relatively cheaper air and rail travel between capital cities to major provincial centres. A natural consequence and complementary development to enhanced mobility and communication will be the growth of mobile business centres. Service industries that offer their product through information channels will be able to bring their access point physically nearer to those clients who require consultation as well as the product. Increasing penetration of information systems and the ability they will possess to communicate with many types of data base. People will be able to transfer funds easily and remotely to cover transport and traffic-related costs. Improved communications will lead to gradual introduction of demand responsive transportation systems.

Australia has become a much more innovative country and intellectual power in the Asia-Pacific region. Its education systems nurtures youth towards a common national purpose, through an education system which encourages ability and which honours high achievement. It is a society based on highly educated, motivated, innovative and enterprising people. There is little regulation of business activity, including shopping hours and working conditions are generally negotiated at the enterprise level. Australia has shaken off its colonial culture. It is a republic, which is culturally and materially sustaining and culturally and racially tolerant, except for the position of Aboriginal people. It understands the culture of its neighbours and in return receives respect from them. It supports the aspirations of other countries in the region and utilises to the fullest, real opportunities for trade, business and cultural exchange between these countries and Australia.

Government promotion of equity has virtually vanished. There still remains significant inequity in the Australian community. However, Australia has developed a culture which promotes enterprising activities on a wide scale. The nation is prosperous. Those wishing to work are rewarded and those not wishing to work are not supported by Government. Those who are unable to work receive adequate support. Australia's population is 25 million. Of these people, Sydney and Melbourne each have 5 million. This is largely due to the fact that the Governments have not been willing to intervene and promote programs and policies

(cont'd)

favouring the development of growth centres outside the main centres. As a consequence, Australia's larger cities are suffering significant economic and ecological problems.

3. *Ecologically sustainable deferred development scenario*

In Australia in 2025, the nation has opted for a lower standard of living in the interests of long term economical sustainability. The dominant political force has become highly mobilised 'people power'. State and Federal parliaments are dominated by independent representatives, including a large proportion of 'green' independents. Many of these independent representatives determine their individual positions through a system of advance technology, instant referenda.

In the late 1990s, large scale community pressure responding to the development of international limits on the emission of greenhouse gases had stopped most freeway construction in Australian cities. They further demanded a major shift towards investment in rail infrastructure. This resulted in a major research and development effort by automotive manufacturers, who by 2002 were marketing solar electric and solar hydrogen cars. As a result of these technological changes, negotiations were underway to recommence the development of a more modest freeway system. Australia was a nation which showed great respect for the development of infrastructure compatible with the natural environment.

As a result of the 'greening' of Australia, a large number of projects which were regarded as environmentally threatening were abandoned. In the main, these involved developments which added value to Australian natural resource based industries, including wool sourcing, paper pulp production and aluminium production. Despite a major effort to develop 'brain based' industries, particularly in the environmental management area, there was insufficient development of these knowledge based industries to replace the income lost from the discontinued natural resource based projects.

Defence spending is abandoned and funds reallocated into solving environmental issues, eg: develop a pilot small city, with low energy usage targets and integrated transport systems (public and private).

Most Australians have accepted that some major sacrifices needed to be made in order to achieve an ecologically sustained world. Australian governments were now putting the interests of its citizens ahead of the interests of big business. Urban life was characterised by an environment free of the dangers, unpleasantness and sterility which beset Australian cities in the 1990s. Streets were given largely over to pedestrians, cyclists and public transport vehicles, with only a small provision for the private motor car. Greater emphasis is placed on repairing, maintaining and recycling buildings and urban infrastructure than on wholesale replacement.

A significant proportion of Australians still hope that by the year 2030, new forms of economic development which are totally compatible with these higher environmental quality standards would be possible and that Australia could then increase its relative standard of living while not damaging the environment. Value instead is placed on all aspects of the environment and appropriate action is taken to ensure its continuance. Australia was one of the world leaders in environmental protection and management where conservation is viewed as an essential and not a luxury.

Source: Based on EPAC, 1995 and personal communications.

ASTEC also developed several sets of scenarios through the process of this study, using primarily facilitated workshops.

Four scenarios were developed as part of each of the Partnership studies on Urban Water Lifecycles and the Health Partnership on neurodegenerative disorders.

A general description of the four scenarios in the Health Partnership is shown in Box 2.7. This illustrates four possible futures structured around two key dimensions of uncertainty – the focus of the health care system. By examining each scenario, the workshop identified the overall impact each future would have on R&D, and other health activity. This was then used to list key R&D priorities across all scenarios (see ASTEC, 1995b).

Box 2.7. ASTEC Partnership Scenarios: The Management of Neurodegenerative Disease in the Elderly

FOCUS ON THE INDIVIDUAL

FOCUS ON TREATMENT — FOCUS ON PREVENTION

FOCUS ON THE COMMUNITY

'Cure Me' Scenario

- Privatisation, market forces
- Global markets, export focus
- Multinationals influential
- Treatment outcomes focused
- Private health insurance only
- Neglected underclass
- Specialists dominate
- Overtreatment, overspending
- High tech prostheses and orthotics
- Paid carers, robotic assistance
- Mood / memory enhancing drugs
- Hormone treatments

'Keep Me Healthy' Scenario

- Global economic boom, including Third World
- Good public - private balance
- Preventive outcomes focused
- Diet, exercise and education
- Incentives for remaining active
- Gene assessment and lifestyle profiling
- Anti-oxidant treatments
- Reduced workplace stress
- Voluntary tests for everything
- Computer-based preventative programs
- Private insurance 'preventative packages'
- Longevity research

'Cure Us All' Scenario

- Mixed economy, broad tax base
- Universal health care
- 15% of GDP spent on health
- Smart community environments
- 'Prosthetic environments'
- Product ergpnomics for the elderly
- Community emergency call systems
- Acceptance of euthanasia
- Behaviour control drugs
- Widely available standard prosthetics
- On-line diagnostic service

'Keep Us All Healthy' Scenario

- Ecological and spiritual values
- Communitarian ethic
- Stress on epidemiology
- Universal 'third age' education
- Environmental sustainability policies
- Restriction on chemicals in the environment
- Centralised health records
- Health cards for all
- Universal screening programs
- Values-based, family friendly organisations
- Acceptance of 'good for you' legislation

Source: ASTEC

The Information and Communications Technology Partnership scenarios looked at Australia in 2010 from the viewpoint of industry development, focusing on demand for 'full service networks'. The scenarios placed Australia along a continuum from a situation of Australia as a global leader due to exceptionally high domestic demand, through a scenario of high demand where developments in Australia keep pace with developments in other industrialised countries, to a scenario where Australia is a slow-follower of international developments. A further scenario suggested a 'disaster' for Australia (ASTEC, 1995d).

In addition, ASTEC developed scenarios for its Key Issue Roundtables as a means to further explore issues connected to the identified needs. The Roundtables on the issues of 'the need for a forward looking S&T system', 'The need to sustain our natural environment' and 'the need for continuous improvements in community well-being', all assumed significant change along one or more continua to contrast with participant's internal 'business as usual' perspectives. Further information on these scenarios and outcomes from these Roundtables can be found in Appendix 2.

The use of scenarios describing radically different or 'wildcard' futures encourages people to consider a world outside the norm. There is a 'comfort zone' in trend analysis, which does not require us to question the assumptions underlying our expectations. One illustration of this was a preference for trend analysis, rather than scenario analysis, revealed at one of ASTEC's Roundtables on 'The need to capture opportunities from globalisation'.

Foresight processes can provide the structure to move outside the comfort zone and to ask and explore difficult questions about the future in a challenging, yet non-threatening way.

The range of types of information used and obtained through foresight methods, including their relative emphasis on expected, preferred and possible futures is discussed further in Part B. The outcomes of studies are used throughout the remainder of Part C to illustrate the variety and impacts of potential changes ahead.

2.4. Conclusion

This chapter has set out the context for the report by briefly outlining a range of futures for Australia into the 21st Century. It has sought to demonstrate that there are many possible futures for 2010.

In contrast most people carry only one picture of the future around in their heads: a personal view of what tomorrow will be like. This is generally ill-defined and based on a continuation of the present: a 'business as usual' approach. This has the advantage that it is a relatively simple picture which can be used to make decisions. The disadvantage is that it can be misleading as a prediction and lead to poor decision making. It can also prevent us from seeing opportunities from unexpected sources.

However, ASTEC recognised the value of the business as usual perspective and used it as a basis, but this was moderated by views of preferred futures and extended by alternative possible futures.

It is important to explore a more complex approach that perceives alternative possibilities and which takes account of critical uncertainties. This allows us to reassess our perceptions of the future and our inner models of reality and their sets of assumptions.

Foresight, as undertaken by ASTEC in this study, has sought to build pictures of the future by combining views of expected, preferred and possible futures. While such an approach is more complex, it can lead to a more realistic assessment of alternative futures.

However, such a view is often too complex for people to be able to 'carry it around in their heads'. We need a simplifying framework to make it useful for use in decision making and establishing priorities for action.

Box 2.8. Suggested Initial Reading:

- IBIS Business Information Pty Ltd (1993), 'Australia's Next Golden Age', IBIS Business Papers, Melbourne.
- McRae H, (1994), 'The World in 2020', HarperCollins Publishers, London.
- Argy, F, (1993), 'An Australia That Works: Vision for the Future. A Long Term Economic Strategy for Australia', Committee for the Economic Development of Australia (CEDA), Sydney.
- Schwartz P (1991), 'The Art of the Long View', Doubleday/Currency, New York.
- Economic Planning Advisory Commission (EPAC) (1995), 'Shaping our Future: Conference Proceedings', Conference Report 4, AGPS, Canberra. Including: Benjamin, C, 'Optimism and Opportunity – Building the 2121 Perspective'

Part B: Key Issues and Key Forces for Change

Looking to the future is often a daunting task – more difficult over a long time frame. However, ASTEC found people became more confident about their ability to face the challenges of the future by participating in the foresight process. If foresight can promote this changing attitude, it is a valuable addition to our planning processes.

This study provided an opportunity for young people to think about Australia's future. While initially most saw it in terms of a worsening of today's global and national problems and difficulties by the end of the process most said it had made them more aware of what could be done to change things and their personal responsibility to contribute to these changes.

Foresight processes have many different objectives – gathering and analysing information of many different types. The ASTEC process sought to identify broad national issues relevant to the Australian S&T system (including engineering) in the context of 'demand-pull' over the next 15 years.

One respected approach to foresight analysis is to identify major trends or drivers of change as a framework for considering possible futures. From extensive consultations, three issues of particular concern and uncertainty clearly emerged:

- global integration and changing international relationships;
- the applications of information and communications technology; and
- our need to sustain the environment.

Further analysis revealed that, while these three are currently crucial drivers and enablers of change, they are likely to remain highly important over the next 15 years and beyond. Developments in S&T underpin the rate of change in these areas and the challenges they present will require S&T as part of the response.

Although not identified as currently critical, the importance of genetic and biotechnology developments emerged as being critical over the next 15 years. 'Advances in biological technologies' are likely to give rise to many important challenges and opportunities with very widespread impacts and this led ASTEC to identify it as a fourth important force for change.

ASTEC distinguished these four forces as 'Key Forces for Change'. They are long-term, have the potential to bring 'paradigm shifts', act across sectors, have an Australian focus, require response and are capable of being shaped.

Chapter 3 provides more detail on the concept of Key Forces for Change. The following four chapters each describe in greater detail one of the Key Forces for Change and outline how the Commonwealth Government could assist Australians to better prepare for the challenges ahead.

Chapter 3. Identifying Key Forces for Change

3.1. Exploring Key Issues from the Study

In the context of science and technology (S&T), ASTEC sought to identify broad issues of national importance to Australia over the next 15 years through the focus of Key Issues for Australia to 2010. It was expected that these themes would also be reflected in other parts of the study.

As described more fully in Appendix 2, ASTEC consulted widely to obtain a range of views on Key Issues from the community, leaders of various organisations, industry and S&T experts. From this comprehensive process of consultation ASTEC chose a set of six priority needs for Australia over the next 15 years. These focused on those future needs where S&T is likely to have a particularly strong impact, reflecting ASTEC's role as adviser to Government on these matters.

The six Key Issues are:

- *The need for innovation and entrepreneurship.* A key challenge of the 21st Century will be to manage the increasingly rapid pace of change. Innovation and entrepreneurship will help us to respond to new needs and opportunities as they arise.
- *The need for a technologically literate society.* The 21st Century will see an increase in the pace with which we introduce technology into our society. The appropriate response to more technology is not to ignore it, but to accommodate it, respond to it and shape it. We need a society that can make informed choices.
- *The need to capture opportunities from globalisation.* As we move toward the global economy of the 21st Century, countries are becoming more interdependent. Global process are creating a new distribution of wealth, skills, technology and production. Australia must identify and capture the opportunities in this evolving world.
- *The need to sustain our natural environment.* Our physical environment is our greatest natural asset and a major inheritance for our children. Increasing development and population growth in the 21st Century must be managed in the context of a sound scientific understanding of the value of our natural environment as the basis for Australia's longer term prosperity.
- *The need for continuous improvements in community well-being.* To realise a more inclusive, cohesive, confident and productive society in the 21st Century, Australians will need to face many new challenges. S&T can help solve current problems, deliver continuous improvements and meet new challenges such as aging.
- *The need to build a forward-looking S&T system.* The strategic direction, skills and knowledge generated by S&T will impact on our ability to meet our future needs. Our S&T system must look ahead to the 21st Century and be open and responsive to early, and possibly weak, signals of change.

Each Key Issue was then explored through a consultative process, generally a Roundtable of about 50 experts from a range of areas, involving scenarios and/or trend analysis. The outcomes of the Roundtables are discussed in more detail in Appendix 2. A number of themes emerged consistently from the Roundtables. These included the role of education, the emergence of the Asia-Pacific region and the growing gap between rich and poor. The Roundtables also highlighted a number of critical themes.

Three themes clearly emerged as particularly significant because of the widespread changes they would bring to all areas of Australia over many years. They are:

- ***globalisation and internationalisation***, eg Australia's changing place in the world, the importance of our developing relationship with the Asia-Pacific region, building effective links with other regions, concerns about national sovereignty and foreign ownership and global institutions, free trade and tariff barriers;
- ***environmental issues***, eg the impacts of a growing global population on world resources, Australia's historic role as a resource-based economy, our potential as the 'food bowl' of Asia, diminishing biodiversity and the impacts of global change, opportunities in environmental management, and the growing influence of 'environmentalism'; and
- ***information and communications technologies (I&CT)***, eg emerging gaps between information rich and information poor, the potential of interactive broadband services, mobile digital communications, security and privacy, and global electronic financial transactions.

Two of these themes – globalisation and environment – were reflected in the initial set of Key Issues for Australia to 2010, and were explored in more detail as part of the Roundtable process.

The themes were also common to several of the Partnerships. Issues related to globalisation were an important theme in the Partnership studies on Shipping and on Information and Communications Technologies – two of the technologies which underpin global integration. Global issues were reflected to a lesser degree in the other three Partnership studies. The Urban Water and Youth Partnerships stressed the crucial importance of environmental issues and they were a contributing issue in the Health and Shipping Partnerships. Information and communications technologies was an important generic theme in all the Partnership studies.

ASTEC also conducted in-depth interviews with a small number of industry leaders from a variety of sectors including chemicals, pharmaceuticals, retail and finance. These interviews identified the dominant trends to which companies are currently responding and for which they are developing plans over the next decade, relate particularly to the challenges of environment and global integration. Concerns about globalisation and internationalisation focused on potential consequences of Australia's relatively small markets and businesses compared to other economies.

The apparent emphasis of many foreign controlled multi-national enterprises on local adaptation of applications, with relatively few examples of global product mandates, is particularly important. The way companies do business, and the demand for various products and services, is being significantly changed by environmental concerns. Some suggested that the relative attractiveness of countries as a base for their operations was to a certain extent influenced by environmental factors. Major technologies which companies are seeking to incorporate are I&CT, and to a lesser extent biotechnology and nanotechnology.

3.2. Generic Themes for Australia to 2010

Further analysis of the three major themes revealed commonalities. Broader than a single technology or sector, they are generic issues or trends that will have pervasive impacts on our economy and society to 2010 and beyond – changing the way we do things – with the next 15 years being critical to their development.

Each has the capacity to generate a 'paradigm shift' – a significant change in the way people conceptualise the world around them. Global integration requires Australians to re-orient their view to confront challenges to national sovereignty and what it means to be Australian. Environmental sustainability requires a continued effort to establish the real value of our environmental assets and natural heritage. I&CT are changing international power structures – providing the currency of an evolving society and altering economic and social transactions.

From the viewpoint of the 'expected global scenario for 2010' (see Chapter 2) these forces are, to a certain extent, inescapable. There would seem to be little Australia can do to stop global integration or either of the other forces. However, it is important to recognise that there is considerable uncertainty connected to each of the forces and, as illustrated by Shell's scenarios, reactions to global integration could lead to a breakdown of the international trade system.

Taken together, *Global Integration, Applying I&CT, and Environmental Sustainability*, provide a broad set of variables with the scope to influence change in many different sectors. Given the criticality of these three generic themes, ASTEC has called them 'Key Forces for Change'.

3.3. An Additional Key Force for Change

An additional theme emerged from many components of the study: advances in genetics and biotechnology. Although perhaps of lower widespread interest at present than the other forces, it has strong S&T elements in areas of Australian research strength, and is likely to increase in importance to become critical by 2010.

Genetics was the focus of the Roundtable on *the need for continuous improvements in community well-being: 2010.* This Roundtable raised issues such as the role of genetics and biotechnology in improving agricultural production and feeding a growing world; the relative strengths of these areas in Australian basic science; potential health and medical benefits; genetic screening, confidentiality and a realm of ethical issues; concerns about equity and access; the release of genetically modified organisms and managing environmental risk; and the impact of these developments on the knowledge of indigenous groups.

The Youth Partnership study was concerned about ethical aspects of new developments in genetics and biotechnology, whilst the Partnerships on Urban Water Lifecycles and Health (neurodegenerative disorders) saw improvements in genetic information and biotechnology as useful in meeting the challenges ahead.

In looking to 2010, ASTEC considered that genetics and biotechnology are a powerful generic technology potentially akin to I&CT in the scale of its impact. Genetics gives us the capacity to create new organisms and treat disease – to change our biology in new ways. It will have widespread impacts on healthcare and food production and consumption – essential features of our daily lives. Applying this power will require new ways of thinking about ourselves and the role of humans in the ecosystem. The last two decades have produced many new tools and concepts to manipulate life and have built a launching pad for a biotechnology era in the 21st Century.

However, the impact of genetics and biotechnology will not be as profound by 2010 as that of the other Key Forces for Change. It is unlikely that a widespread understanding of the full changes possible in biotechnology and genetics, let alone widespread use of many of the envisaged products, processes and services by 2010.

Yet many experts believe that the period to 2010 will be critical in determining Australia's response to this revolutionary new technology. Will we provide the resources for our research and development (R&D) to remain at the leading edge and generate key intellectual property?

Will we confront the ethical and environmental issues early and in a constructive way? Will we adopt a rational, national and cohesive approach, or have our future determined by a tyranny of small decisions?

ASTEC therefore considers *Advances in Biological Technologies* as a fourth Key Force for Change into the 21st Century.

3.4. ASTEC's Four Key Forces for Change to 2010

Each of the four Key Forces for Change can be considered as producing a continuum of many possible future outcomes. For example, as shown by Royal Dutch/Shell (Chapter 2) the same motivation or force for change – trade and economic liberalisation – can produce two entirely different outcomes from responses leading to divergent sequences of events. The Key Force of global integration can incorporate all possibilities from a totally integrated world with one global governing body, to a break-down in current arrangements and a retreat into national sovereignty. Similarly, environmental sustainability could include all possibilities from radical 'greenism', to a reaction that provoked a return to development at all costs. It is important to identify key branching points and choices.

Viewed in this light, ASTEC's four Key Forces for Change are:

- ***Global Integration***
  - a continuum of responses to trade and investment liberalisation which ranges from global unification, through transitional regional economies, to initiatives to erect new national barriers and boundaries;
- ***Applying I&CT***
  - a continuum of responses to the possible development and use of I&CT, which ranges from the ultimate in techno-globalism, through specialised uses, to rejecting I&CT due to costly mistakes and information warfare;
- ***Environmental Sustainability***
  - a continuum of responses to environmentalism and global change which range from anti-development perspectives on conservation, through integration of environmental values in economic decisions, to the rejection of all non-economic values; and
- ***Advances in Biological Technologies***
  - a continuum of responses to the potential increased knowledge of genetics and biotechnology which ranges from increased productivity, health and environmental benefits, through slower development to ensure safe, ethical and effective use, to costly biological disasters and rejection of the technology.

While ASTEC is predicting these four dimensions of change will be important, we are not predicting where Australia will be on each of the four continua in 2010. We have not set priorities within the set – one is not considered more important than another. All will not progress at the same rate over the next 15 years. However, some possibilities are more likely than others and these will be explored in greater depth in the following chapters.

Although the Key Forces are relatively independent and can be treated as distinct they are interlinked. For example, I&CT can also be considered an enabler of global integration and it is their interaction which is likely to shape the future in profound ways.

In addition, ASTEC's Key Forces for Change are not necessarily the most important influences in any particular situation or organisation and in some cases a specific sectoral factor may be of greater importance. For example, in the health delivery sector, a trend to prevention rather than treatment could be more significant over the next 15 years than the four generic forces identified by ASTEC. However, the capacity to develop effective health prevention programs is based on the data management capabilities of up-to-date I&CT and developments in biotechnology will also be a key factor. Also, another area of importance identified in overseas studies is new materials. Developments in this area will be critical in some sectors, particularly materials production and fabrication in manufacturing. While new technologies in this area will have significant impacts, ASTEC did not consider them to be as critical and widespread in the Australian context as the other four forces.

The Key Forces are particularly important for Australia at this point in time: they are time and situation dependent. They have a unique Australian focus. Although there are some similarities to the lists proposed by other countries they reflect the challenges Australia must face.

If responses to these Key Forces are adequate and effective, ASTEC considers that Australia will have an economically, socially and environmentally more viable society in 2010. Therefore our plans for the 21st Century must include an effective response to these Forces for Change.

3.5. The Role of S&T in Key Forces for Change

S&T is embedded in all the Key Forces for Change and many changes in these areas will be technology driven. Particular developments in fields of information technology or biological sciences will underlie development potentials in *Advances in Biological Technologies* and *Applying I&CT*. *Global Integration* is enhanced by developments in communications and transport technologies. *Environmental Sustainability* will be improved by scientific and technological developments in a range of areas from chemistry and mathematics to engineering and membrane technology.

However S&T is not only part of the driving force of each of the Key Forces for Change. It must also be considered a very important part of the responses we develop to shape the Key Forces for Change (see Box 3.1).

One way of unravelling changes over the next 15 years is to examine the expected changes in S&T. We use information from technology forecasting and technology foresight studies to describe potential S&T developments. These reports allow us to build a picture of global available technology in 2010.

A feature of this study is the 15 year time frame. It is now widely accepted that the development of a technology typically passes through a 10-15 year gestation period (eg Grupp, 1993). Technologies which are currently the subject of scientific exploration (ie still largely at the basic or strategic stage) will not achieve market penetration in much less than 15 years. Where prototypes or initial technological realisations have already been produced, the full economic potential of such technologies may be realised in 8-10 years. This provides some basis for projecting general technological developments over the next 15 years. However, it does not allow confident identification of the particular value added products and services which produce the spurt in demand necessary to realise the economic potential of a technology.

Box 3.1. Key Forces for Change Reflected in S&T Priorities.

Interestingly, ASTEC's four Key Forces for Change were reflected in the S&T requirements identified by the Health Partnership on Neurodegenerative disorders (NDDs) for the next 15 years and beyond. These are:

- Improved biomedical knowledge-base achieved through the genome project, resulting in improved diagnostics and treatment of NDDs (corresponding with *Global Integration*);
- Increased application of information technology developments on health diagnosis, treatment and prevention, resulting in increased accessibility to information at every level (corresponding with *Applying I&CT*);
- Improved understanding of the effects of environment on human health and NDDs (corresponding with *Environmental Sustainability*); and
- Increase in bio-materials and bio-sensors applications, creating new opportunities for novel treatments and prevention strategies. This will apply a suite of technologies, emanating from diverse scientific fields, including polymer chemistry and micro-electronics (corresponding with *Advances in Biological Technologies*).

Source: ASTEC 1995b

Scientific and technological developments are embedded in the context of our society and our world. Technology is a powerful force providing many experiences and images which shape meaning, perceptions and behaviour. But society can also exert a strong 'selection pressure' for and against certain technologies. Successful innovation is the result of a complex interaction between the possibilities presented by the technology and the demand for applications. Some innovations are picked up quickly, many others fail.

3.6. Comparison with International Priorities

Whilst the Key Forces for Change emerged from the Australian context it is valuable to compare the priorities developed by other countries with ours. This is not an easy task as they generally had quite different objectives and methodologies. Even so, it is useful to consider whether some of the forces are global, emerging from many studies. It is also possible that other studies found new trends which can point us to areas for further investigation.

A recent survey of technology forecasting from 1970-1993, found four 'enabling' technologies and one 'enabling issue' turned up consistently in the technology forecasts in many fields (Coates et al, 1995). The survey found consistent references to:

- *information technologies* – computers, computer networking, data gathering, telecommunications shaping every field;
- *genetics and related biotechnologies* – becoming increasingly prominent in forecasting from the late 1980s. While not every field identifies genetics as relevant, a majority do;
- *materials S&T* – critical to any field that manipulates structures, devices and artefacts;
- *energy technology* – an underlying theme of developing energy in forms and prices to be sustainable, but there is relatively little systematic, comprehensive, in-depth, or goal-directed forecasting of the energy future; and
- *environmentalism* – nearly every S&T field at some point recognises the environment is critical to its future. It has effects not only in the area to which it is immediately directed, but also brings about basic changes in many other areas.

Box 3.2. UK 'Generic' Science, Engineering and Technology Priorities and ASTEC's Key Forces for Change

UK 'Generic' SET Priorities:	*ASTEC Key Forces:*
Harnessing Future Communications and Computing Technology	— **Applying Information and Communications Technology**
A Cleaner World	— **Environmental Sustainability**
From Genes to New Organisms, Processes and Products	— **Advances in Biological Technologies**
Social Shaping and Impact of New Technology	—
Getting it Right: Precision and Control in Management	—
New Materials, Synthesis and Processing	—
	— **Global Integration**

Source: ASTEC

Of these five priorities ASTEC's Key Forces For Change correlate with three: information technologies, genetics and related biotechnologies, and environmentalism. The category of energy technology is subsumed in the ASTEC Key Force for Change of *Environmental Sustainability*. New materials was not a consistent theme in the ASTEC study, and materials S&T is critical mainly to fields which manipulate structures, devices and artefacts (Coates et al, 1993). In comparison to major industrial nations such areas do not have a significant presence in Australia.

An examination of major foresight exercises in other countries was carried out for ASTEC (Bourke and Butler, 1995). Bourke and Butler considered the most important recent outcomes of foresight exercises were provided by the UK Technology Foresight program. This sector-based study examined generic technologies underlying 15 sectors. It identified six broad areas of 'generic science, engineering and technology priorities' that are likely to have pervasive effect across a number of sectors (UK OST, 1995). Interestingly, as shown in Box 3.2, ASTEC's four cross-sectoral Key Forces are closely related to three of the UK generic priority areas.

The UK priorities in manufacturing of 'Getting it right: Precision and control in management', and 'New materials, synthesis and processing', were not central themes of the ASTEC study. This could reflect the design of the ASTEC study or their lesser importance to the Australian economy, and is one issue that will be explored in greater detail later in the report. 'Social shaping and impact of new technology', will be addressed by ASTEC's framework of impacts and potential responses.

A unique feature of the ASTEC list is the identification of *Global Integration* which ASTEC considers is a particularly important force of change for Australia at this moment in our history.

Australia's unique environment and cultural identity have been shaped by a history of relative isolation, but this is changing. Technology is overcoming distance and the Asia-Pacific region is emerging as a economic growth area. Global Integration is related to human actions and the policies of governments. For example, 2010 is the target for removing tariff barriers in the industrialised countries of APEC. For relatively small economies like Australia, global integration places a focus on diffusion of knowledge rather than creation of knowledge as factors in productivity growth.

When comparing the UK foresight study with other foresight studies conducted by the UK, US and Japan, an additional aspect emerges from these later studies – the importance of transport. As transport is particularly relevant, along with I&CT, to global integration, this brings the ASTEC study into even closer agreement with the broad outcomes of the various studies.

The New Zealand government's strategy for S&T to 2010 identified eight 'Key Science Areas', considered to be strategically important to maintaining New Zealand's scientific capability. These areas, which are intended to be updated regularly, were:

- evaluating the resource potential of New Zealand's Exclusive Economic Zone;
- characterising New Zealand's biodiversity;
- sustainable biological production systems;
- understanding biological hazards;
- innovative industrial processing and manufacturing;
- product development;
- New Zealand social and cultural dynamics; and
- information and communications.

While the New Zealand list develops 'environmental sustainability' in the areas of marine, biodiversity, biological production and biological hazards, the most obvious difference is the inclusion of priorities relating to manufacturing – innovative industrial processing and manufacturing, and product development.

Therefore the ASTEC Key Forces for Change align well with international experience although there are some important differences in emphasis. These differences are critical. Technology forecasts are increasingly recognising the impact of social and environmental shaping of new technology. Old approaches, of a more technology-push type, have given way to a more complex and subtle view that seeks to take into account human values and actions and the environment.

3.7. Exploring the Key Forces for Change

The next four chapters provide a brief overview of Key Forces for Change in Australia to 2010 and detail how they emerged from the study. They outline some of the changes we might see over the next 15 years, including some of the developments in S&T predicted in international foresight studies.

Each chapter also seeks to describe an important challenge Australia will face over the next 15 years and puts forward an *Area for Action,* where what we do today can improve our ability to shape responses to each Key Force for Change.

Chapter 4. Global Integration

4.1. Introduction

> *'Australia's unique environment and cultural identity have been shaped by our history of isolation. But this is changing. Technology is overcoming distance. And the centre of global economic growth is shifting to the Asia-Pacific region. This will present a range of opportunities and challenges for the next century. While priority is currently being given to opportunities in Asia, we cannot afford to ignore our traditional markets in Europe and North America, or the newly developing regions to our east and west.*
>
> *2010 is the target for removing tariff barriers in the industrialised countries of APEC. It will presage a decade where fast growing countries of the Asian region will have greater access to Australian markets than Australia will have to theirs. The achievement of targeted reductions in current Australian tariffs by 2010 will be both a major opportunity and a threat to Australian industry. How can our science and technology (S&T) best help to meet these challenges?'*
>
> (ASTEC, 1995a)

Countries are becoming more interdependent and integrated. Global processes and global competition are creating a new distribution of wealth, skills, technology and production. The pace and extent of globalisation, and the increasing internationalisation of culture and communications, is influenced strongly by technology, particularly transport and communications. These processes have a powerful potential to reshape Australia's place in the world.

The term 'globalisation' has become a much used and somewhat ill-defined term. It is most commonly used to describe processes of technological and economic global integration, eg the activities of multi-national firms in resourcing, in one or more countries, their production, marketing and research and development (R&D), etc. The term is closely related to 'internationalisation', which refers to the opening up of national economies to the international marketplace and the linkages this has encouraged (EPAC, 1995b). ASTEC uses the term *global integration* to encompass both these processes. The impacts of global integration and reactions to it will be experienced in many ways through economic, political, social and environmental dimensions.

There is a continuum of possible futures. As one of ASTEC's Key Forces for Change *global integration* is capable of bringing about a quantum shift in our world view of nation states. At one extreme, as suggested by Robert Reich:

> *'We are living through a transformation that will rearrange the politics and economics of the coming century. There will be no national products or technologies, no national corporations, no national industries. There will be no national economies, at least as we have come to understand that concept. All that will remain rooted within national borders are the people who comprise a nation. Each nation's primary assets will be its citizen's skills and insights.'*
>
> (Reich, 1991)

At the other extreme, a reaction against integration might impact on the political and policy frameworks affecting national border policies, and could bring about trade wars. To illustrate this, ASTEC developed a counter-scenario to the 'expected future to 2010' discussed in Chapter 2. 'Fortress Australia', based on the Shell 'Barriers' scenario, illustrates the need for those looking toward the future to consider a number of alternative perspectives (Box 4.1). However, much of the material presented in this chapter represents the expected view of continued integration.

Box 4.1. 'Fortress Australia' – a Possible Future Scenario Counter to Expectations

During the late 1990s, trade liberalisation stalled as the World Trade Organisation (WTO) unsuccessfully sought to mediate unresolvable conflicts such as that between China and the United States.

Japan's population was one of the oldest in the developed world – a community keen to enjoy some of their hard won prosperity with increasing comforts in their old age. By 2005, their savings ratio had fallen well below the levels of other industrialised countries. Compounding this, the country was rocked by a major earthquake centred on the city of Tokyo. The Government introduced a range of infrastructure bonds. The Japanese, encouraged by strong feelings of nationalism, withdrew their savings from companies overseas and particularly in the United States (US), to invest in these bonds.

The WTO was besieged by requests for exemptions, sparked by the Japanese disaster. These requests took the WTO by surprise and provoked a debate over the costs and benefits of free global trade. Groups in many countries used this opportunity to lobby against free trade in the name of patriotism. Even 'free trade countries' like Australia re-engaged in the debate when allegations surfaced of how other countries have misrepresented their trading situation.

Global financial markets, unhappy with the US deficit, became more nervous as they watched a withdrawal of capital from the US. They started to panic and commenced selling down the American dollar. In response, the new Republican President of the United States, elected on a mandate to focus on domestic rather than foreign policy issues, introduced a range of new measures to protect American companies. These served to increase the relative prices of imports, whilst cutting across commitments to North American Free Trade Agreement (NAFTA). South American countries, which had been looking forward to the extension of NAFTA to all America, became very concerned that they would be left in the cold again. US and Japanese companies also withdrew their foreign direct investment from South East Asia, leading to stagnation in regional growth.

The Japanese and American governments discussed at the next G7 meeting establishing global controls on financial markets to ensure national sovereignty in economic planning. Germany supported this, because of the difficulties it was experiencing in the reconstruction of East Germany.

Developing countries in Africa and South America became concerned that these new measures would worsen their national debt situation. Rising nationalism, backed up by armed groups of militants, led to calls by charismatic leaders for debt repudiation. Major political uprisings, involving violence, exposed security problems in global information and communications technology systems. 'Cyber-terrorists' attacked major international banks, disrupting global money supply. Confidence in the system of global financial markets declined further.

Source: ASTEC

The importance of *Global integration* is widely recognised. It was identified as one of two fundamental long-term challenges for Australia at the Prime Minister's 1994 'National Strategies Conference':

> *'The force and inevitability of continued internationalisation was recognised and accepted from all quarters, as was the potential for deriving major benefit from pursuing a global orientation in the country's affairs. What is now recognised as unavoidable, has also become a strongly shared objective, that is, for Australia to develop fully as a global nation to achieve its national objectives. ... the task ahead was seen as pursuing global integration with a regional focus.'*
>
> (EPAC, 1995a)

Attitudes to global integration vary – a recent study revealed that in Australia those most in favour of opening markets and reduced trade protection were highly educated 'symbol manipulators', whereas manual workers were not in favour of continued liberalisation (Bean, 1995). It is likely that similar divergences exist between groups within other countries and between countries. Such differences highlight cultural and political influences on the speed and extent of globalisation. The community's perception of opportunities and threats in global integration is perhaps more important to Australia as an island continent than it is to many other countries.

4.2. The Significance of Global Integration in the ASTEC Study

ASTEC's consultations with industry revealed global integration as one of the major forces to which industry was responding.

The Reference Group canvassed the possibility of an Australia without traditional borders, a more open economy having global information and communication flows and a freer flow of skills and people (Box 4.2). They focused on Australia's place as the only European nation of Asia, on a trajectory towards being 'Eurasian', with the potential to become a dynamic node of a powerful regional economy.

Box 4.2. Reference Group Views on Issues Related to Global Integration

A growing and world competitive industrial and services structure will require an appropriate alignment and continual strengthening of science, technology and engineering input and process for each of business, defence and government strategic directions, operational methods and innovation. Decisions and actions are needed that strengthen Australian core science, technology and engineering competencies, together with complementary processes and systems that leverage on the rest of the world for essential and peripheral technologies.

Dr AR Kjar, President, Australian Industrial Research Group

We need to take account of the role of Asia in wealth creation: in this regard, we are already moving in the right direction.

Mr Peter Robson, formerly Australian Council of Trade Unions

There is a trade imbalance of $3 billion a year in chemicals. There is a prediction that we can turn around our deficit in pharmaceuticals by the year 2000 and be one of only five countries to have a surplus in this area. A good target for 2010 would be to achieve a similar turn-around in chemicals.

Prof Graham Johnston, Federation of Australian Scientific and Technological Societies

Box 4.2. Reference Group Views on Issues Related to Global Integration (cont'd)

The generation of wealth based on the creative, innovative and accountable capacities of 'the next generation' is the only firm foundation for our place in the Asia-Pacific Century.

Mr Colin Benjamin, Director, Horizons Network

My vision for Australia in 2010 is a country in which there is substantial understanding and acceptance of our place in the Asian region, better access to information, particularly for small and medium sized companies, and improved education and training, especially in management skills.

Mr Ian Spicer, Chief Executive Officer, Australian Chamber of Commerce and Industry

It is important that we look not only to the north, but also to the west. Africa is not often mentioned, yet it promises great economic opportunities.

Mr Bob Davidson, former adviser to then Minister for Industry, Science and Technology

There is a blurring of the notion of what a company is in 2010: companies may become smaller and more focused.

Ms Barbara Gibson, General Manager, ICI Operations Australia

With only eighteen million people, less than Mexico City, Australia had better do a few things really well. We did this in the last century, but have forgotten how to do so since. We need to decide what smaller number of things we should tackle and that may mean some loss of sovereignty.

Mr Phillip Ruthven, Executive Chairman, IBIS Business Information

We have to face a much more open community in Asia. If we want to build markets we cannot isolate ourselves from developments elsewhere. There has been progress in building networks. The question is how to do this without losing the things we value and have built here.

Professor Michael Pitman, Chief Scientist

People need a broader understanding of the world than was once the case: more effort is required in keeping up with developments.

Sir Arvi Parbo, President, Australian Academy of Technological Sciences and Engineering

By 2010 China will be well on the way to becoming a replacement in economic terms for the United States. The education system will have to deal with this situation. There will be a need for research linkages and transfers to markets in China. And tourism from China, especially environmental tourism, will become important.

Mr John Plunkett, former Chairman Industry, Research and Development Board

A recent ARC study on international links shows clearly that there is an increasing tendency towards regional integration of S&T, for example, in Europe. What steps can we take to ensure adequate integration in our own region of knowledge and of S&T?

Professor Paul Bourke, President, Academy of the Social Sciences in Australia

Our community consultations showed that Australia's place in a changing world is seen as an important issue facing Australia to 2010. Australians no longer see themselves as isolated from problems overseas, and tensions about Australia's place in a global community underlie responses on a range of issues, from global population to threats to our cultural identity from developments in I&CT.

Most Australians consulted by ASTEC considered global integration to be more of a 'challenging opportunity' than a threat. Consistent with EPAC's report our consultations revealed an almost uniform theme of the need to draw on the dynamic Asia-Pacific region for building international linkages. Australia was seen as uniquely well-positioned to do this, though some cautioned against losing sight of other global opportunities (including in the Indian Ocean rim) by too exclusive a focus.

Global integration was addressed in three of six ASTEC Roundtables on 'Key Issues for Australia to 2010'. Indeed, *the need to capture opportunities from globalisation: 2010* was selected as one of the six, and much of this chapter is based on that Roundtable discussion.

Discussions on the Key Issue of *the need for innovation and entrepreneurship: 2010* identified opportunities for long-term growth in areas of Australian strength, such as telecommunications, computers and transport; agri-industry; and services and environment management. Also, success in high technology research fields such as medicine and biotechnology will require drawing upon and interacting with the global pool of knowledge.

ASTEC's Roundtable on the Key Issue of *the need for a forward-looking S&T system* focused on a scenario for 2010 which included features of a globalised S&T (S&T) system: a world-wide belief in the values of a market economy model; the disappearance of effective national borders on science, technology and industry; and widespread use of new I&CT to allow immediate interactions with collaborators around the globe. Discussions highlighted some potentially negative aspects of a global market-driven S&T system, particularly the impact this would have on public good research and research of strategic importance to Australia. A balanced approach to managing change was suggested, to allow the broader engagement of Australia with the world, while ensuring the maintenance of a national benefit component of our S&T system.

4.3. Key Trends in Global Integration to 2010

Global integration has brought profound shifts in the paradigm governing national sovereignty and international competitiveness. The blurring of national boundaries places greater emphasis on regional and local sources of competitive advantage and on skills, innovation, S&T. Paradoxically, this view of global integration places more emphasis on the importance of regions, networks, clusters of businesses, and an individual's creativity, than does the presently dominant 'national' perspective. Ten trends predicted to escalate over the next 15 years are:

- increasing manufacturing export orientation;
- emerging global networks of production and the end of mass production;
- increasing numbers of global companies;
- increasing off-shore production;
- internationalisation of services industries;
- increasing integration of services and manufacturing;
- trend to regionalisation;
- changes to global finances and savings;
- the trend to global employment; and
- increasing importance of localisation.

a) Increasing Manufacturing Export Orientation

The 1980s and 1990s have seen rapid growth rates in international trade, especially in higher R&D or knowledge intensive goods. An illustration of the change underway in Australia is the very substantial growth in recent years by exports of the more sophisticated 'elaborately transformed manufactures', from 7.6 per cent of total exports in 1985-86 to 15.0 per cent in 1994-95 (Sheehan et al, 1995).

In an integrated world, large scale manufacturing production and large domestic markets could decline in importance, and many smaller national markets will give way to a single global market. This situation provides opportunities through a substantial increase in the scale and number of potential markets, particularly for small and medium-sized enterprises (SMEs) manufacturing 'niche' products.

SMEs will have the potential to operate with virtually no home market and be completely export-oriented. Indeed, an Australian Manufacturing Council (AMC) study identified a growing number 'born global' Australian firms, who view the world as their marketplace from the outset (AMC, 1993). A global outlook enables them to survive and grow, as they can react rapidly to market signals, and provide quality and technology as their prime selling factor, rather than quantity. Growth of such businesses has potentially significant impacts on national economies. However, small firms may not have such easy access to international capital markets as larger companies.

b) Emerging Global Networks of Production and the End of Mass Production

Twenty first Century manufacturing is predicted to be a constantly changing dynamic of global, 'virtual enterprises' made up of work units operating autonomously, but cooperatively. Any given entity may be participating in several virtual enterprises concurrently, all supported by the same human resource, knowledge and infrastructure. Such enterprise integration on a global scale requires the development of infrastructure for efficient interactions. Systems integration through the development of technologies such as Computer-aided Acquisition and Logistic Support (CALS) can provide a means to develop the necessary infrastructure.

It has been suggested that future manufacturing industry will be capital intensive, with small units closely integrated with suppliers and customers through multi-purpose communication links. These highly automated and integrated units will stress information and knowledge in readily assimilable forms which can be acted upon in real-time. This view holds that there will be a paradigm shift in manufacturing towards global, smart and agile operations, with considerable effects on the nature of society through changing work and skills patterns, new products, greater interaction between suppliers and consumers and an increasing standard of living (Adam, 1995).

Increasingly, competitiveness will arise at a regional level. In a globalised world, where national boundaries are no longer seen as limiting factors in company development, competitive success depends on localised concentrations of competitive companies with skilled people and technology, and networks of sub-contractors supplying specialised labour or components.

While very large factories may not disappear entirely, fewer people are expected to work in them, and their unit size will continue to decline, so that new plants will be much smaller than old. The factories of the future will produce batches of individual products, crafted to meet the needs of particular markets, instead of long lines of identical items. Computer technology will be used to match demand to supply. In Japan, such changes are now being seen as the end of the mass-production era.

c) *Expanding Numbers of Global Companies*

Currently most multinational companies have offices, plants and subsidiaries around the world and many foreign shareholders. However, with a few exceptions (eg Shell and Unilever) executive control still rests largely in the country where the original business grew up. IBM and Exxon remain essentially US companies, Toyota is Japanese and British Petroleum is largely British.

Over the next fifteen years, multinationals with a central base in one country are likely to adopt a strategy of becoming multi-domestics with semi-autonomous bases spread across the world. This will allow them to transfer operations from one country to the next to give them the best competitive edge, as well as helping them develop local market knowledge. An international spread of shareholders also provides a defence against protectionism through a local lobby of share owners whose interests would be damaged by trade barriers. It also provides a wider range of sources of new external capital, so that companies will no longer be at the mercy of national governments or their political priorities. It is quite possible that international portfolio investment will become a contentious issue over the next 15 years as tensions between countries and companies increase.

A challenge for the giant corporations over the next twenty-five years will be how to behave like smaller, more flexible enterprises in an increasingly competitive international market.

d) *Increasing Offshore Production*

Overseas investment by companies has been one of the great forces internationalising the world economy during the 1980s. As companies invest abroad, they transfer skills and technical knowledge as well as money. During the second half of the 1980s, the amount of corporate 'foreign direct investment' soared, rising in value from around $50 billion a year in 1980 to 1985, to nearly $200 billion in 1989. This might grow to $800 billion a year by 2020 or even more.

International production is replacing international trade as a way of getting products to foreign markets. In 1990, world trade totalled $3,800 billion, but the production of companies in countries other than their home base was $4,400 billion. US-owned companies operating outside the US sold twice as much as the US exported.

This process of replacing exports with local production means that goods will either be made close to their markets, or where costs are lowest. Increased global integration has allowed many companies to transfer substantial amounts of production and assembly operations to lower-wage regions of the world. Firms can purchase inputs from the cheapest source, and reduce labour costs either by moving to countries with lower rates or using technology to reduce them through automation.

In a competitive environment driven by innovation, no nation and no state can be competitive in every field – niches become more important. The profit is less in manufacturing and more and more in design, branding and marketing.

e) *Increasing Importance and Internationalisation of Service Industries*

The central element in the services revolution is not the increase in their importance, but the internationalisation of services – the ability to deliver services in a substantial way across national boundaries: 'the internationalisation of services will likely lead the next stage of economic globalisation' (World Bank, 1995).

Services is the largest sector of the Australian economy, accounting for 70 per cent of output and 80 per cent of employment. It has been the major contributor to economic growth in the last decade – a dominant characteristic of most developed economies.

Services have a high potential to generate export income to pay for the imports of goods and service needed by the economy. Only 2.1 per cent of known Australian service enterprises are exporting, although service exports are expected to more than double between 1993 and 1998 from $15 billion to $33 billion (LEK partnership, 1994).

An important, incremental and long-term trend is the increasing domination of modern economies by service industries. An abrupt change likely to emerge over the coming decades is the globalisation of services, with the activities involved in the production of either goods or services being provided from different locations, in large part across advanced communications networks. By 2030 the value of exports of services from the OECD countries will surpass the value of their exports of goods (Sheehan et al, 1995). The ability to compete in services will therefore be as important in the 21st Century as the ability to compete in goods is today.

Services enter more intimately into the social and cultural fabric of the community to which they are delivered than goods: they reflect and are shaped by its culture. The development of the services sector in Asian countries will be heavily shaped by their diverse cultures and distinctive traditions and mores. As Asia becomes the economic engine of the global economy, and European dominance of the nature of economic activity declines, Asian influences on services will have an inevitable flow-on to the global economy. China and Indonesia will most probably become Australia's most important new markets for services in the late 1990s (LEK Partnership, 1994).

Australia has the attributes to become a substantial player in global services, especially in the Asian region.

f) Integration of Services and Manufacturing

Another important trend is the increasing integration of services with manufacturing. The links between these three concepts – goods, services and knowledge intensity – are becoming increasingly more complex.

Goods have always substantially been produced for their service potential, for their ability to provide services to their owners or consumers (cars to transport people, refrigerators to keep food wholesome, drugs to cure illness). The process of applying knowledge or technology to goods production has largely been to increase the service potential of goods, as is evident in the advanced integrated circuit, the intelligent phone or the 'hard-wiring' of software applications into many electronic machines. The service sector has been defined as the sector which 'transforms the state of material goods, people themselves, or symbolic material – information' (Miles, 1995). While a distinction might still be made between making material goods and transforming their state, it is evident that this distinction will become increasingly tenuous in a modern, knowledge intensive economy.

Comprehensive data is not readily available on world services trade, but aspects of the available information on merchandise exports (ie all goods, including agriculture and mining as well as manufacturing) and services exports for the Organisation for Economic Cooperation and Development (OECD) region are summarised in Box 4.3 for the period 1985-1992. OECD services exports have grown somewhat more rapidly than merchandise exports over this period (a rate of 13.6 per cent per year for services, compared to 11.1 per cent for goods), totalled $US759 billion in 1992 and were equivalent to nearly 30 per cent of goods exports.

Box 4.3. Goods and Services Exports Organisation for Economic Cooperation and Development (OECD) 1985-2002

	1985 $US billion	1992 $US billion	Average Annual Growth 1985-92	2002[1] (projected)$ US billion
Merchandise Exports	1 248	2 606	11.1%	7 466
Services Exports				
Travel, transportation & official services	207	454	11.9%	1 398
Other private services	102	305	16.9%	1 454
Total Services	309	759	13.6%	2 852
Total Exports	**1 557**	**3 365**	**11.7%**	**10 318**
Services exports as a proportion of Merchandise exports		*24.8%*	*29.2%*	*38.2%*

Notes: 1. Based solely on continuation of 1985-1992 growth rates over the period 1993-2002
Source: Sheehan et al, 1995.

Some components of service exports have grown fairly slowly (eg exports of transportation services by 10.3 per cent per year and of official services by 6.2 per cent per year), while travel service exports have grown rapidly (15.2 per cent per year), as growth of travel around the world has exploded.

But the critical item in Box 4.3 is other private services, which covers a wide range of business, financial, research, advisory and other services. It is in this area in particular that the growth in knowledge intensive services trade is to be found. OECD exports of other non-official services have grown by 16.9 per cent per year between 1985 and 1992, totalling $US305 billion in 1992 and constituting the most rapidly growing of the goods and services trade aggregates considered here. If these and other growth rates continued to 2002, by that date OECD non-official services exports would amount to some $US1,450 billion, or over half of total OECD services exports.

While exports of other non-official services have been growing more rapidly than exports of either goods or total services since the 1970s, the emergence of more rapid growth in services than in goods trade is a relatively recent phenomenon, dating from about 1985. However, it will undoubtedly be a pervasive feature of the future international environment.

g) Moves Towards Global Employment

Employment is predicted to change towards less permanent, full-time, life-long careers in the one company. Flexibility will be the key, with a trend towards 'portfolio' working: self-employed people working for two or more corporations on a contract for a fee.

Companies will be able to buy top talent from anywhere. Many senior executives consider Europe and North America as a single market and Japan is expected to be drawn into this international market for skills, as its production experts are poached by other countries seeking their technical and human-management skills. Workers able to do most of their work from home will have much greater freedom to choose where they live, not only within countries, but also between them. Job migration is likely to become a much more contentious issue over the next twenty-five years.

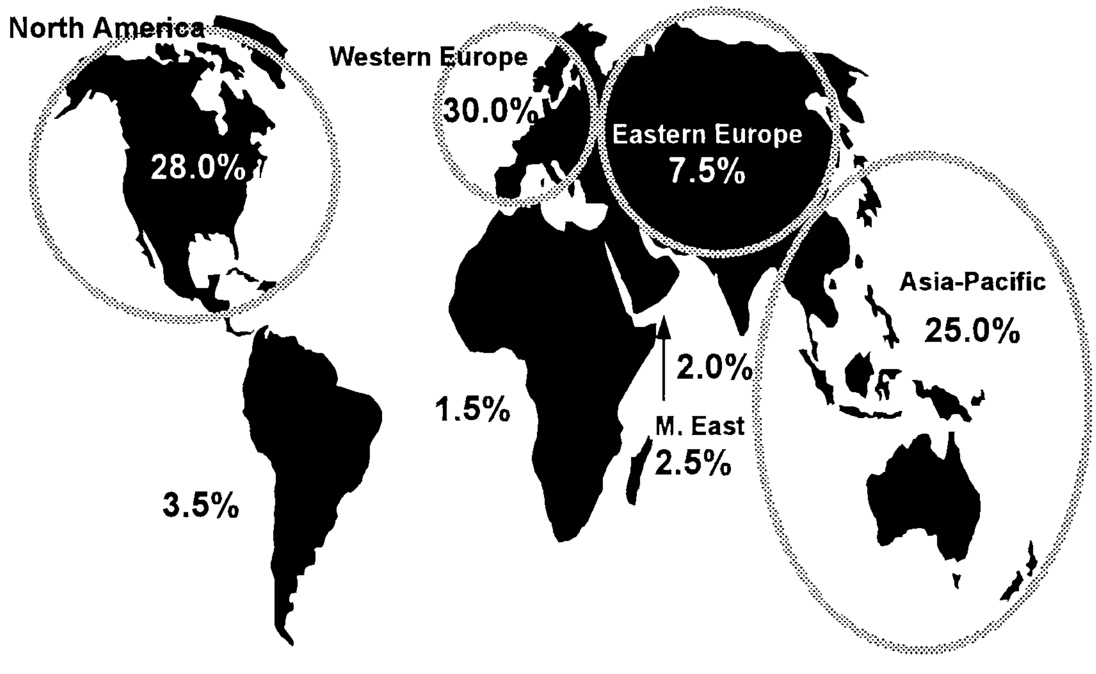
Clerical jobs may migrate to low-cost areas, as factory jobs have tended to do. Any labour-intensive screen-based function, like word processing, could be handled in countries where there is a ready supply of cheap well-educated labour, giving developing countries a new area where they can compete without running into trade barriers, provided they have the necessary infrastructure. Already many US companies have their computer software written in India. This work is currently done by batch-processing, but as the cost of telecommunications lowers this type of white-collar trade could move on-line. For example, it would be technically possible for a British bank, wanting to provide 24-hour telephone facilities, to provide night-time cover from Australia.

h) Increasing Regional Focus

Regionalisation can be viewed as a stepping stone toward global integration. The current trend is toward the formation of international groupings and trading blocs such as the European Union (EU), North American Free Trade Agreement (NAFTA) and Asia Pacific Economic Cooperation (APEC) group.

Many changes in global shares of Gross Domestic Product (GDP) are expected over the next twenty five years to 2020. Global GDP shares in 1992 are shown in Box 4.4. The Asia-Pacific region, which has nearly doubled its share of world over the past 17 years, is expected to almost double its share again by 2020. However, North America (Canada, US and Mexico) will have its share diminished from 28 per cent in 1990 to around 18 per cent. Western Europe has risen from around 25 per cent of world GDP in the mid 1980s to 30 per cent in 1992 and is expected to hold its share in the medium term, before declining to around 15 per cent by 2020. The share of world GDP of Eastern Europe (the Commonwealth of Independent States and others) was reduced from 17 per cent in the 1980s to 7.5 per cent in 1992 and this will ease further in the medium term with the region rising to around 10 per cent of world GDP by about 2015. Eastern and Western Europe are also expected to merge into one economic bloc at some time over the next twenty-five years (IBIS Business Information, 1993d).

Box 4.4. Major Economic Regions – Share of World GDP basis 1992



Source: IBIS Business Information (1993d)

The regionalisation of the world economy is reflected in the rising importance of intra-regional trade. Currently over 70 per cent of exports from Western Europe are to other nations in the region. In North America intra-regional exports currently account for 34 per cent of the total exports originating in the region, compared to 26 per cent a decade ago. In the case of the Asia-Pacific region, 45 per cent is now intra-Asian compared to 33 per cent a decade ago. Intra-Asian exports are forecast to rise to over 65 per cent of exports originating in the Asia-Pacific region over the next two decades. As the fastest growing and most dynamic regional economy, the Asia-Pacific region will also be the fastest growing trading bloc. This is particularly important for Australia.

There will be some trade tensions between established trade blocs, but it is in the interest of the existing industrial world not to permit any trade wars to develop. Areas where trade barriers might be especially damaging are between the mature industrial states and the newer, low-wage economies seeking to export to them, eg between North America and China.

i) Global integration of Finance and Savings

From the mid 1980s, securities markets replaced banks as the main intermediaries between savers and borrowers, due largely to the aging of the population of the industrial countries. Pension-funds prefer equity investments, which guarantee control through ownership. This has important implications for the relations between countries and companies as it means that any large company will increasingly be owned by investors scattered around the world, rather than confined to the country of its corporate headquarters.

The growing freedom of financial markets limits the ability of governments to set trade controls, controls on capital movements, or on the assets that companies will increasingly hold in many different countries.

The savings ratios in the dynamic economies of East Asia are double those of the established industrial countries. At this stage of their economic development they need these savings ratios to support their rapid economic growth, although some shading-down of the savings rate is likely later on. But if they continue to save at higher rates than Europe or North America as their economies mature, they could build up foreign assets which will give the region a powerful degree of influence over world economic relations.

j) Growing Importance of Local Areas

Some analysts suggest that Australia may have much to lose from globalisation. For example, global competition can lead to a single global market where profits are lean and technologies become 'commodities'. Ohmae (1995) suggests strategies in a borderless world should focus on linking to regional 'nodes', 'clusters' or 'networks' of activity, capability and competence. It is a mistake for businesses to think in terms of United Nations defined 'nations', as much activity now crosses traditional national borders. Such ideas highlight the importance of a region's trans-national industrial fabric and the potential significance of building regional linkages.

Capturing these opportunities requires strategic choices. One option is to concentrate on products we can manufacture and services we can provide, in which we can be competitive through geography, process or product type. Value-added from this approach will increasingly come from R&D, design and production of knowledge-based goods and services and value-added agricultural products. Many other strategic approaches are available for indigenous or foreign owned companies operating from Australia in a 'global' way, eg ranging from Australian-based exporting, to multi-domestic or integrated global strategies.

To capitalise on opportunities, Australians must ensure we have appropriate knowledge, skills and support structures to support international interactions. In a competitive environment, driven by innovation, nations and states cannot be competitive in every field – niches become more important. Creativity is required in the identification of opportunities, for example based on un-met needs of other nations, regions or firms, and on understanding of other social, economic, environmental and cultural contexts. A region's economic framework may render inappropriate many conventional Australian business practices, eg warehouse distribution systems.

4.4. *Some Science and Technology Developments to 2010 Related to Globalisation*

International foresight exercises provide information about the expected direction and speed of S&T developments over the next 15 years. They identify a number of important developments which will enable the growth of a global, internationally networked economy. Some prospective developments are outlined below, including improved international communications; language translation abilities; and prospects in transportation. Also important, though not discussed below, are 'people' technologies, including skills in management and in new ways of doing business, eg logistics and advanced manufacturing or service methods.

a) Communications

International communications are vital in a global world and progress in these technologies is set to continue at its present fast pace. Communications technologies will allow dispersed teams to share a common 'work space', eliminating distance and time barriers. Businesses that can integrate such technologies into their operations will be able to better serve their global customers. In the UK foresight study, the communications sector panel identified four main trends as driving technological developments (Office of Science and Technology, 1995h):

- the massive decline in the cost of computing power (at constant performance, cost reduced by a factor of ten in one decade);
- decline in the cost of bandwidth (data carrying capacity), as transmission and switching technology advance and telecommunication competition increases;
- an explosion in networking and the development of client-server technologies (ie LANs and the Internet as models for future public networks); and
- techniques enabling the 'engineering' of the radio spectrum to allow more efficient use and higher frequencies to be used (eg 'split spectrum' technology).

Specific examples of developments include:

- advanced multimedia software and terminals;
- mobile radio-based communications developing as the primary access medium;
- 'synchronous digital hierarchy' to provide robust networks; and
- data-oriented services outstripping voice and providing a rich set of integrated services: fast fax, video phones, video conferencing, home and office multimedia, telemetry and alarms.

The 1992 Japanese Delphi survey has similar themes for the technological trajectory of communications: increased personalisation of communications, more robust systems for business through the improved safety and security of networks, diversification in telephone services to include multi-media and advanced radio-based technologies. Two examples of Delphi topics that illustrate these trends are:

- widespread use of personal teleconference systems in offices though desk-top terminals capable of providing video, drawings, documents, graphics and other data, separately or integrated by 2002; and
- widespread use of next generation cable TVs capable of transmitting programs on 300 channels or more by means of data compression to more than 50 per cent of households by 2007.

A recent US study suggests that the future holds, among other things, the rapid extension and expansion of electronic commerce. Important developments will be the integration of communications into office equipment (multimedia communication workstations) and wireless multi-point personal communicators; and into the home through interactive shopping and entertainment (Institute for the Future, 1995).

Surprisingly, the 2020 scenario for wireless personal communicators shown in Box 4.5. is perhaps too conservative. The most recent Japanese-German 'mini-Delphi' revealed average years of realisation around 2002-3 (with a high degree of similarity between countries) for the use of pocket-sized personal communicators allowing integrated telecommunications services and video transfer (NISTEP FhG ISI, 1994).

Box 4.5. A Mobile Personal Digital Assistant – the 'Hypertel'

Intriguing 2020 scenarios developed by CSIRO researchers illustrate some future possibilities of personal wireless mobile communications with the 'Hypertel':

'It is September 2020. Back in the nineties, I used to cart an office around with me so that I could go to meetings, do my other work, keep contact with my staff, send faxes and read my electronic mail .... Now-a-days, you can have all that technology in one small unit – a personal communicator. The personal communicator is a whole lot of things ... it's a mobile phone ... it includes a radio and television, a Global Positioning System with a map locater .... The whole thing only weighs 150 gram .... An enormous range of services is available now ... full radio and TV service and the full mail service. Phone, remote banking and remote shopping ... a library subscription, as well. That lets me access any book, picture or video material that is available within the Australian library and museum system. All the printed material in the libraries is accessible in digital form now, together with stereo pictures of display material.'

Source: Frater and Elsum, in Eckersley and Jeans eds. 1995.

b) Language Translation

Another important aspect of global integration is the issue of language. Global integration is a phenomenon often associated with the speaking of English, but ultimately this may be an impediment to the development of novel international networks and linkages.

The 1995 Japanese-German 'mini-Delphi' (NISTEP FhG ISI, 1995) suggested a number of important developments in the use and translation of languages that might help overcome barriers:

- highly advanced, universal languages are developed which can describe problems using text or charts by 2008 (Japan) and 2004 (Germany);
- equipment for automatic writing of summaries and abstracts of books and other documents is developed by 2007 (Japan) and 2008 (Germany);
- a machine translation system to translate scientific or technical documents is in widespread use by 2006 (Japan) and 2007 (Germany); and
- a real time interactive system having spontaneous speech input/output capability with tens of thousands of words of vocabulary is developed by 2008 (Japan) and 2005 (Germany).

c) *Transportation*

Personal mobile multimedia communicators and translators, while eliminating distance for many purposes, will not remove the need to travel or move goods. People 'on the ground' greatly assist the formation of global business relationships and transport will remain critical to international trade.

It is predicted that more exports are likely to leave by air, especially high value or perishable goods. The increasing number of aircraft, mainly from US and Europe, has reduced the cost of moving goods internationally and will allow rapid response times for exports. Aircraft will assist further in the integration of Asian and South American markets into the global economy. Asian economies in particular are expected to generate a growing proportion of international air traffic.

As an island continent, transport is critical for Australia's global integration. Prospective developments in long distance freight transport and shipping are of particular importance. ASTEC has undertaken a Partnership with the shipping industry, which examined some aspects of future sea transport systems (see Appendix 2).

Importantly, the US, Europe and Japan are all seeking more effective and efficient 'intelligent' transportation systems, including prospects for radical changes in both vehicle technology and infrastructure for passenger and freight transportation.

The UK foresight study focusing particularly on road transport, noted the transport sector is strongly influenced by government policy and regulations. The three major areas for developments were identified as:

- vehicle development, with greater efficiency and reduced environmental impact;
- capacity management, with improved management of transport infrastructure through use of control systems to make better use of existing capacity rather than new construction; and
- demand management, coping with the rate of growth in car use through reduced mobility while maintaining access, implying technologies in travel and traffic systems, road pricing and ticketing etc.

The Japanese 1992 Delphi highlighted technologies for achieving higher road transport speeds and density, including developing intelligent vehicles and using new materials to reduce weight and new engine technologies. Some prospects include:

- widespread use of traffic control systems on roads, for optimal control of the flow of traffic in cities based on determinations of types of vehicles on road, speed and level of congestion (2003);
- widespread use of cars with extremely low fuel consumption, eg 30 per cent lower than the current fuel consumption, due to reduced weight by the use of new materials (eg ceramics, aluminium and resins) and increased output by higher engine efficiency (eg direct injection, 2 cycle engines) (2003);
- widespread use of continuously variable transmissions, which are free from slippage and which are optimally controlled by computers (2003); and
- widespread use of electric-powered automobiles capable of running in urban traffic, based on the development of batteries with a charged capacity sufficient for commuter trips. (2004).

Sea transportation will be particularly important for Australia as an island continent. In this context the 1992 Japanese Delphi predicted the widespread use of commuter and business sea traffic transportation network systems which use mass transportation (300 passengers +), high speed (30 knots +) in the areas around big cities by 2005.

However, radical ideas, such as the use of high temperature superconductors for very high speed magnetic levitation trains (a potentially important development for Australia) and sea water magneto-hydrodynamic thrust ships, appear to be further in the future than 2010. The recent German-Japanese mini-Delphi survey placed the average realisation of these developments in the range of 2015 to 2018.

The selection of S&T developments to 2010 from international foresight studies provides a small indication of the role of S&T in enabling and developing future forms of globalisation. Transportation topics anticipate greater efficiency in use of energy, especially through the application of information technology and materials. The realisation of many topics requires complex activities and a high engineering content. However, such developments will play a key role in promoting new networks, collaborations and business ventures. They also illustrate the need for Australia to develop its unique capabilities and make the best use of available technology through creative applications.

4.5. A Key Challenge for Australia in Global Integration to 2010: Managing our Role in APEC

Since the mid 1970s, the Asia-Pacific region has been an area of most remarkable growth. The region has nearly doubled its share of world GDP over the past 17 years, rising from 14.5 per cent in 1975 to 26 per cent in 1993. It is expected to almost double its share again to around 45 per cent over the next twenty-five years, thereby reaching the same peak achieved by the US alone in 1945 (IBIS Business Information, 1993d).

As the fastest growing and most dynamic regional economy, the Asia-Pacific region will also be the fastest growing trading bloc. In the case of the Asia-Pacific region, 45 per cent of trade is now intra-Asian compared to 33 per cent a decade ago. Intra-Asian exports are forecast to rise to over 65 per cent of exports originating in the Asia-Pacific region over the next two decades.

As the breadth of Asian growth, and its importance to the world economy, has become more widely realised, forecasters have sought to estimate its future patterns. Many growth forecasts have been made about the future path of the key economies of the region. These quantitative expressions of current expectations, driving current investment and other business decisions, should not be viewed as an infallible guide to the future.

They reveal that while Japanese growth is expected to slow to less than 3 per cent per year (by comparison with figures for US of 2.4 per cent and for Australia of 3.4 per cent) each of the other Asian countries shown are expected to achieve growth rates over the next ten years in the 5–9 per cent range. The inevitable consequence is a major shift in the distribution of world GDP (see Box 4.6). Whereas total GDP of ten key Asian countries amounted to only 45 per cent of that of the US in 1970, in purchasing power parity terms, by 1995 total GDP of these countries had already exceeded the USA figure by 20 per cent, and by 2005 is expected to be almost double the US figure (Sheehan et al, 1995).

For Australia, the estimates are striking. Whereas Australian GDP amounted to 13 per cent of that of the nine East Asian and ASEAN countries in 1960, it is expected to be only 4 per cent of their combined GDP in 2005. Australia is also a classic example of the regionalisation of world trade trends. Currently 60 per cent of Australia's exports of goods and services are to the Asia-Pacific region. This is expected to rise to over 65 per cent by the year 2000, and to over 70 per cent by 2010.

Over the next 15 years we must focus more on developing opportunities in our local region, which has a growing number of potential customers. Data on real purchasing power suggest that China is the world's largest economy after the United States, with an estimated one million millionaires (Tegart, 1995). Increasing affluence in the developing economies of Asia is also illustrated by India, where it has been suggested there are 150-200 million people with average incomes comparable to those of Australia.

Box 4.6. GDP Levels and Growth Rates – US, Australia and Selected Asian Countries, 1950-2005

	Average Growth Rates of Real GDP			Total Real GDP		
	1950-79 (% per year)	**1979-95**	**1995-2005**	**1960 ($US 1990 billion, PPP)**	**1995**	**2005**
United States	3.8	2.4	2.4	2133	6237	7945
Selected Asian Countries						
China	5.5	9.6	8.9	179	2131	4984
Japan	7.5	3.2	2.8	355	2331	3082
South Korea	12.3	7.8	6.4	15	459	855
Taiwan	9.6	6.7	7.0	13	209	410
Hong Kong	10.2	6.5	5.1	7	121	199
Malaysia	6.8	6.8	7.5	17	169	348
Indonesia	5.7	6.2	6.9	83	625	1223
Thailand	7.6	7.8	7.9	29	390	832
Singapore	8.5	7.6	6.6	4	61	116
India	3.4	5.3	7.0	260	1121	2198
Total				962	7617	14247
Australia	**4.3**	**3.0**	**3.4**	**86**	**311**	**435**

Note: PPP = purchasing power parity
Source: Sheehan et al 1995.

The region also has a high capacity to provide capital for investment. An important factor in this are overseas Chinese business networks in Asia. Between 30 and 35 million Chinese live outside of China, Hong Kong and Taiwan, and recent estimates suggest that this group's 'GDP' was around $US450 billion in 1990. In the same year their liquid assets were estimated at around $US1.5 trillion. Australia's growing cultural diversity puts it in a strong position to link into this capital resource which is driving the development in much of the region (Tegart, 1995).

The growing population in Asia, coupled with increasing per capita income and trade liberalisation, implies a need for large scale development of infrastructure such as energy, educational and medical facilities, telecommunications and transportation. Estimates of East Asian infrastructure investment levels by the year 2000 range between $US1 and 2 trillion. Much of this will be spent on energy, telecommunications and transportation (see Chapter 9).

The region's needs are so vast and demands on resources so great, governments have difficulty financing them. The needs in China are greatest because of its sheer size, population and pace of economic growth.

The region will also need development in services. In common with other developed countries, Australia has a services-based economy. Services, at $US934 billion in 1993, accounted for 22 per cent of world trade. It is the knowledge-based services such as professional and technical services, information technology services, banking and insurance, travel, modern health care and education that constitute the dynamic edge of the services economy today.

Australia's capacity to participate fully in regional growth will depend on the extent to which Asia-Pacific countries seek to implement global integration. Currently, the focus for this is APEC, an unprecedented institutional framework for the Asia-Pacific region. The APEC forum comprises 18 countries that account for half of world output and include the world's three largest national economies: US, Japan and China.

In 1994, APEC countries gave a commitment to achieve 'free and open trade and investment' in the region by 2010 for the industrialised nations that make up 85 per cent of regional trade and by 2020 for the rest. In 1995, they set out a detailed Action Agenda and agreed to begin implementing this by January 1997. APEC has three economic goals:

- to resist protectionist measures which could jeopardise Pacific growth by maintaining the momentum of liberalisation in the face of uncertainty about the global trading system;
- to counter inward-looking regionalism elsewhere, particularly in Europe and North America; and
- to provide better ways to deal with the economic conflicts that pervade the area.

At the recent Osaka meeting, agreements were reached on key trade facilitation issues, including customs harmonisation and simplification, product standardisation and mutual recognition agreements for product testing and certification. If Australia is to maximise the benefit from economic growth in the Asia-Pacific, then it will need to effectively manage its position in APEC.

4.6. Conclusions

Australians need to understand and accept the opportunities and threats of Global Integration through promoting informed discussion. This should be an important part of a debate about Australia in the 21st Century, which should extend beyond the current 'Republic debate' to include issues such as national sovereignty, foreign debt and foreign ownership in a global world.

While it is important to identify and protect Australia's short-term position, this needs to be in the context of long-term opportunities. It is therefore critical to improve the capacity of government, industry and the broader community to anticipate structural shifts in economic and political space; and to ensure Australian industry and other organisations pursue international best practice in activities where territoriality matters.

It is critical not to become so preoccupied with opportunities that threats are ignored. It will be important to identify those areas where sections of Australian society and industry could be disadvantaged by global integration and develop appropriate responses and monitoring mechanisms. It is worth noting the concern amongst manual workers about reducing trade protection.

At present the significant contribution of S&T across the broad range of Australia's international activities is not recognised. Instead, the consideration of S&T has been limited to

Australia's presence in global S&T fora and bilateral agreements between S&T agencies. Yet this is only a small part of the picture.

One of the elements in Australia's international relations is S&T, although the nature of the S&T will vary. In our relations with Pacific countries, S&T can play a large role in discussions about aid and resource management issues. With newly industrialised countries, such as Indonesia, the S&T component of infrastructure and services projects such as public telephone systems will be important. With industrialised nations, such as those in the OECD, S&T is also central to discussions on issues of standards, trade and investment.

S&T plays an integral, if unrecognised, role in many aspects of Australia's international activities, eg aid, shipping, housing, environment, trade, industrial relations. There will be increasing S&T in such areas in the future and we need to ensure we are maximising this. Potential shifts in the role of S&T as a critical element of global integration requires monitoring of its ongoing role.

It may be important, at least initially, to establish an overall process to monitor progress in Australia's participation in global integration and how effectively we are using S&T. This process should interpret trends and evaluate emerging responses and ensure this information is readily available to Ministers and decision-makers more broadly.

S&T will be central to ensuring international standards provide a fair and level playing field. Effective Australian participation in work on standards in APEC, the OECD, a range of UN fora and the World Trade Organisation requires that government S&T agencies have identified long-term needs in these areas and are ensuring that priorities for longer term work are set.

An important part of standards setting is international bench-marking. Remaining attuned to the latest developments and striving for world's best practice is critical. S&T has a particularly role to play in this. Australians must accept and welcome the opportunity to introduce national and international bench-marking in many areas rather than seek to stay with the known and comfortable.

Global Integration will be of major importance to Australian industry and will affect all aspects of the way companies plan and execute their business strategies. Australian business people will require a sound understanding of the changing context for their work. ASTEC supports the recommendation of the Karpin Committee for an industry based program to provide opportunities for up to 1500 Australian managers to undertake structured international study tours each year.

Given our limited experience, it appears important to establish a process to monitor progress in Australia's participation in globalisation and to assess how effectively we are using S&T. The process should interpret trends and evaluate emerging responses and ensure that this information is readily available to government and industry.

Area for Action:
Global Integration

ASTEC considers it necessary to develop a response to globalisation that makes the most effective use of Australian S&T. This can be achieved by actions, among others, to develop targets and benchmarks in industry and research; programs which promote Australia as a technologically advanced nation; and encourage business to become aware of, and rapidly adopt, internationally competitive business approaches.

S&T can also play a strong role in developing Australia's international relations. We need to ensure that there is a clear strategy for integrating S&T in Australia's negotiations on international trade agreements and that our S&T system can contribute effectively to the work of international bodies setting rules for business on a regional and global basis, eg for standards and intellectual property.

Priority Action for the Commonwealth Government – 1

ASTEC recommends that as a priority the Minister for Science and Technology consult with the Minister for Trade to:

- establish, in consultation with relevant industry, research and statutory bodies, a set of strategic principles to guide Australia's proactive participation in a variety of international fora (eg for setting rules for global businesses in areas such as standards and intellectual property) and, in particular, to identify the needs for, and contribution of, S&T; and
- encourage the demonstration and promotion of sectoral benchmarking within Australian companies and publicise the outcomes of examples of international best practice in leading edge activities particularly in manufacturing, eg in advanced and 'intelligent' manufacturing engineering and systems and the integration of services with manufacturing exports.

Chapter 5. Applying Information and Communications Technologies

'Those nations which prove most adept in making institutional innovations which match the emerging new techno-economic paradigm are likely to prove the most successful in growing fast, catching up or forging ahead. Those, on the other hand, which suffer from institutional 'drag' or inertia may experience a prolonged mis-match between their institutions (including management systems at firm level as well as government structures) and the growth potential of new technologies.'

(C Freeman, 1994)

5.1. Introduction

An ability to harness, access and use information – and the sciences and technologies underlying it – will be critical to Australia's economic success, community well-being and the management of our environment in the next century. The revolution in information and communications technologies (I&CT) is changing the nature of economies and societies around the world. It has, for example, contributed to a fundamental reshaping of manufacturing. It is accelerating the globalisation of existing service industries and the development of new services and products, particularly in the area of multi-media. It is fundamentally changing world labour markets and our daily lives.

I&CT is playing a central role in the changing context of Australian economic growth. The growth, development and particularly the application of I&CT was identified as an ASTEC Key Force for Change to 2010.

If I&CT become all pervasive, then it will underlie a new 'techno-economic paradigm' – a complete convergence of communications, broadcasting and computing in a digital realm. Advocates for this view consider that, over the next 10-20 years, the application of global I&CT and associated services will be all-pervasive, with information technology and electronics becoming one of the world's biggest industries by the turn of the century (Office of Science and Technology, 1995l).

While the promises of I&CT are great, it should be noted that realisation will depend not just on exciting technology forecasts, but on the development of demand in the market. In general, conditions that favour the successful introduction, application and diffusion of new technologies include user-friendliness of both hardware and software, prices, the extent to which these technologies meet customer's needs and the existence of substitutes. Given the scope and complexity of the issues involved in information infrastructures, there are a number of analysts who believe that it will take at least one generation before the information society can be considered mature. According to such analysts, the transformation towards an information society should therefore be considered evolutionary rather than revolutionary.

A worst case scenario for I&CT over the next 15 years is one in which various difficulties create a 'disaster scenario'. The difficulties could relate to slow growth in demand for services, serious fraud affecting electronic transactions, major disruptions of networks or mistaken adoption of technologies that rapidly become obsolete. These scenarios are generally considered less likely than ones of higher growth.

5.2. The Importance of I&CT in the Future Needs Study

This section explores potential developments in I&CT over the next 15 years, based on work undertaken throughout the study. I&CT was considered important by the Reference Group (Box 5.1) and industry consultations identified I&CT as a critical operational technology.

Box 5.1. Reference Group Views on Issues Related to I&CT

The revolution in information technology and the wave of global mass culture potentially threatens our unique identity and any form of censorship will be difficult to apply.

Dr Ric Simes, Senior Adviser to the then Prime Minister

Foresight can provide us with opportunities to discover in more detail what our science and technology (S&T) needs are. In information technology there is a continuing balance of payments problem and we need to identify the niches where we can make a profit and encourage strategic investment for industry development.

Dr John Bell, Deputy Secretary, Department of Industry, Science and Tourism

As the world is made smaller and young people become more computer literate, it will be possible to link suppliers and users and eliminate middle people. In my alternative vision of 2010 the traditional Australian stockman is replaced by a man or woman in a mobile office, marketing directly from the paddock to the store.

Ms Deborah Thiele, Chair, Agriculture and Horticulture Training Council of South Australia

We are not making effective use of information and communication. With a small population in a large country, we have to learn to manage information and communications; this is not just an issue for the IT community. Australia is in a strong position to address this issue which depends on how you select and use, value and broker information in various types of partnerships.

Professor Mary O'Kane, Vice-Chancellor, University of Adelaide

Young people, frequently excluded from decisions that affect them, can be empowered through information technology. Decision-makers, generally 'old men in suits', should engage more with young people, tapping into their views at various levels....there is an increasing group of people who are 'information poor' and do not have proper access, not even to a telephone. This equity issue must be given a high priority.

Ms Penny Sharpe, former President, National Union of Students

Although I&CT did not emerge as strongly from initial community consultations, it was a major feature of ASTEC's program of national consultations, particularly for its access and equity implications. For example, it was seen potentially to:

- increase the input of local communities to government decisions (Townsville);
- reduce the disadvantage of Tasmania's isolation from mainland Australia and facilitate direct interactions between Tasmania and the rest of the world (Hobart); and
- revitalise and support agricultural communities across Australia (Adelaide).

The contradiction highlighted during discussions in Perth was that while small isolated communities can potentially obtain more benefits from I&CT than people in the big cities of eastern Australia (eg reduce the disadvantages of isolation), they probably will not have this recognised in delivering them access to the technologies.

I&CT underlay ASTEC's consideration of all the six Key Issues for Australia to 2010, yet with a different emphasis in each of the Roundtable discussions, eg:

- *the need for innovation and entrepreneurship* and *the need to capture opportunities from globalisation* identified I&CT as an enabling technology for the emerging fifth generation innovation process, based on networking and improved information flows;
- *the need for a technologically literate society* highlighted access and equity issues, including concerns that current gaps between groups in society would determine their access to I&CT and particularly older women may be excluded and marginalised within a more technological society;
- *the need to sustain our natural environment* and *the need for continuous improvements in community well-being* both stressed the critical importance of sophisticated information management including monitoring to making the complex policy decisions required of the Australian community in the coming decades; and
- *the need for a forward-looking S&T system* would require global I&CT to facilitate real time global networking and new forms of scientific endeavour and there is a potential role for universities as information managers into the 21st Century.

One of the five ASTEC Partnership studies focused on I&CT, specifically industry issues related to the development of full service networks in Australia (ASTEC, 1995d). Further details on this study are provided later in the chapter.

In relation to other Partnership studies, I&CT emerged as:

- critical to developing an integrated systems approach to the urban water life cycle;
- a priority to ensure that older people, with neurodegenerative disorders, will be able to fully access and use I&CT to enhance independent living; and
- critical to the management of research information particularly in the areas of monitoring, data sharing and data access.

As part of the Health Partnership study on neurodegenerative disorders, ASTEC surveyed 200 health and medical organisations throughout Australia on the major health issues to 2010 and the possible contribution that S&T could make to tackling the issues identified. One of the six key health issues to 2010 was identified as the impact of advances in communication, electronic transfer and I&CT. This was considered a suite of technologies which promise to have a major impact on both the conduct and the delivery of medical services, particularly digital imagery, data transmission, bioinformatics, distance education and telemedicine, which are all seen as S&T advances with significant medical applications. How they are made available – access – was seen as an outstanding issue.

Young Australians see both potential advantages and disadvantages from I&CT and believe it will have a large impact on society. They look forward to increased access to information from global sources and the social and cultural benefits it allows. They were also concerned that information was expensive, creating a gap between rich and poor, that it could lead to an invasion of privacy, an increase in white collar crime and create an anti-social world with people tied to computers. Approximately 80 per cent of young Australians (interviewed in a national opinion poll) thought governments will use I&CT to watch and regulate people more. Almost 60 per cent considered that computers and robots are taking over jobs and increasing unemployment and one third considered computers and machines will eventually take over the world.

5.3. The Significance of I&CT

The widespread use of information infrastructures is expected to have a significant social impact by transforming the way we live, work and take our leisure. The working environment is expected to change with a focus on constant updating of knowledge and skills (life-long learning). Work time arrangements will become more flexible, with concomitant impacts on employee skills and the work location.

I&CT encompasses a diverse set of technologies and services – ranging from the provision of hardware products and optic fibres, through to software, content and other services. While each of these areas has its own particular features, it is the set of technologies and related activities which carry the transformative power of I&CT.

The following section looks at the significance of I&CT in three areas: economic impact, transformation of production processes and its impact on society, particularly equity issues.

a) Economic Significance

Information and communications services and technologies constitute the fastest growing category of world trade. Although a variety of definitions are used, its importance is clear. The UK Foresight study estimated that the information technology and electronics sector would grow from its current 4 per cent of world GDP, estimated at $US431 billion in 1994, to be one of the world's largest sectors, accounting for about 10 per cent of global GDP by 2005 (Office of Science and Technology, 1995j).

A little more than half the current industry is in telecommunications services and equipment, with the remainder in computer hardware, software and services (detailed breakdowns for the I&CT market in 1993 can be found in ASTEC, 1995f).

The present market is dominated (80 per cent) by five developed nations (USA, Japan, Germany, France and the UK). Despite this, the dynamic Asian economies of South Korea, Taiwan and Malaysia are strongly influencing developments. Such nations make up 12 per cent of world production of office computing and accounting equipment. In 1993, the estimated size of the Asia-Pacific information technology market (excluding Japan) was $US17 billion and it is expected to grow to $US29 billion by 1997. Trade in electronic components also reveals the growing strength of dynamic Asian economies.

Future growth is expected to be greatest in South-east Asia, China and the Pacific Rim, but also in developing countries, where the need for modern communications will be amplified by population increases. There will be rapid global growth in communications, with specific emphasis on mobility, multimedia and broadband and satellite services. The expected economic importance of such technologies communications is illustrated by (Box 5.2).

b) Transforming the Processes of Production

I&CT is causing fundamental changes in production, transactions and services delivery that will be the source of growth in many sectors including manufacturing, finance and transport. They impact on every function in an economic system – eg design, R&D, transport, administration) – and can integrate industrial systems, making firms 'smarter', more efficient, responsive and more 'biologic'. Such a pervasive combination of systems innovations affecting the entire economy represents a change of 'techno-economic' paradigm.

I&CT are driving many changes in organisational and work structures and culture. These include changes in customisation of work and associated systems flow such as (Freeman, 1994):

- from standardised to customised;
- from automation to systematisation;
- from dedicated to flexible;
- from departmental to integrated;
- from centralised to distributed;
- from product with service to service with product; and
- from single firm to networks.

Box 5.2. Communications Technology Impacts on Wealth Creation

The UK Technology Foresight 'Delphi' survey on Communications Technology lists the top ten topic areas that UK experts believe will have the greatest impact on wealth creation over the next 10-20 years:

1. Widespread interconnection of industry via electronic networks as the major vehicle for commercial transactions;
2. Widespread demand from UK users for high band-width real-time communications and massive expansion of the public network;
3. Practical use of mobile personal communications terminals capable of providing multi-media services over radio networks;
4. Widespread use of broad-band networks by individuals and companies enabling seamless operation of 'virtual companies';
5. Widespread use of interfaces to broad-band networks allowing user selection of bandwidth in both directions of 64kb/sec to 10Mb/sec;
6. Complete merger and integration of mobile, personal and fixed communication into a ubiquitous telephony service;
7. Development of object-oriented and other new design methods to enhance the productivity of software for telecommunications networks;
8. Practical use of portable multi-media communications terminals with low power/high definition displays;
9. Widespread use in developed countries of radio call boxes for wireless public access; and
10. More than 90 per cent of commercial trading between UK organisations (including government) as entirely electronic.

Source: Office of Science and Technology 1995h.

As a result of globalisation, and in order to retain a competitive edge, it will become increasingly necessary for a company to operate around-the clock world wide. An advanced information and communications base will be indispensable as an enabling technology and will deeply affect the organisation of work as well as the volume of employment.

Traditional production of goods and delivery of services has been tied to geographic areas because of the need for skilled labour, access to certain information and customer markets, resulting in most economic activity being centred in and around urban areas. However, the information and communications services and technologies are reducing the importance of geography and distance.

c) Impacts on Society, Equity and Access

I&CT provides the opportunity to address long-term social challenges. Geographical isolation can be addressed directly by communication technology. For example, information infrastructures enable a certain level of service to be maintained in rural and sparsely populated areas through using remote delivery of distance education and telemedicine. People with special needs, such as the older people and the disabled, will be able to participate more effectively from their own homes and regions.

By enabling a greater range of development opportunities in rural areas I&CT can assist in reducing or reversing over-concentration in urban areas. For example, in Norway and Sweden, with their sparse population and considerable distances, new opportunities for rural areas are being provide by information technologies. Japan sees new opportunities through I&CT for its regions to reduce pressure on the Greater Tokyo Metropolitan Area.

The German Delphi Survey noted some concern and mistrust of computer systems in parts of the society (NISTEP FhG ISI, 1994). Problems associated with smart cards and electronic voting need to be addressed through strict regulations and the high security.

A number of national reports and policy papers on information infrastructure have drawn attention to the potential threat of a society divided by information 'haves' and 'have-nots'. This theme was strongly reflected in the consultations for this study. I&CT has the potential not only to perpetuate, but to widen the gaps between social groups. To address equity issues, most countries are seeking to ensure that information infrastructures are available to all by expanding the concept of universal service. Non-discriminatory and equitable access to emerging information services and technologies is fundamental to a democratic and equitable society. A national approach to information services provides the opportunity to plan for a fairer, healthier, better educated and more productive 'information society'.

Adequate education and training is fundamental for preparing people to function in the information society. Information infrastructures can provide better forms of education and training, support a more diverse range of curricula activity and reduce dependency on local teaching resources. Teachers and students will potentially have access to a greatly expanded range of educational material through interactive networks.

To develop a skilled workforce able to effectively use I&CT networks, it is important that school children have access to information and communications services. Industry will require people capable of using and developing new information services in order to stay competitive nationally and internationally.

Most OECD countries have started building networks linking schools, integrating computer-based education material as well as starting pilot projects for various specific educational and training applications. Several countries, including Australia, emphasise the necessity of developing applications based on the national identity, culture and language, eg the Australian educational network (EdNA) initiative reflects this trend.

5.4. *S&T Developments to 2010: Outcomes of International Foresight Studies*

What developments are driving I&CT? How far might they be expected to go in the next 15 years? These issues have been examined by a number of foresight studies, including ASTEC's I&CT Partnership. Major global developments over the next 5-10 years are seen to be (ASTEC, 1995d):

- widespread commercial transactions using global networks;
- real-time usage of broadband network services by the community, including multimedia;
- merging of mobile, personal and fixed communication networks; and
- a ten-fold increase in software applications through object oriented developments.

To achieve these changes will require many developments across a broad front, emphasising technological fusion and digitalisation. International foresight studies indicate that, by the early 21st Century, these developments will create new ways to communicate and interact with information, eg computers responsive to speech and small mobile networked computers.

Japan's Fifth Technology Delphi Forecast Survey (NISTEP, 1992) highlighted several trends for information and electronics, particularly aimed at increasing information-intensiveness, reliability and flexibility, and improved human interfaces. Brief indications of changes expected in some of the areas of chip technology, photonics, software and human interfaces are outlined below:

a) Chip Technology

The development of miniaturisation technologies has now proceeded virtually down to the atomic level for the design and production of integrated circuits or 'chips', and, together with parallel advances in manufacturing technologies, has led to massive changes in the performance of computing devices and rapid reductions in the price of such devices.

Whereas the initial transistors of the 1970s were objects of household scale, today millions of transistors are packed onto a chip the size of a finger nail and continuing competition is pushing commercial production to known physical limits. An indication of expected developments from the British 'Technology Calendar' (Box 5.5 below) suggests that by 2010 we will have very fast computers (greater that 1012 operations/second) and powerful associated hardware (eg Gbyte memory chips with chip details down to 10nm size). The 1992 Japanese Delphi survey predicted widespread use of Very Large Scale Integration with at least 10 layers of devices by 2007 and logic memory devices employing super lattices structures by 2008. These expected achievements reflect the developments in nanotechnology, which will set new limits.

Reflecting these changes, the price/performance ratio for information processing fell by a factor of 10,000 between 1975 and 1995, and continuing reductions at a similar pace are inevitable in the future (World Bank, 1995).

b) Photonic Communications Technologies

Photonics combines a large number of technologies, eg microelectronics, optoelectronics, integrated optics and micro-electronics. In principle, the transmission of information by light messages through optical fibre cable offers a vast capacity both in terms of numbers of lines and the bandwidth available to those lines (Gilder, 1993). It is also suited for use in parallel processing, which has potential in pattern recognition and artificial intelligence.

A crucial future role for photonics is in the creation of broadband interactive networks. Realisation of this potential requires many further developments, notably massive investment in optical fibre networks and advances in transmission and switching technologies. Other communications modes such as wireless based technologies using satellites and mobile radio platforms will continue to be important. But optical fibre offers 'the prospect of providing an enormous amount of bandwidth that can be used for almost any imaginable communications service or purpose in a way that cannot be conceived for any of the other platforms...' (BTCE, 1994b).

In turn, this has required the development of common international standards and protocols, such as the Synchronous Digital Hierarchy standard (SDH) for photonic transmission facilities, the B-ISDN standard covering multiple services over photonic transmission facilities and many others. The Japanese 1992 Delphi predicted widespread use of B-ISDN technology by 2003. Such trends will increasingly permit the upgrading of existing systems and the construction of new products and services on an integrated worldwide basis. (BTCE 1994b).

The consensus of foresight suggests that global digital telecommunications, mass market broadcasting and mobile communications, the Internet and pay television, are evolving toward an integrated digital broad-band network – a so-called 'Information Superhighway' (Box 5.3). This future reveals information and communications services and technologies as enablers and drivers of many major opportunities for commerce and community. The consequence of these technological trends has been, and will continue to be, rapid falls in the cost of communications.

Box 5.3. I&CT: Bringing New Products, Processes and Services

The Internet – now

The 'Internet' refers to the global set of interconnected networks which use common communications protocols (based around TCP/IP and others). This 'network of networks' has been growing exponentially with the number of 'host' computers connected to the Internet growing from 1000 in 1984 to some 4.85 million in January 1995. Some estimates suggest that the number of Internet users passed 30 million in mid-1995. At the time of preparation connections to the Internet are estimated to be doubling every six to eight months. By mid-1996 it is estimated that almost one quarter of all Americans aged over 16 will have access to the Internet.

The Internet is seen by many as a prototype of an 'Information Superhighway'. Challenging national boundaries, the Internet has opened up inexpensive global communication to vast numbers of people and created new opportunities for international information exchange, commerce and the formation of new sub-cultural groupings.

Yet the Internet, despite its success, is struggling to comply with essential requirements for security, privacy and recognition of intellectual property rights. Such deficiencies could frustrate the creation of networked information trading markets using current systems. However, the rapid growth and development of the Internet have made it a valuable global resource, and many companies are establishing a presence. The commercial use of the network is expanding rapidly with many firms exploring new secure transaction methods, eg using cryptographic methods. The future of the Internet is a key uncertainty in applying I&CT to 2010, especially for possible futures of broadband networks in Australia.

Source: ASTEC

For consumers they might mean new products and services, eg electronic mail, distance education, home shopping, telecommuting and entertainment. The 1992 Japanese Delphi survey predicted widespread use of electronic document communication (electronic newspaper etc.) in households by 2004 and systems for the retrieval of still or motion picture video information from electronic libraries through broadband lines by 2005. The next-generation cable TVs capable of transmitting programs on 300 channels or more by means of data compression to the extent of more than 50 per cent of households by 2007. The Japanese Delphi also suggested widespread use of personal teleconference systems in office though desk-top terminals (capable of providing video, drawings, documents, graphics and other data, separately or integrated) by 2002.

Box 5.3. I&CT: bringing new products, processes and services (cont'd)

Broadband Interactive Networks – the near future?

Broadband interactive networks are a key example of the potential demonstrated by the fusion of digital optical and electronic technologies. There is much current activity toward developing a 'Full Service Network', which integrates entertainment and switched telecommunications, each with multimedia capabilities based on digital technologies.

As discussed by the BTCE (1995) 'Broadband' services can be considered in three categories:

- Distributive Broadband Services, eg digital television services;
- Centralised Interactive Services, eg multimedia 'person-to-database' services, such as home shopping, gambling, or distance education; and
- Communicative Broadband Services, eg multi-media 'person-to-person' communications such as video telephones etc.

When will these occur and what services will prove to be the drivers of change? A possible time frame of events has been suggested by the BTCE (1995), 'Communications Futures':

A Pay TV Scenario for Australia

1995 Pay TV services only commenced.

1996 Telstra passes about one million households with a Hybrid Fibre-Coaxial (HFC) network. Digital Sound Broadcasts commence.

1997 About 530 000 households subscribed to Pay TV.

1997 Satellites, with digital compression and 300 channels of capacity could have some 'footprints' over Australia.

1997 HFC passes 1.8 million households with HFC cable, possibly upgrading to digital based on near-video-on-demand.

1998 Inner urban areas covered by some form of pay TV network. Sydney 2000 Olympics provide a boost to introduce digital broadcasting, esp. by free-to-air broadcasters.

2000 Pay TV in around 14 per cent of the nation's households.

2003 Wireless pay TV in around one million households, but losing ground to interactive products based on HFC.

2005 Pay TV in 2.5 million (30 per cent) of households. Rural and remote areas are unlikely to receive pay TV services.

2005+ Hopes of remote areas receiving switched video products via satellite.

Note: The ASTEC Partnership on I&CT (see Box 5.6) considered that critical uncertainties for the development of broadband services centred around the importance of meeting consumer requirements – establishing value and trust. There is presently no strong evidence of large markets for broadband interactive services, and these will not be firmly established until broadband technologies are deployed, through the use of test-beds and trials of technology and services.

c) *Development of Supporting Technologies*

Central to the actual application of these radically new computing and communications systems have been parallel advances in technologies related to the capture, storage and use of information in digital form.

High definition monitors, scanning and imaging technologies, memory and storage technologies, and copying technologies are critical to the current state of the information industries. Prospective advances in peripherals will allow large wall-hung high definition colour displays and high definition portable computers. The 1992 Japanese Delphi survey suggested that by 2005 we will see widespread use of large (screen size in the order of 100 inches) colour panel displays with a contrast ratio of at least 1:10 and portable electronic notebooks having the same contrasts as that of paper and sustaining the contrast after power-off.

d) *Software*

The escalating capabilities of computing and communications systems on the hardware side are vital enabling technologies, but they require effective software development to be undertaken in parallel. Thus the past decade has seen a major emphasis on software development, including attempts to create and extend sophisticated tools for the development of software. The Japanese 1992 Delphi suggested large software databases enabling re-use of much software by 2003, and the development of new programming methods useable through only the knowledge of applications without conventional programming language by 2004. Software is also expected to allow many scattered people to share a 'virtual space', and for 'natural language' home information retrieval and interaction across broad-band networks.

Other important and sophisticated applications of pattern recognition and artificial intelligence are illustrated by the Japanese Delphi. These include widespread use of three dimensional image processing technology capable of detecting moving objects and recognising moving patterns and changes in shapes by 2003; the transmission of images and knowledge bases for emergency medical treatment between hospitals and ambulances by 2003; and general purpose 'speech-input' typewriters, converting continuous Japanese speech into text (including 'kanji' characters) by 2008.

With the capabilities of the hardware technologies certain to increase further over the next decade, the central place of software development in developing new applications the industry will be enhanced further.

A summary scenario of important technology developments, set out in the UK Technology Foresight Communications Panel report, identifies three major changes over the next 15 to 20 years as:

- *within 10 years* it will be normal for commercial transactions, other than the delivery of goods, to take place over electronic networks;
- *within 15 years* it will be commonplace for interactive multimedia services to be used from the home for entertainment, shopping and education; and
- *within 20 years* the majority of these services will be in use from personal mobile units.

The picture is one of the wider application of computing equipment and new sensors producing a 'smarter' world with more efficient and 'intelligent' machines, and the realisation of an 'information Superhighway'. Box 5.5 provides a more detailed timeline for expected developments (Pearson and Cochrane, 1995).

Box 5.5. I&CT in the 21st Century: a Technology Calendar

Technology in widespread use

2001 Colour video display with greater than 2000 x 2000 pixels
2001 Home (health) diagnostic systems, daily check-up
2002 Replacement of card-based identification by other methods
2003 Broadband ISDN and ATM switches
2003 Living area use of virtual reality (sceneries)
2003 Home artificial intelligence-based elderly and handicapped support device
2003 High-quality A3 flat displays
2003 Use of fibre gyros in car navigation
2004 Electronic notebook; contrast equal to paper even after power off
2004 Self-recovering multi-processor systems
2004 Broadband networked electronic libraries
2005 Use of solar cells for residential power supply
2006 Blue semiconductor lasers
2007 Solar cells with efficiency greater than 30 per cent
2008 Highly integrated biosensors
2008 1 Gbyte memory chip
2008 Audio transmission at 2-4 kbit/s; quality equal to analogue telephony
2008 VLSI with at least 10 layers of devices
2009 Video playback over network at 10 times normal speed
2009 Large, wall-hung high-definition colour displays
2009 Computers with speed exceeding 10 TFLOPS (10^{12} floating point operations per second)
2009 Optical inter-chip connection
2009 Large area amorphous solar cells with efficiency greater than 20 per cent
2010 Natural language home information retrieval and interaction
2010 Many scattered people sharing a virtual space
2010 Electronics with 10 nm line spacing
2010 Positioning sound at any point in space
2010 Large-capacity recording faster than 1 Gbit/sec.
2011 Video wall
2011 Optical ICs: optical devices and waveguides on semiconductor substrates
2011 Speech dialling: recognition in switch equipment
2011 Very intelligent knowledge pursuit and consultation
2011 Three-dimensional opto-electronic integrated circuits for image processing greater than 500 x 500 pixels
2012 Fire detection by odour or vibration
2012 One chip multi-speaker-learning voice recognition
2012 Electronic newspaper to households
2013 Hard X-ray holography

Box 5.5. I&CT in the 21st Century: a technology calendar (cont'd)

2013	Odour sensors comparable to human
2014	Personal numbering
2014	Superconductive magnetic levitation railways at 500 km/h
2015	Tactile sensors comparable to human sensation
2015	Integrated logic devices with switching speed less than 1 picosecond
2015	Memory with access time of 1 nanosecond
2016	Polymers with conductivity greater than copper at room temperature
2016	No-contact identification of individuals
2016	Three-dimensional TV without need for special glasses
2016	Devices roaming within blood vessels under own power
2016	100 Gbyte non-volatile erasable random-access memory in few centimetres square
2018	Portable translation device for simple conversation
2018	Digital, optical binary logic using phase information
2018	Material, refractive index variable by 0.1 or E or M field
2018	Multi-layer solar cells with efficiency greater 50 per cent
2018	Three-terminal superconductive devices
2019	100-channel of 100 Gbit/sec. per channel on single fibre
2019	100 Gbit/s on optical fibres over long distance
2019	Quantum-effect interferometer for flux measurement
2019	2048 x 2048 pixel displays with 1/500th sec. refresh rate
2020	Behaviour alarms based on human mistake mechanisms
2020	Artificial senses, sensors directly stimulating nerves
2020	Retrieval from 1 Terabyte database within 10 sec.
2020	Fire-fighting robots that can find and rescue people
2020	High performance non-linear optical third-order devices
2020	Super-lattice two-or three-dimensional controlled semiconductor devices
2021	Conversion/storage of solar energy as biochemical energy
2021	All-optic integrated logic, switching below 1 picosecond
2022	Light detection sensitivity exceeding shot-noise limit
2023	Optical neuro-computers
2023	Systems to understand text and drawings (for example patent information)
2023	Autonomous robots with environmental awareness sensors
2023	Optical exchanges for 1000 video terminals
2024	Intelligent robots for unmanned plants
Box 5.5. I&CT in the 21st Century: a technology calendar (cont'd)	
2024	Parallel computer with greater than 1 million processors
2025	Wide screen (greater than 2.5 m) with contrast ratio greater than 10:1
2025	Nuclear propulsion systems

Box 5.5. I&CT in the 21st Century: a technology calendar (cont'd)

Technology in Practical Use

2005 Anthropomorphic robots used for factory jobs
2004 Photochemical hole- burning memory at 100 Gbyte per square centimetre
2004 Robots for almost any job in home or hospital
2010 Fine particle beam gene engineering
2010 Machine use of human memorising, recognising, learning
2011 Sensors directly connectable to sensory nerves
2012 Intelligent materials with sensors, storage and effectors
2012 Water decomposition by sunlight
2012 PCs with clock rate greater than 100 GHz
2013 Continuous sheet production of Large Scale Integration semiconductor substrate
2013 Housework robots for cleaning, washing, etc.
2013 Three-dimensional video conferencing
2014 Laser interferometer detection of gravitational waves
2014 Self-diagnostic self-repairing robots
2014 Membranes with active transport and receptors
2015 Biosensors capable of processing information
2015 Neuro-computers with logical structures based on brain
2014 Biosensors with auto-reproductive ability
2015 Near-Earth space tours business
2016 Actuators resembling human muscles
2016 Odour sensors comparable to dog for specific odours
2016 Titanium refinement with cost equal to aluminium
2016 Office automation systems using functions similar to brain functions
2017 Processing vague information by common sense inference
2017 Super parallel computer, with greater than 1000 million processors
2017 Determination of entire human DNA base sequence
2018 Organic-based light energy storage systems
2018 Computer links to biological sensory organs
2018 Artificial-intelligence technologies imitating thinking processes of brain
Box 5.5. I&CT in the 21st Century: a technology calendar (cont'd)
2019 Automatic abstracts and summaries
2020 Materials superconductive at room temperature
2020 Manufacture of long diamond fibres
2020 Molecular memory at 1 Terabyte per square centimetre
2025 Artificial brain with 10 000 cells
2025 Artificial eyes

Box 5.5. I&CT in the 21st Century: a technology calendar (cont'd)

Technology in Development

2017 Machine use of human creativity

2019 Elucidation of encoding/retrieval of human memory

2019 Production, storage and use of antimatter

2020 Communications using non-electromagnetic waves

2021 Artificial peripheral nerves

2021 Storage of living bodies by hibernation

2021 Elucidation of logical reasoning mechanism in brain

2022 Direct computer brain link

Note: The original source provides a graphical picture of the spectrum of views about realisation times for various stages of development: 'Research', 'Development', 'Practical use' and 'Widespread use'. However, this table illustrates only the earliest realisation time for the 'highest' stage of technology development, eg 'Widespread use'.

Source: adapted from Pearson and Cochrane 1995.

There will be a vast range of S&T developments over the coming decades to a large extent reflecting the very rapid growth and high levels of investment in research and development (R&D) in I&CT around the world, particularly in industry.

Australia is generally characterised by its relatively low, although increasing, levels of business expenditure on research and development (BERD). I&CT has been significant part of this growth with the two highest ranking product fields in Australian being software and electronic equipment, which together account for 31.4 per cent of BERD or about $875 million in 1992-93.

5.5. A Key Target for Australia to 2010: Development of Full Service Networks

The Australian Information Industries Association believes that Australian revenues from the information and communications industries can rise from $A23.5 billion in 1993 to $A40 billion by 2000, with exports of $A10 billion per year by the turn of the century compared with $A2.6 billion in 1994 (Industry Commission, 1995b). While our location within the fast growing Asian Pacific region is an advantage, markets may dissipate quickly because competitors within the region are rapidly exploiting information technology. Some believe there is a relatively small window of opportunity for Australia in this area.

One of the major challenges for Australia is the potential establishment of full-service networks. ASTEC established a Partnership study to investigate the critical factors underlying the possible future development of broadband, or full service networks in Australia (ASTEC 1995d). Its objectives were to understand the forces that will shape the future development of full service networks, to identify the skills needed for network deployment and, to explore how Australia can take full advantage of opportunities for innovation.

The Partnership identified a number of critical uncertainties for the development of full service networks in Australia, leading to the development of four scenarios based on different levels of industry development (Box 5.6.).

Box 5.6. ASTEC I&CT Partnership Scenarios for Full Service Networks in Australia

Four scenarios were developed that illustrate plausible paths for different futures to 2010, each depending upon how the 'critical uncertainties' play out.

1. Riding The Wild Surf

In this scenario business and industry lead the way in take-up of broadband and narrow band interactive services. By 2010 Australia industry and business are large and successful users of broadband interactive networks to give them an edge in the globalised economy. A highly competitive telecommunications services sector has developed and there have been many winners and losers along the way. An important stimulus to rapid industry take-up was an early reduction in ISDN pricing which stimulated development within the on-line services industry.

Government is a medium-level user of communicative broadband network services in cases where the services can contribute to clearly demonstrated efficiency gains (cost savings in public expenditure)

Residential demand for distributive broadband services (pay television) has grown slowly but steadily. Residential demand for narrow band interactive (eg on-line) services has grown steadily, but this has not led to growth in demand for communicative broadband services. Access to interactive services (both broadband and narrow band) is considerably lower in the less lucrative markets such as rural and remote areas

2. Navigating The High Seas

This scenario sees a high take-up of broadband interactive services in all main sectors – business and industry, government and residential. A number of new, unforseen interactive services have emerged which have contributed significantly to the growth in use. There is an internationally competitive telecommunications sector and an early drop in ISDN prices stimulates the development of the on-line services industry.

Government promotion of standards development for inter-operability has minimised consumer confusion. Government programs for promoting community use of on-line services (including special programs for rural and remote areas) have contributed to rapid adoption, as has the development of innovative and effective designs for human interfaces to the technology (assisted by the efforts of Australian researchers).

There have been significant changes in social behaviour (eg in the organisation of work, ways of doing business, recreation and attitudes to the use of computers) which have contributed to a high acceptance and use of computers and interactive services. Much of this change has been driven by young people and their favourable experiences with the new technologies and services in schools, TAFE colleges and universities.

Box 5.6. ASTEC I&CT Partnership Scenarios for Full Service Networks in Australia (cont'd)

3. Drifting in the Doldrums

In this scenario there has been a slow take-up of most services in all sectors – business, government and residential. Australia is very much a slow follower of overseas developments and opportunities for Australian development of innovations have been missed.

Confusion and conflict about the multitude of standards and services has led to consumer frustration and a slow take-up of distributive pay television and narrow band on-line services. Growth in use of the Internet began to taper off due to congestion and user frustration in not being able to find the information they wanted. ISDN prices remained high into early in the next century.

Slow economic growth has contributed to the slow take-up of services, as has a perceived lack of government policy leadership in areas such as access, facilitation of standards and innovation.

4. Shipwrecked

This scenario is a 'disaster' scenario in which various difficulties subvert what was promising beginning in the roll-out of an advanced full service network. The nature of the difficulties relate to: growth in demand for services is not as fast as originally anticipated; serious fraud using the newly introduced electronic cash; major disruption of the network, both intentionally by 'Cyber-terrorists' and unintentionally by accidental destruction of key switching nodes; and difficulties in choosing an efficient upgrade path to the next generation of network technology.

Source: ASTEC 1995d

The Partnership scenarios, *Riding the Wild Surf* and *Navigating the High Seas* contain features that are attractive to many Australians. A vigorous market place with falling real prices and strong business adoption of information and communications technology are positive features of the first scenario, although the growth in social inequality and the emergence of information rich and information poor are clearly undesirable. Most of the features of *Navigating the High Seas* are also desirable. On the other hand, the other two scenarios, the *Doldrums* and *Shipwrecked*, are as undesirable as their names imply.

Analysis of the scenarios leads to the view that the main driver of change – and the most important uncertainty – will be the demand for new services.

There are actions that the Government can take now that will encourage both business and residential demand for services and thereby make a desirable future more likely. Full service networks must be largely demand-led, with attention to the critical variables identified in a scenario process, which will drive that take-up of services on these networks. These variables include:

- the consumer variables (value, trust, backlash, human interface factors, user creation of information); and
- the deployment variables (in particular, access, cost, innovation and standards).

Box 5.7. Opportunities for Areas of Innovation in Broadband Network Technology Identified by ASTEC's I&CT Partnership Study

Network Topologies And Protocols

- protocol conversion (eg Local Area Network (LAN) emulation over asynchronous transmission mode (ATM) platforms)
- interworking units for multi-point distribution systems
- self-healing network architectures

Network Management

- special ATM services and ATM network management

Transmission Technologies

- optoelectronic/electronic circuits
- optical routing and switching, wavelength shifting
- dispersion compensation
- technology for integration of cable television and telephony services
- wavelength division multiplexing and transmultiplexing
- Erbium doped fibre amplifier systems and components

User Interfaces

- digital set-top box design

Related Systems, Software and Tools

- terminals
- home LAN management
- video enhancement
- customised integrated circuit design
- software design tools
- compression and coding
- tools to facilitate content creation
- improved encryption algorithms and security systems
- signal processing for telecommunications applications

Personal Communication Networks

- millimetre wave microcellular and nanocellular networks

Source: ASTEC 1995d

The Partnership identified a number of opportunities for Australia (Box 5.7). It found that the single most important way for Australia to generate further innovation is to ensure the essential conditions are present to encourage deployment of a full services network as quickly as possible by investing in test beds and pilot projects. The partnership noted that Australia is advantaged by having no legacy of old cable systems and can therefore deploy state-of-the-art hybrid fibre coaxial cable that can be upgraded to an integrated, fully digital, full services network.

The Partnership considered that Australia has a short window of opportunity to exploit its advantages in this area. There is a need to:

- establish trials and test-beds, including providing for a sophisticated consumer base for trialing new systems, software, services and content;
- establish appropriate data collection and monitoring regimes;
- examine import, and export replacement, requirements for implementing full service networks;

- examine human and social factors, especially in demand and use areas, and monitor changes in access;
- continue to attract a strong local manufacturing presence in telecommunications equipment through vibrant competition between Australian manufacturers encouraged by a commitment of the carriers to open, rather than proprietary systems; and
- sustain a diversity of firms, centres of research excellence and an associated knowledge and skills base, which promote synergies.

ASTEC endorses the recommendations of the Partnership shown in full in Appendix 2.

5.6. Conclusions

Without exception, governments across the world now understand that developments in information and communication technology have the potential to result in economic and social benefits. Information infrastructures are expected to stimulate economic growth, increase productivity, create jobs, increase the quality of services and improve the quality of life. The opportunities provided by the new technologies give governments additional means to address economic, social and environmental challenges.

Australia is in the midst of a far-reaching transformation of its communications and information systems prompted by the technological convergence of telecommunications, computing and broadcasting. During 1994-95, the Australian Government directed significant attention to the development of I&CT and services and the implications for policy (BSEG 1995, BTCE 1995, ASTEC 1994).

Australian industry, government and community discussion on information infrastructures has included a number of substantial investigations including for: higher education research requirements; whole-of-government requirements; community demand; and multimedia issues (ASTEC, 1994; BSEG, 1994; BTCE, 1995). The former Labor Government initiated the development of a national information services strategy. The present Government has announced its intention to establish an Information Policy Task Force to examine issues connected with Australia's information infrastructure. A number of programs have commenced to provide the whole-of-government approach including development of a national education network (EdNA), a community services network (CIN). ASTEC has provided advice to Government on the adequacy of the Australian skills base underpinning the development of information and communications services and technologies (ASTEC, 1995e).

The most optimistic predictions for I&CT over the next 15 years reveal a vast potential, in terms of economic activity, as well as its potential to alter society and redress long-term social disadvantages. It is a scenario that no country can afford to ignore.

Looking ahead reveals a rapidly evolving array of technological prospects. Very high levels of R&D investment are producing rapid developments in many areas. New developments in one area or discipline can impinge in unexpected ways on other areas – technology fusion is a common feature of new digital technologies. The technologies underpinning the I&CT revolution are in a state of rapid flux. It is almost impossible to predict the particular S&T developments that will determine the infrastructure of the future.

However, we do know if this scenario plays out there will be more I&CT and it will have more applications with many new products and services. At present I&CT debates focus on broad-band service and personal computers, but these will not remain the centre of attention. New developments that embed I&CT technologies into a range of products will be one area where some potentially unexpected developments could occur. This could be in technologies such as smart furniture which adjusts automatically to the anatomical peculiarities of a person.

I&CT will provide a more 'intelligent' technological regime; one where our technology and artefacts will be more interactive, communicative and responsive. A pervasive embedding of such systems into all aspects of work and everyday life presents a challenging picture of the future: global information services, 'smart' buildings and appliances, new services and leisure products, electronic cash, sophisticated farm management systems, advanced manufacturing products and processing, and transport equipment etc.

Even if the I&CT scenario does not play out as rapidly as currently expected, there will still be a range of new developments, combined with an increased demand from developing and industrialising countries for more established technologies and leap frogging technologies such as mobile telephones.

Given this rapidly changing situation, the challenge for government is to build the most flexible and appropriate strategy which can take advantage of opportunities as they arise. This strategy cannot be built entirely on hardware and infrastructure alone. Instead it must be built on the skills of all Australians. As a nation, we need a skilled labour force able to interpret and respond to changes. We must have the abilities to develop new technologies and software and have the knowledge to be demanding consumers and reliable suppliers, demanding innovative solutions to leading-edge problems. Australians need to ensure that the skills and capabilities are in place to use international best practice and maintain state-of-the-art knowledge in components and systems.

The pervasive potential impacts and the depth of changes in the interactions in our society due to I&CT mean that it is essential that we recognise that these changes must include all the Australian community. We need to ensure that appropriate skills are built from an early age and that Australians are able to renew these skills throughout their lives.

Australians need to ensure that the skills and capabilities are in place to use international best practice and maintain state-of-the-art knowledge in components and systems. Australia needs to develop and maintain a high quality engineering base and support for longer term research and applications.

Australia needs to ensure that it can develop as a knowledge-based society through the integration of I&CT as a key technical component of all sectors of the economy and society.

Area for Action: Applying Information and Communications Technology

ASTEC considers it necessary to effectively apply I&CT to develop Australia as a knowledge-based society in 2010. This will require actions to ensure that I&CT technologies are integrated as key components within all industry sectors, that Australia's I&CT infrastructure is internationally competitive and that all Australians are skilled to provide a flexible response to the challenge of these technologies.

To maximise long-term competitive and community benefits from I&CT, information services policy must contribute to enhancing awareness of the transformative impacts of I&CT on all aspects of economic and social activity – including health care delivery, training and employment, financial services, innovation and advanced manufacturing.

Actions that might be considered include work in conjunction with State governments to develop guidelines for education services at all levels, to promote high quality exposure to I&CT services and digital electronics in primary and secondary education and to encourage life-long education for competency in I&CT. It is also necessary to ensure that the strategies to meet the information skills and infrastructure requirements of Australia industry are put in place.

Chapter 6. Environmental Sustainability

6.1. Introduction

Much of European and Australian history can be told in terms of people subduing the land. However, there has been a significant change in recent decades as people became aware of the finite nature of global resources and the needs of an ever-expanding population. An attitude of stewardship is now driving Australia towards a goal of environmental sustainability.

There are many possible environmental futures. At one extreme, economic development could be radically slowed to ensure maximum protection of environmental values. At the other extreme, economic priorities could overwhelm 'green' values. Most Australians want an approach that combines environmental and economic values to improve the total quality of life while maintaining the ecological processes that will be essential for our future. This goal is illustrated by a National Strategy for Ecologically Sustainable Development promulgated in 1992 (Box 6.1).

Box 6.1. 1992 National Strategy for Ecologically Sustainable Development

The Goal: Development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depend.

The Core Objectives:

- To enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations.
- To provide for equity within and between generations.
- To protect biological diversity and maintain essential ecological processes and life support systems.

The Guiding Principles:

- decision making processes should effectively integrate both long and short-term economic, environmental, social and equity considerations;
- where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- the global dimension of environmental impacts of actions and policies should be recognised and considered;
- the need to maintain and enhance international competitiveness in an environmentally sound manner should be recognised;
- cost effective and flexible policy instruments should be adopted, such as improved valuation, pricing and incentive mechanisms;
- decisions and actions should provide for broad community involvement in issues which affect them; and
- the need to develop a strong, growing and diversified economy that can enhance the capacity for environmental protection should be recognised.

Note that the objectives and principles were considered as a package, with no objective or principle predominating over the others. Source: DASET 1992

6.2. The Significance of Environment in the ASTEC Study

Attitudinal issues are a major input to the consideration of environmental sustainability as a Key Force for Change and the high profile for environmental issues in this study is consistent with the outcomes of international foresight work. It is also consistent with *Environmental Sustainability* being identified as one of the four goals for Australia agreed at the EPAC 'Shaping our Future' Conference in 1994.

As part of this study, ASTEC collected views on the importance of the environment from the Reference Group, industry and community consultations. It emerged as a consistent theme throughout the Key Issues and was the basis for strong findings in the Youth and Urban Water Partnerships. Overwhelmingly, emphasis was placed on the importance of environmental issues into the 21st Century and the need for Australia to understand, accept and deal with this as quickly as possible. The mood is optimistic and Australians see opportunities abound, but they question whether we are moving quickly enough to take advantage of them.

a) Initial Consultation

Interviews with industry leaders identified environmental sustainability, including sustainable energy use, as a dominant theme in their forward planning. They suggested that the relative attractiveness of countries as a base for their operations was influenced by environmental factors. New international standards for environmental management provide a vehicle for companies to demonstrate that they have a responsible environment management plan and are meeting that plan based on a systems approach rather than arbitrary end-of-pipe limits. Failure to conform to adopted standards could severely restrict trade for companies that manufacture or sell products abroad.

More than half the members of the Reference Group nominated environment as one of their three key issues for Australia to 2010 – particularly significant given the diversity of opinion encompassed by this group. Their views covered the range of environmental issues from the role of the environment in uniting the community, to alternative energies and the integration of economic and environmental issues (Box 6.2).

Box 6.2. Reference Group Views on the Importance of the Environment

S&T can play an important role in solving environmental problems. This is a major concern for all age groups and a high priority for youth. It can be used to unite people in a common purpose.

Ms Penny Sharpe, former President, National Union of Students

Sustainability of the physical environment is a key consideration. The priority areas are as follows: Energy is vital. Marine research and the marine environment have not been given enough attention. We are now responsible for a vast area of sea. Land degradation is a major issue. We have many appropriate programs, but there is a concern that interest and hence funding may not be sustained as their political attraction wanes. The Murray-Darling scheme is an example. There are vast seas of salt waiting to render whole areas wasteland. Addressing this issue would be more useful than worrying about small specific mining projects.

Dr John Stocker, former Director, Pratt Industries, former Chief Executive Officer, CSIRO

Box 6.2. Reference Group Views on the Importance of the Environment (cont'd)

There will be massive restructuring to meet external pressures. For example, we now have payroll tax, but not taxes on the use of resources. This will have to change by 2010. We shall also require cleaner energy production and industries that impose small resource burdens.

Professor Ian Lowe, Head, School of Science, Griffith University

The link between environment and business will be important. Population growth, particularly in China, Africa and South America will be an important factor, driving a host of changes. Other changes may include a ban on the movement of crude oil by sea, a requirement that all cars be powered by electricity or that there be no cars. Such changes will have a major impact on extractive industries and hence on Australia. Shortages of water will also be a problem and there are predictions that water could be the cause of the next world war.

Mr Bruce Kean, Company Director

Finite natural resources is a key issue for 2010. We need to consider how to better manage our land, water and people. In people, we have a largely untapped resource in women; sustainable agriculture must become more than rhetoric; and cleaner production and renewable energy sources must be pursued. Australia should seek a bigger role internationally in addressing these issues.

Ms Deborah Thiele, Chair, Agriculture and Horticulture Training Council of South Australia

The culture of the Aboriginal people sets them apart from the white people. White people say that the question of sacred sites is too hard to deal with, but they have to know about it. Aboriginals and white people have to understand each other.

Mr Charles Perkins, former Deputy Chair, Aboriginal and Torres Strait Islander Commission

Climate change is important. Are rising carbon dioxide and other greenhouse gas concentrations going to cause our climate to change? Will other natural processes affect the climate significantly? If so, when might there be a problem and what will be its magnitude? What would be the nature of the impacts and how could we adapt? There could be major roles for scientists, technologists, engineers and social scientists.

Sir Rupert Myers, former President, Australian Academy of Technological Sciences and Engineering

The first issue is ecologically sustainable food production. We are seeing ceilings on yields and, in some cases, declining yields. Land degradation will continue and we should be looking at de-stocking the arid zone. Problems internationally could worsen eg Africa is already a net importer of food and its population is still increasing.

Professor Ralph Slatyer, Institute of Advanced Studies, ANU

Box 6.2. Reference Group Views on the Importance of the Environment (cont'd)

There is no advanced economic modelling in Australia that takes account of environmental costs. Factors that should be addressed in this regard include living standards, the tax regime, the place of green jobs in industry and the opportunities for job growth in the environment. The three issues for 2010 are natural resources, where water will be a global imperative, biodiversity and ecological integrity, where forests are the principal concern, both as an industrial and a technological issue and sustainable industries and cities, linked to concerns about the greenhouse effect.

Ms Patricia Caswell, former Director, Australian Conservation Foundation

The major issues will be food, water, air, energy and communications and all these must be addressed in Australia.

Dr John Webster, Chief Executive Officer, Institution of Engineers, Australia

Environmental consciousness, building on Australia's investment in its unique differentiation as 'the Cleanest, Greenest Continent', will convert thirty years of ecologically sustainable development into a leisure and lifestyles aspiration and inspiration for the rest of the world's communities.

Mr Colin Benjamin, Managing Director, Horizons Network

One of my three key issues for Australia in 2010 is soil and salinity.

Mr John Ralph, former President, Business Council of Australia

The environment was nominated by over 50 per cent of people in our broad community consultations, consistent with a 1993 Australian National Opinion Poll survey, which found environment to be the most important issue on the nation's long-term agenda. Community responses argued that Australia must respond to this challenge, and industry and economic activity must be radically reshaped by 2010 in order to deal with environmental problems. The public perceived an excellent opportunity for Australian S&T in developing new 'environmentally friendly' technologies.

b) Key Issue Consultations

Following these early consultations ASTEC identified *the need to sustain our natural environment* as one of six Key Issues for Australia to 2010 and it was the focus of a Roundtable, discussed later in this chapter. Environmental sustainability issues also underlay discussions of other Key Issues:

- discussions of *the need for innovation and entrepreneurship* and *the need to capture opportunities from globalisation* identified niche opportunities for environment-based businesses such as clean green food, environmental monitoring, waste management and energy;
- discussions of *the need for a technologically literate society* identified the need to resolve environmental issues as requiring higher levels of S&T literacy across the community – our S&T education system is not preparing us to make complex environmental decisions involving S&T within different socio-economic contexts, nor to easily identify the range of environmental opportunities for Australia in 2010, eg assisting other countries in the Asia-Pacific region to restore their degraded environments;
- discussions of *the need for continuous improvements in community well-being*, which focused on genetic predispositions for disease, identified the importance of environmental

factors as triggers and the need for a more complete understanding of the interactions between these two; and

- discussions of *the need for a forward-looking S&T system* considered that new 'green' regulations could act as a driver of change in the S&T system, for example, by reducing rapid product obsolescence and use of resources – it suggested the emergence of powerful, global, 'S&T aware' consumer organisations as a counterbalance to transnational companies and the need for the S&T community to consider how to interact with these community groups.

c) Young Australians

'Australian youth care about the future of our global environment, perhaps more so than any other issue. They are articulate and passionate about the likely ecological crises they see emerging in the years between now and the year 2010. In addition to highlighting a plethora of key environmental issues that they deem significant to the quality of life of humans and of our planet, they propose a range of preferable and strategic actions necessary for a sustainable existence on earth. They envision a future in which economics and environment embrace and progress hand in hand.'

(ASTEC, 1996a)

Young people consider that the urgency of the environmental crisis will encourage the evolution of alternative and renewable energy resources, biodegradable and recyclable materials, widespread solar power, possible nuclear fusion, more nutritious food (from 'super-plants') and less harmful agricultural practices. Some of the problems which young people consider S&T will probably solve include desertification, disappearing species (cloning is suggested a possible solution) and ozone depletion (artificial ozone may be produced) (eg Box 6.3).

Box 6.3. Expected and Preferred Futures of Young Australians for the Environment in 2010

ASTEC's Partnership on Youth explored expected and preferred futures of young Australians and the role of S&T through a process involving initial exploratory scenario building workshops followed by a national opinion poll. The following illustrates some of the views arising from the workshop phase.

Expected Future

In the eyes of our youth, the anticipated future of our local and global environment is bleak. In view of the snail's pace progress being made today towards minimising environmental degradation, they hold little hope for a timely correction to our vandalistic practices. 'Disaster' and 'Armageddon' are amongst the descriptions they volunteer.

Towards 2010, young people see the conservation of the environment remaining as an unresolved yet critical problem. They possess a catastrophic vision of a planet in which environmental degradation (of land, water and air) has escalated to an irreversible point. Destructive natural disasters and prolonged droughts are suggested features of our future environment.

> *'the world has already reached boiling point – if we don't clean up our act, in 15 years, the whole thing is going to be muck. I know it's a negative thing to say, but that's what I think.'*

(cont'd)

Box 6.3. Expected and Preferred Futures of Young Australians for the Environment in 2010 (cont'd)

Preferred Future

Australian youth are quick to volunteer solutions and initiatives concerning preferable environmental practices. They think that 'because of no action, the problem is increasing'.

On a personal note, many believe that in order to undertake the challenge of thoughtful resource and land management we will need to adopt an accommodating change in lifestyle. Australians need to embrace a sustainable, low impact existence in which we retain a spiritual link to, and appreciation of, our natural environment and other species.

> *'We need to address the livability of urban centres and the preservation of wild places. It's not just an environmental thing, it's also a spiritual thing.'*

Source: ASTEC, 1996a

One of the strongest findings in the national opinion poll undertaken as the second phase of ASTEC's Partnership was that over 57 per cent of young people believe Australia's natural environment will be worse in 2010 than it is now. Only 27 per cent believe it will get better (15 per cent – the same, and one per cent – don't know). However, those considering it will get better believe it will only get better if we change the way we do things.

As discussed in Part A, two different scenarios for Australia in 2010 were presented to determine the expectations and preferences of young Australians: a 'growth' scenario and a 'green' scenario stressing community and environmental values. While young people expect that Australia will be closer to the 'growth' scenario than the 'green' scenario in 2010 (60 per cent), their strong preference (80 per cent) is for Australia to be closer to the 'green' scenario.

The practice of S&T is seen as being instrumental in both the destruction and healing of the earth's wounded environment. S&T are seen as tools that may, if used constructively, assist us with our quest to mend our global environment. Many believe that Australians have much to contribute to S&T developments. This was recognised, for example, by the Council of Australian Governments which adopted a strategic water reform framework in 1994. This framework is aimed at achieving an ecologically (and economically) sustainable water industry.

d) Other Partnership Findings on Environment

Currently, one of the main drivers for change in the urban water industry is the ground-swell of ecological awareness and the expectation that the industry must operate in an ecologically sustainable manner.

The importance of environmental factors was recognised early in the Urban Water Partnership (examples are shown in Box 6.4).

One of the four scenarios developed by the Partnership was driven by ecological disasters. In 'Eco-Event' the steady build-up of ecological problems and crises worldwide drove dramatic change. In Australia, all infrastructure projects are required to follow Ecologically Sustainable Development (ESD) principles and water is not the only environmental product that has been badly affected. In this scenario, the disasters lead to the full internalisation of environmental costs. The price of water has risen but this is offset by successful demand management and innovative technology for water re-use. Innovation is targeted to meet rising environmental standards with a lower priority for economic, social and health concerns. The Partnership considered this should be avoided by ensuring that we did not allow ecological problems to build-up to the point of an 'Eco-Event'.

Box 6.4. Environmental Issues for Consideration by the Water Industry

ASTEC's Partnership on Australia's urban water system in the 21st Century identified many environmental and water resource issues that the water industry needs to address:

- the volume of water we need to store to provide an adequate supply in drought conditions;
- the levels of water restrictions the community will accept in drought periods;
- the likely impacts of changing demands for water (through both public education, pricing signals and other demand management strategies on infrastructure needs);
- the maximum probable flood that needs to be handled by a dam without risk of a breach that might devastate downstream communities, and the assessment and management of flood risks on flood plains that house urban communities;
- the land use and land management strategies that are appropriate to provide high yields of good quality water;
- how much water we can capture in a dam and extract from a river and still maintain the basic ecological processes that provide for other community values from the river – the aesthetic, recreational and possibly waste disposal opportunities from a river;
- the ecological processes within streams and water storages that can lead to improvement and degradation of water quality;
- understanding how we can intervene in a cost effective and timely way to minimise water quality problems and risks;
- the effects on humans and the environment of the chemicals we use to treat drinking water and waste waters;
- the appropriate indicators and monitoring regimes to ensure public health and the maintenance of ecological integrity of waterways;
- the pipe systems (and their maintenance and management) to safely deliver the water to consumers and to collect waste water – the new technologies that are emerging that allow for cost-effective replacement of aging pipes;
- the metering and monitoring systems required to measure the quantity of water in streams, drains and within pipe systems – the emerging technologies in information and communication that can make these elements more cost-effective;
- the opportunities for treatment and re-use of waste waters from sewage, greywater and urban stormwater to meet future demands for water with costs and risks that are understood and accepted. Sticking with large 'end-of-pipe' solutions versus distributing small treatment plants throughout the urban catchment – this might offer better opportunities for re-use of treated effluent;
- the types and level of treatment required for effective disposal of waste waters to various types of receiving waters, including the appropriate levels of nutrient removal from effluent before discharge;
- the continuing use of scarce water as a transport medium to carry wastes away from the household, and alternative options; and
- better understanding of the pollutant load coming from diffuse run-off from urban and rural lands and how we might manage such areas to minimise impacts.

Source: ASTEC 1995c

The Health Partnership identified a strong link between environmental and genetic factors in human health. It concluded that one of the four major S&T developments over the next 15 years, which will impact significantly on the delivery of services to older people with neurodegenerative disorders (NDDs)will be an improved understanding of the effects of the environment on human health, including its influence on the occurrence and effects of NDDs. The Partnership recommended that the National Health and Medical Research Council (NHMRC) seek research proposals directed to the identification of environmental risk factors which contribute to NDDs in older people. The research should consider how these factors should be monitored, how unfavourable factors can be controlled and how favourable factors can be promoted.

6.3. *Key Trends in the Environment to 2010*

Current trends suggest that over the next 15 years, industrialised countries will apply increasing resources to achieve higher environmental standards. Emerging middle-classes in the present generation of newly industrialised countries are also likely to demand much higher standards in air and water quality and waste disposal. In these countries, rapid environmental improvements may be possible by the use of new technologies developed in the rich countries under the influence of tough environmental controls.

However, other countries (or regions) at the earliest stages of industrialisation will be struggling with even more serious problems than they do at present. Environmental degradation will escalate cycles of poverty and increase the need for high levels of on-going international aid.

Some have predicted that in the early 21st Century environmental change will occur much faster and be more widespread and severe. Much of the planet's remaining virgin forests will vanish along with the range of species they shelter. We will also see the exhaustion and pollution of many rivers, aquifers and other water resources; the collapse of key fisheries; further ozone depletion in the stratosphere; and maybe significant climate change due to global warming. Poor countries are likely to be affected sooner and more harshly by environmental scarcity than rich countries, as they are less able to buffer themselves from environmental scarcity and the social crises it can cause. Experts have proposed tighter links between environmental change and conflict (eg Worldwatch Institute 1995).

Global warming, due to an enhanced greenhouse effect, is a more uncertain threat. It is predicted to affect agricultural production, particularly coastal croplands in countries such as Bangladesh, Egypt and China vulnerable to storm surges. It could also change rainfall patterns and soil moisture, benefiting some agricultural regions at the expense of others. In general, the magnitude of climate change is likely to be less of a problem for poor countries than the rate of change. It is important to explore the compromises and trade-offs that are involved in ESD, including the role of S&T (eg Box 6.5 below).

Local pollution is already a grave problem, particularly for those countries in the early stages of industrialisation. The impact of human activity on the world is not considered to be sustainable. It has been estimated that 35 to 40 per cent of terrestrial production of biomass is used, directly or indirectly, by humans and 24 to 35 per cent of the aquatic production in freshwater, up-welling and shelf systems is accounted for in the current fish catch. Thus, on land and on sea, humans consume a large fraction of the total available photosynthetic product. In addition, key indicators of food production per head are all falling at the global level (Brown, 1995) leading to obvious concerns about the sustainability of the current level of population growth.

Box 6.5. Enhanced Greenhouse Climate Change in 2010 – a Scenario Case Study

This scenario case study was one of three developed for use in the ASTEC Roundtable on the need to sustain our natural environment. The scenario does not necessarily reflect either ASTEC's view or preferences for the future. Rather, it was used as a starting point to explore issues and tensions in achieving global and national agreement on the nature of appropriate responses. It also aided discussion of underlying S&T needs and priorities.

Description: By the late 20th Century evidence of an enhanced greenhouse effect due to increases in CO_2 and other greenhouse gases was accepted in the international scientific community. This was despite strong resistance to reducing greenhouse gases, particularly by energy producing countries, in the 1990s. This argument was overturned early in the first decade of the 21st Century when the community began to associate the increase in costly natural disasters with a changing climate. Community concern was supported by the insurance industry whose alarming cost projections received wide publicity.

In Australia, the loss of the 1997 grape crop in South Australia due to extremely hot weather and the appearance of pests in southern Australia, which were previously only seen in tropical Australia or in countries to our north, was linked to climate change, as was unusual flooding in the Northern Hemisphere. Internationally, smaller island states, such as the Maldives and Fiji, started to agitate more effectively in international fora as the predictions for sea level rise provided firmer dates for their inundation. World stability was threatened by the rise of fundamentalist governments and terrorist groups, which drew support from terrified local populations in some of the most threatened countries such as Bangladesh, China, India and Egypt. In response, parties to the Climate Change Convention agreed to reduce and stabilise greenhouse gas emissions to 1988 levels in industrialised countries by 2010. Further reductions are expected over the next half century. Programs to moderate increases in greenhouse gas emissions from developing countries were negotiated. There was global agreement to acceptable limits for climate change within which national plans are constructed. It is accepted that any increases for developing countries, outside their national plans, must be accompanied by additional reductions in developed countries to ensure restraint in global growth. There is therefore global demand for energy efficiency, new technologies and new ways of urban planning. The Australian Government responds to the challenge of reducing greenhouse gas emissions through economic measures and the introduction of full social cost pricing. This has led to a sharp increase in the price of energy, particularly coal, as its relative impact on greenhouse emissions is factored into its price which now includes the long-term impact of climate change on snowfields, beaches, coastal developments, infrastructure and agriculture. The flow through to the rest of the economy, particularly those industries which are large users of energy, and the impact on individuals is dramatic. In the late 20th Century, 80 per cent of Australia's electricity was derived from burning coal (56 per cent black and 24 per cent brown) and 12 per cent ($7.6 billion in 1993) of total merchandised export earnings were derived from its sale overseas. The Australian Government's 'no regrets' policy achieved only minimum reduction to this. Within industry those who are large users of energy, ie aluminium, face almost total loss of market. For individual consumers, the energy rating of an appliance becomes one of its most important features. The transport sector is given stringent goals for greenhouse gas reductions and the private car is seen as a major problem. There is a flow through to almost every aspect of life – building, transport, manufacturing, balance of payments, trade, cost of living, employment. There is a new demand for S&T which allow countries to adapt to climate change and sea level rise, eg sea walls, genetically modified fruit which tolerate variations in temperature.

Source: ASTEC 1995i

In the global context, the Australian environment is seen as relatively pristine and unspoiled, yet it has been seriously degraded by the impact of the last 200 years. Over half of our agricultural and pastoral lands are in need of remedial treatment for land degradation, including soil erosion, salinity, acidification and structural decline. The cover of tall or medium height forests, just 10 per cent when European settlement began, has been almost halved. More than 31 million hectares of forest (43%) have been destroyed, including 75 per cent of the nation's rainforests, although the rate of clearing has slowed considerably in recent decades.

More recently recreational and tourist activities has begun to place a heavy pressure on our natural heritage, particularly in environmentally sensitive areas such as beach dunes and alpine areas. Serious air and water pollution has occurred in and around urban areas. These house about 85 per cent of our entire population, making Australia one of the most urbanised countries on earth.

The financial cost of this has spiralled. On top of the lost productivity caused by land degradation, there are costs related to water treatment, river and harbour dredging, research programs, increased fertiliser use, road maintenance and other engineering works. Unlike most industrial nations, we have no significant problem with air-borne sulphur dioxide or acid rain. The standard of our food is generally very good, with low levels of chemical residues and metals. Away from major urban areas, our oceans and estuaries are in relatively good shape. Our urban housing is generally of good quality and the system for protection of historic places is now well established.

One of the most urgent environment issues facing Australia is the loss of biodiversity as a result of the loss of habitat in each of the main biological systems of land resources, inland waters, estuaries and the sea. This loss of habitat is continuing, although mechanisms for the conservation of both species and ecosystems are established. Overall planning is essential for sustainable cities – transport planning, management of urban waste and curbing the impacts of human settlements on coastal and inland water systems. There is an ongoing need to monitor and reinforce reductions is Chlorofluorocarbon (CFC) use, in line with international agreements, in order to constrain the development of the ozone 'hole', which has become larger and deeper each year. There is concern about the decline of some marine species, such as mammals, reptiles and certain types of fish. It is unclear whether some types of forest are adequately protected to ensure their survival. Issues of land degradation, such as soil erosion and the continued productivity of agricultural land, especially in marginal cropping areas, need to be addressed.

Environmental and natural resource management, predicted to be a huge industry world wide by 2010, presents significant opportunities for Australia. A Parliamentary Report (House of Representatives, 1993) estimated that if Australia captured only two per cent of the world market for remediation of pollution by the turn of the century it would generate 150,000 jobs and $8 billion in business. For example, China expects to spend $3.7 billion between now and 2000 on projects primarily in the area of water and air pollution and waste disposal.

Australia is currently a leader in environmental regulation, through programs such as those established by the Victorian Environment Protection Agency for industry, and could become a world leader in meta-environment – the new growth industry of environment management policy.

Of the many challenges and opportunities facing Australia today, none match the potential rewards offered by the sustainable development of Australia's newly declared 200-nautical-mile Exclusive Economic Zone (EEZ) and associated marine territory, a combined area of 14,000,000 sq km. If the EEZ is developed and managed carefully, it has the potential to provide food, energy, medicines, mineral wealth, tourism and recreational opportunities for future generations. With dedicated scientific research, government leadership and industry initiative, Australia's marine territories could contribute between \$50 and \$80 billion a year to the national economy by 2020 (PMSEC, 1995).

Economic growth and employment will increasingly go hand-in-hand with environmental protection and renewal. Protecting and improving our rural environment is essential to the success of the food, fibre, fishing and forest industries; just as adopting clean production methods is essential to the success of our manufacturing industries and eco-tourism is becoming a vital element of the service sector. Growing development and population pressures must be managed with the help of a sound scientific understanding of the real value of our environment.

In recent years Australian Governments have set a number of targets for environmental improvements by the year 2000, such as halving waste going to landfill, stabilising CO2 emissions at 1988 levels; reducing the logging of old growth forests for wood chip exports, planting one billion trees and phasing-out CFC production.

Many of these commitments are derived from international conventions. The increasing number of these global agreements on the environment will contribute further to the processes of global integration over the next 15 years.

6.4. S&T Developments to 2010 Related to the Environment: Outcomes of International Foresight Studies

The environment, including energy, is an important theme of international foresight studies. Some of the outcomes of these studies are discussed briefly. While discussion here stresses the role of S&T in addressing environmental issues it is important to recognise that S&T has a number of roles to play. For example, S&T is crucial in identifying and documenting problems, often through basic science studies, such as measuring changes in the ozone layer. S&T is also important in communicating problems, with global telecommunications allowing many people to become rapidly aware of events such as oil spills.

Changes driven by environmental factors are influencing the design and manufacture of products, selection of raw materials, collection and analysis of natural resource management and environmental data and communication of the resultant environmental information to industry, government and the public.

a) Japanese Delphi Survey

The Fifth Japanese *Delphi* in 1992 reflected an increasing importance for environment, with a 15 fold increase in the number of environmental questions it asked of experts. Of those topics identified as most important and achievable before 2011, two of the top five concerned environmental protection and waste management. These were:

First of five:

- practical use of technologies that eliminate nitrogen oxides and other pollutants that cause today's air pollution (2003); and

Fifth of five:

- progress in the development of technologies, including those for absorbing carbon dioxide, artificial photosynthesis, turning wastes into harmless substances and preventing desertification, leading to world-wide implementation of measures for global environmental protection (2011).

Other environmental topics concern monitoring, elucidating and forecasting changes in the global environment and the development of new technologies for improved recycling and for preventing environmental pollution at the production stage. Some indicative developments suggested in the survey include:

- widespread use of product design techniques that make it easy to separate and recover the materials of disposed durable consumer goods for recycling purposes (2002);
- widespread use of biodegradable packing materials that can be decomposed naturally to harmless substances by micro-organisms etc. (2003);
- widespread use of techniques for the preservation of water quality and environmental planning, applying natural purifying mechanisms of rice paddies, irrigation ponds, waterways etc. (2003); and
- globally more than 10 per cent of automobiles as urban transportation systems (eg electric automobiles) which do not cause conventional atmospheric or noise pollution. (2006).

In Japan, perhaps recognising special concerns about nuclear power and the disposal of nuclear wastes, the Delphi survey indicates that high hopes are held for projected new energy fields, eg for the practical use of *high performance solar cells* and the practical use of *large-area, thin-film solar cells*, which promise good conversion efficiencies.

b) The German Delphi Survey

In the German *Delphi* study, which repeated the Japanese survey, the two most important developments which reflected environmental concerns were:

- development of planning and construction technology, enabling new urban development or urban redevelopment in harmony with the natural environment; and
- development of waste recycling technology, enabling the amount of city waste (ie that which must be disposed of) to be reduced to half its current level.

It identified alternative and renewable energy as an important area for S&T.

c) Joint Japanese-German Mini-Delphi

Topic statements from the 1994-95 joint German-Japanese 'mini-Delphi' survey illustrate key prospects in relation to energy technology:

- solar cells combined with a building material for walls and roofs of buildings are in widespread use Japan (J) and Germany (G), (2003);
- large area amorphous silicon solar cells with a conversion efficiency of more than 20 per cent are practically used J(2004-2005), G(2005-2008);
- solar cells on residential houses are in widespread use for the decentralised residential power supply and the supply of temporary excess to the power grid without subsidy J(2008), G(2009); and
- electric-powered automobiles with their own photovoltaic power generation as a supplementary power source are in widespread use J(2009), G(2012).

These and other topics in energy technology reflect a move from fossil fuels toward a diversity of energy sources, including increased use of solar power, the use of alcohol fuels and waste products and biomass to generate energy. Other topic statements suggest achieving higher efficiency with existing energy sources, including self-sufficiency and local level generation.

d) *US Critical Technologies Panel*

The latest US Critical Technologies Panel report has eight categories of technologies. Two of these relate to the environment. They are seen to contribute to national goals of health of the population, job creation and economic growth, the efficiency of physical infrastructure, the ability for eco-system management, growing export business opportunities, national security and improving competitiveness. They are described in detail in Box 6.7. In summary they are:

- environmental quality including monitoring and assessment, remediation and restoration and pollution avoidance and control; and
- energy – including efficiency, energy storage, conditioning and distribution and transmission, and improved generation.

The Panel's assessment is that the US is on a par with the best in the world in critical technologies in the energy category; it is also a leader in many technologies in the environment quality category.

Box 6.7. US Critical Technologies Related to the Environment and Energy

i) Results of the third Biennial US National Critical Technologies Review relating to environmental management

Critical technologies sub-areas in ***monitoring and assessment*** include integrated environmental monitoring and remote assessment of biosystems. The former contribute to such national goals as the health of the US population, job creation and economic growth, the efficiency of the physical infrastructure, and the ability for ecosystem management and ex-post monitoring and evaluation to understand how humans interact with the environment. These technologies also contribute to national security and war fighting capabilities by, for example, helping to assure non-proliferation of weapons of mass destruction and providing accurate information about battlefield environments, thus increasing troop effectiveness and reducing casualties. Within this area, Russia is behind the United States in remote sensing technologies; the United States leads in satellite-based, multi-spectral data processing technology capability, followed by Russia (based on military capability), France and Japan; in the specific area of qualitative risk assessment tools, Europe lags the United States, with Japan further behind.

Development of timely and cost-effective ***remediation and restoration*** technologies is critical, both to reduce costs to the US economy in addressing indigenous contamination problems and to promote US competitiveness in global remediation markets. These technologies can contribute to job creation and economic growth, both by creating new jobs and by helping reduce clean-up cost liabilities faced by many manufacturers. They can contribute to the health of the US population by reducing risks associated with contaminants in the environment. There is general parity between the United States and Europe, which has successfully used US technology for relatively large-scale, on-site remediation efforts. While Japanese firms are capable of being major players in bio-remediation technology – they appear to lag slightly in actual demonstration of this capability. In nuclear wastes storage and disposal, Europe is slightly ahead of the United States in technologies for decontamination and decommissioning of nuclear reactors, with Japanese firms at about the same technology level as US firms.

Pollution avoidance and control technologies contribute to the security of food, water and air, to lowering costs of R&D activities and the health of the population. Foreign firms are slightly behind US firms in separation technologies, although Europe is ahead in nuclear applications because of the policy decision to manage waste as it is produced rather than to accumulate it for future treatment.

(cont'd)

Box 6.7. US Critical Technologies Related to the Environment and Energy (cont'd)

In non-nuclear separation technologies, European firms are behind US firms, who have superior technology. Japanese firms are behind US firms in nuclear and non-nuclear separation technologies.

Overall, although the US is currently a leader in many technologies in this category, trends indicate that other countries are making progress in attaining the same level of technology.

ii) Results of the third Biennial US National Critical Technologies Review relating to energy

Critical technologies in the ***energy category*** fall into three general areas: energy efficiency; energy storage, conditioning, distribution and transmission; and improved generation.

Technologies in the energy efficiency area – which include building technologies and non-internal combustion propulsion systems – increase US economic productivity by increasing economic output per unit of energy input and by offering a growing export business opportunity. They also contribute to US national security by reducing dependency on foreign energy sources and, when exported, by moderating energy demand in developing countries. Building technologies improve the competitiveness of US construction and building industries in world markets by making the sale of turn-key installations more likely and make a small contribution to national security by allowing more efficient management of facilities that frees funds for other uses.

Although US technology now competes favourably in this area with the most efficient Japanese and European products, it still trails Japanese and European firms in some products. Non-internal-combustion propulsion systems – particularly in 'clean cars' – could provide a significant advantage to a sector comprising one-seventh of the US economy. Japan and Europe are about even with the United States in electric vehicles, and Japanese alternating current motor technology lags that of the United States, but is probably ahead of that of the Europeans.

Technology sub-areas in the ***energy storage, conditioning, distribution and transmission*** area – including advanced batteries, power electronics and capacitors – are enabling for both economic prosperity, with industrial, commercial and residential applications, and national security with military applications. In advanced battery technologies, the Japanese are slightly lagging US capabilities, although aggressive research is improving the Japanese position and European firms are slightly behind US firms. In power electronics, the United States is behind in high-power, solid-state switch technology except for a few niche areas. In capacitor technologies, especially those suited for military applications, the United States is the world leader. Japan is behind the United States and is losing ground, and Europe is also behind the United States and probably losing ground.

Technology sub-areas in ***improved generation*** – including gas turbines, fuel cells, next-generation nuclear reactors, advanced power supplies and renewable energy – are critical to economic prosperity because of the confluence of rapidly growing demand for electricity worldwide, increasing environmental pressures from electric generation and utility deregulation. In gas turbine technologies, Europe and Japan are slightly behind the United States in developing rotating machinery suitable for high-efficiency power generation. In fuel cells, the United States is the overall world leader across a wide range of fuel cell technologies but Japan is a very strong competitor in some segments, while European fuel-cell projects are highly dependent on foreign technology.

(cont'd)

Box 6.7. US Critical Technologies Related to the Environment and Energy (cont'd)

In next-generation nuclear reactors, US firms have remained competitive in design services and are active members of international alliances, because most current reactors are based on US technology; however, the United States is likely to fall behind in next-generation reactors because of large funding cuts for reactor R&D. In advanced pulsed power supplies, Russia is slightly ahead of the United States, while Europe and Japan are behind the world leaders overall but are at parity in some niche areas, such as switching capacitors and transformers. In renewable energy, Europe and the United States are about even in solar thermal energy technology, slightly ahead of Japan; in photovoltaics, Japan is continuing to lag slightly behind the United States and Europe; Europe is slightly ahead of the United States in wind turbine technology, while Japan lags behind the world leader in innovative turbine designs; and Europe is slightly ahead of the United States in bio-fuels, with Europe leading in bio-diesel fuels and the United States leading in ethanol production from biomass.

Overall, the United States is generally on a par with the best in the world in critical technologies that fall into the energy category.

Source: US OSTP 1995

e) UK Technology Foresight Studies

One of the sectoral panels in the UK foresight study addressed the issues of agriculture, natural resources and environment. Environment was identified as a sector where international competence will be mainly, although not exclusively, dependent on the stimulus provided by political, social and regulatory environments. Other sectors in this group included transport, energy, retailing and distribution and agriculture. The UK study also considered that while regulatory, social and economic policy factors are likely to be the main drivers in the sector of agriculture, natural resources and the environment, advances in scientific understanding of the processes of environmental change will also be fundamental.

The foresight panel considered that all economic and leisure activities will be affected by legislation promoting pollution control and sustainable use of the environment. This, in turn, will lead to continuing growth in what has already become a new 'environment industry', including treatment plants, clean-processing technologies, environmental monitoring, research and consultancy. The UK already has a trade surplus of over 200 million pounds a year in this sector. Environmental policy will continue to be an important driver for reusable, recyclable and other novel materials and products, efficient energy plants and vehicles.

Against this background, the Panel's key recommendations include research to improve our understanding of environmental change (including environmental values and attitudes), further work on sustainable resourcing of new materials, development of remote sensing and survey systems, and more research into predictive modelling, fish conservation and aquaculture.

The United Kingdom previously conducted a stand-alone foresighting process which focused solely on the environment. According to its participants, the environmental agenda that the UK will face in the year 2005 (or thereabouts) will look familiar. A survey of leading UK non-governmental organisations, concerning issues of future environmental importance for the UK, concluded the following:

- 'Energy use and policy' was identified by all survey respondents as being of importance for the UK in 2005;
- 'Transport related environmental problems' were mentioned by 90 per cent of respondents; and

- 'Land use and planning', 'climate change' and 'sustainable development' were mentioned by the majority of respondents as issues of future importance.

6.5. A Key Target for Australia to 2010: Integrating the Environment and the Economy

Given the stated intention of Australian governments to develop our natural resources in an ecologically sustainable manner, we need to invest in understanding those resources and the consequences of human activities, existing and planned. This is a major challenge for Australian S&T.

Considerable effort goes into research and the collection of data relevant to environmental issues. In addition to the formal research and data gathering networks, there is a volunteer effort involving many thousands of Australians. Despite this effort, there is still insufficient information to judge whether the current pattern of development is sustainable.

There is a powerful case for an enhanced effort in monitoring, data collection and environmental research. This has to be a higher priority for decision-makers to enable their judgements to be based on solid, credible information about the current state of the environment. Currently it remains true, as reported by ASTEC in 1990, that 'Australia lacks an integrated national system for measurement of environmental quality a national database of sufficient calibre to assess and manage environmental quality and appropriate national baseline data to evaluate the effectiveness of strategies'.

The collection of data must, however, be undertaken anticipating the use to which it may be put. Increasingly decision-makers are considering the interaction that exists in managed ecosystems between environment, the economy and society, and attempting to progress each aspect not at the expense of another. The development of performance indicators and measures, and systems of data collection and analysis to support these, is necessary and assists in focusing efforts in data collection. An interesting example is provided by the work of the Standing Committee on Agricultural and Resource Management. This seeks to develop indicators for sustainable agriculture by linking the three aspects of environment, economic and society. The key indicators are in turn supported by defined attributes and linked algorithms, which are intended to provide the basis for the collection of critical data.

However, recognising the necessary interaction of environmental, economic and social factors, traditional economic frameworks do not provide an appropriate structure to reflect environmental values. Some countries have now developed a system of resource accounting, enabling a record to be kept of the natural capital stocks. It has been suggested that a prerequisite for ESD is the establishment of a more sophisticated system of national accounts, measuring genuine contributions to community welfare and making allowance for depletion of stocks of natural capital.

The Australian Bureau of Statistics (ABS) has embarked on a project to develop an enhanced system of accounts for Australia. It is evident that better ecological, social and economic information will be needed for this. The 1995-96 Federal Budget allocated $3.5 million to ABS to devise a system which will link environmental and resource statistics to the national accounts. The system will list environmental impacts of industrial growth and measure natural resources used by industry. It will be an accounting method which will show the environmental and resource impacts of economic activity.

This could prove a break-through in the re-valuing of resources, essential for the economic viability of developing countries. Already, the important contribution of developing countries to the continuing health of the global environment is being reflected in programs such as 'Debt for Nature' swaps. However, developing countries will always be relatively poorer than the advanced industrialised countries, as long as they rely heavily on primary commodities, such as copper and rubber, for export earnings. The values for primary commodities have failed to keep pace with the value of manufactured products and the international division of labour is systematically biased against the interests of countries that rely heavily on the export of primary products. The inclusion of finite natural assets in economic decision making frameworks could change this.

A vital first step, expected over the next decade, will be to reinvent the national income accounts by which gross national product is measured. Gross Domestic Product (GDP) is the foundation on which national economies are built, yet its calculation does not take into account resource depletion. Currently a country can consume its forests, wildlife and fisheries, its minerals, its clean water and its topsoil, without seeing a reflection of the loss in its GDP. Nor are ecosystem services valued – sustaining soil fertility, moderating and storing rainfall, filtering air and regulating the climate, though their loss may entail great expense.

To develop a useful approach will require a much greater understanding of the complexity of natural resource systems. It would be very short-sighted to base resource accounting solely on factors such as their value in production, eg logging, harvesting or fisheries, without also acknowledging the role of factors associated with nutrient recycling and biogeochemical pathways. These are crucial elements in any resource and contribute to the net value of the system. The technologies and information to incorporate these processes into a resource accounting system do not currently exist. Without developing sufficient understanding of processes within ecological systems, the risk inherent in a resource accounting approach to Australia's environment is that it may significantly underestimate the value of natural resource systems.

The scenario in Box 6.8 was prepared for the Roundtable on the Key Issue 2010: *the need to sustain our natural environment*. While not predicting how a system of valuing the environment in economic terms would be implemented, it sought to examine the implications of a future where there is full environmental accounting.

Box 6.8. Resource Accounting in 2010: a Scenario

This scenario, prepared for the Roundtable on *the need to sustain our natural environment*, was used to help participants consider implications of a possible future in which there was a full recognition of environmental costs and benefits.

The last twenty years of the 20th Century were characterised by debates about environment versus development eg forest usage, carbon taxes and optimum population levels.

It was argued that these types of debates would only be resolved when economic and planning frameworks took account of environmental values. In other words, when there is a way of costing environmental impacts and benefits into traditional decision-making frameworks. In the 1990s economic valuation could only take into account the productive potential, not the environmental values of natural assets like clean water.

But by 2010, there has been a paradigm shift in the way the community considers the relationship between the environment and development. Environmental impacts and benefits are now costed into traditional decision-making frameworks. Most environmental costs have been valued. This includes a full acceptance of the concept of intergenerational equity, achieving long-term sustainability and taking into account habitat and species loss. The community has arrived at the point where these values have been agreed. And all environmental costs have been factored into price-setting mechanisms.

(cont'd)

Box 6.8. Resource Accounting in 2010: a Scenario (cont'd)

In general, activities which have negative impacts on the environment are no longer economically 'profitable' or socially acceptable. The exception is when some activities are so profitable or of such social importance that the community is prepared to pay for their continuation.

The environmental debate in 2010 is not the same as it was in the 1990s. The community has become so educated and aware of environmental issues that it is able to make more informed decisions about risk. For instance, the community is able to understand and debate the risks and benefits of storing potentially hazardous waste plants in urban areas and consider mining in national parks based on scientific as well as cultural criteria.

The extent of change in community attitudes over the next 15 years is demonstrated by looking at the new areas of environmental debate. Radical conservationists of 2010 are arguing that it is insufficient just to penalise developments with a negative environmental impact, while allowing those with neutral impacts to proceed. They want only developments with a net positive impact on the environment to go ahead. While, the community accepts the value of this in human environments, there is a question of whether it is a useful concept when it is applied to the natural environment.

Source: ASTEC 1995i

The change envisaged in this scenario provides an alternative to the 'business as usual' view. As it provides a way of looking back to the present from 2010, it can alert us to underlying assumptions and simplify the range of current environmental issues. It also serves to identify the alternative futures possible between now and 2010 and can therefore assist us to develop strategies that will not only allow us to be prepared, but to take advantage of such a future.

Considering alternative possible futures allows us to identify winners and losers from various scenarios. It is clear that some groups within society have benefited more than others from practices which cannot be sustained. This scenario allows us to identify and then develop policies to compensate those who will be most disadvantaged by a transition to a sustainable society.

The Roundtable concluded that some of the S&T required for this scenario was already being developed, but often it was disconnected, its viability based on the isolated application of a technology rather than its use in new types of systems. For example, we have world-leading technology in some components of alternative energy systems, but our current economic assumptions mean that we have not considered how they might contribute to a whole system set within a new economic framework. There might also be gaps in our S&T necessary to produce such a whole system. Energy emerged as a threshold issue across various situations.

Two priorities for S&T which emerged were the critical role of I&CT and the development of 'full footprint' costs and impacts. Consideration of a longer term scenario also highlighted a number of tensions, including: the need for more strategic S&T, whilst promoting good basic research for the long-term; the need for both a global and a local focus; and the different roles of science vis-a-vis technology in implementing ESD. It also highlighted the need for better links within the science community and between S&T experts and the broader community, and the need for an improved focus on prediction.

Whilst not necessarily accepting the economic framework envisaged in the scenario, Roundtable participants agreed that society must have some decision-making framework to understand the compromises and trade-offs involved in ESD. Regardless of the specific framework, scientists need to improve their understanding of environmental tolerances and capacities and what measures can be taken to minimise or reduce impacts.

One of the important issues identified in the discussion was the need to ensure that the education system is preparing young Australians for alternative possible futures, including those where the environment is integrated into decision-making. This implies new needs for industry, new skills to make investment decisions, new requirements in S&T, etc. A recent OECD report argued the importance of a new paradigm in environmental education which integrates economic development and environmental objectives.

6.6. Conclusions

To properly incorporate environmental and natural resource management concerns in our country's economic planning frameworks will require a range of new scientific information as well as new paradigms in accounting. It could make a number of current technologies too expensive and improve the economic viability of other new or emerging technologies.

Do we have the scientific knowledge on which to make informed decisions on environmental issues? Can we develop new 'environmentally friendly' technologies that reflect environmental values? What are the best structures for integrating competing environmental and economic objectives?

Central to ecological economics is the precautionary principle, now included in the Intergovernmental Agreement on the Environment. This principle suggests that lack of scientific knowledge should not be used as an excuse for allowing development with possibly irreversible and adverse consequences for the environment.

Australian Commonwealth and State governments are undertaking a range of programs, individually and jointly, to reduce the impacts on the natural environment from development, improve our knowledge of ecological processes and build better understanding in the broader community environment such as through environmental education, etc. ASTEC supports such programs.

However, there is an advantage to Australia in considering a scenario that gives a higher priority to environment and the way it would require us to re-value many of our current activities and change priorities. Australia needs to be prepared for a world that could move to a higher valuation of environment relatively quickly. At the Roundtable, questions were raised about how ready our industry is for some of the changes, eg are our farmers ready for full resource costing?

Australia needs to be prepared for the possibility of fundamental changes. Developing resource accounting, valuation systems, decision-making and assessment processes, cost sharing principles, the use of economic instruments and further understanding the relationship between macro-economic management and environmental conservation are critical to this new framework to integrate environment into decision making.

Do we have the scientific knowledge on which to make informed decisions on environmental issues? Can we develop new 'environmentally friendly' technologies that reflect environmental values? What are the best structures for integrating competing environmental and economic objectives?

Australia needs to be prepared for a world that could quickly move to a higher valuation of the environment. There is an advantage for Australia in implementing actions to promote realisation of a scenario that gives a higher priority to the environment. Revaluing many of our current activities, and changing priorities, will lead to more efficient use and allocation of resources and improved long-term competitiveness.

Developing S&T capabilities to support resource accounting, valuation systems, decision-making and assessment processes, cost sharing principles, the use of economic instruments and further understanding the relationship between macro-economic management and environmental conservation are critical to this new framework, to integrate the environment into decision-making.

Area for Action: Environmental Sustainability

ASTEC considers it necessary to implement actions that promote ecologically sustainable development, as a means to underpin progress towards more sustainable outcomes in government, industry and the community. The integration of the environment into economic frameworks will be an fundamental shift in developing a sustainable future. This integration will ensure that long-term costs and benefits of economic activity are considered in a broad context and will enhance not only the bases for long-term economic growth and competitiveness, but also community well-being and the preservation of diverse ecosystems.

An immediate area of action is to develop a strong national capacity in environmental economics, based on sound scientific knowledge (including resource accounting and analysis of long-term social benefits and costs). This will require an improvement in Australia's S&T capacity to monitor and analyse changes in the environment and their impacts and values and effective mechanisms to contribute such information to decision-makers.

Priority Action for the Commonwealth Government – 2

ASTEC recommends that as a priority the Minister for Environment, in conjunction with the Minister for Science and Technology, take action to:

- establish a Task Group, involving economic and scientific experts and in consultation with stakeholders, to establish the broad parameters for a system of resource accounting and its scientific and technological requirements, and develop an agreed strategy for developing our national capacity in this area;
- accelerate work on resource accounting currently underway in Commonwealth departments and agencies, and put in place the means to carry forward the strategies developed by the Task Group;
- ensure the development and maintenance of adequate infrastructure for scientific and technological efforts contributing to effective resource accounting systems; and
- encourage Commonwealth S&T funding agencies to give priority to strategic research in this area.

Chapter 7. Advances in Biological Technologies

7.1. Introduction

> *'Biotechnology is one of the two great generic technologies of our times which, with information technology, is profoundly altering society. We all feel and see the impact of the information technology revolution in our everyday lives. The impact of biotechnology is just starting to be felt: the technology is so powerful and developing with such speed that it is difficult even to predict how it will change our lives in the next century.'*
>
> Adrienne Clarke, Chair, CSIRO

Human knowledge is currently at a stage where our understanding of the processes of life has opened up the possibility of 'playing Creator'. A key point was the elucidation of the structure of DNA by Watson and Crick in 1953. Twenty five years later genetic 'engineering' or 'manipulation' was launched with the developments in 1978 of a 'pomato' and the first genetically engineered bacteria able to produce insulin. The last two decades have seen further rapid progress. Advances in genetic engineering and biotechnology are now revealing their truly revolutionary potential (eg ASTEC, 1993).

Until recently our capacity to change life was tightly defined by limits such as species barriers. Now it is conceivable that genetic information can be transferred between remarkably different organisms through genetic engineering. Biotechnology is now enabling both established and newly emerging industries to design, create and produce highly specific substances derived from molecular structures and processes in naturally occurring biological systems.

Unlike ASTEC's other Key Forces for Change which have already impacted on society in many areas, our capacity to manipulate biology is only starting to mature. Over the next 15 years further technological development will need to be matched with development in other areas to address issues of equity, safety and ownership.

An optimistic scenario is that over the next 15 years, technical barriers and related social, economic and environmental issues will be effectively addressed so that biology based technologies become integrated in our daily lives.

On the other hand, a 'disaster scenario' could lead to widespread public concern, constraining research and its commercialisation. Such a disaster might be catalysed by a number of possible events such as a damaging 'accidental release' of a pathogenic organism, or the development of transfer of new pathogens across-species boundaries, or ecological damage caused by weeds arising from disease resistant transgenic crops.

However, it is likely that the impact of genetics and biotechnology will not be as profound by 2010 as that of the other Key Forces for Change. For example, it is unlikely that a widespread understanding of the full changes possible in biotechnology and genetics, let alone actual products, processes and services will be widely available by 2010 (eg New Scientist 1995a).

Genetics and biological technologies are of particular interest to Australia because large sectors of our economy use biological systems in their production processes, and Australia has great strengths in scientific fields related to biotechnology. Just one example is the potential economic benefits for agriculture through the commercialisation of disease resistant crops which reduce the need for pesticides, eg *Bacillus thuringiensis* toxins in cotton. Furthermore, Australia, is a bio-diverse country, with unique biota and considerable genetic resources. Australia has strengths in biological research relevant to these new technologies and it also has excellent potential for applications of these technologies particularly in relation to its agriculture and environment.

7.2. The Significance of Advances in Biological Technologies in ASTEC's Study

Views of Reference Group members stressed the need for, and the potential of, biology-based technologies (Box 7.1). However industry leaders considered biology based technologies to be longer term issues with their potential most obvious in areas such as pharmaceuticals.

Box 7.1. Views of the Reference Group

It is becoming increasingly difficult to cure the diseases we get. This could be an effect of the environment or our lifestyles, but it may also be that we have reached a point of weakness in our genetic make up. It is a matter of concern that increasingly only the rich can afford the cures for modern diseases.

Ms Lyndsay Cattermole, Aspect Computing

There is no way to predict the future in health – AIDS was not predicted. However some things are fixed – Australians will still get sick probably from the same diseases (cardiovascular and cancer) but we will be older when we get them. Human genome mapping is looming on the horizon and this will inevitably lead to better diagnosis.

Dr Warwick Anderson, National Health and Medical Research Council

Australia has a strong capacity for medical research – it is one of our core technologies. We are in a prime position in the context of rapidly improving lifestyles in Asia to use this capacity as an economic opportunity and build on our national advantages.

Mr Peter Laver, Corporate General Manager, BHP

We need to maintain a strong focus on leading the world in breeding and biotechnology..... our standards need to be the best in the world.

Dr Edwina Cornish, Florigene

I foresee a revolution occurring in the area of disease and genetic defects leading to the need for preventative technologies to enable a lifetime orientation to reducing risk, with people in the future able to profile their lifetime expectations of health.

Sir Gustav Nossal, President, Australian Academy of Science

Initial community responses did not highlight these issues, but the later program of national consultations raised concerns about the broader social context. Concerns about biological technologies included the need for greater community awareness and debate on the issues surrounding these technologies; their potential benefits to agriculture; a general community fear of developments in these areas; a concern about environment risks; and a concern that we have very little knowledge of an issue with such profound impacts. In Alice Springs concerns were raised about issues of control over indigenous knowledge.

ASTEC explored genetics and biotechnology as the focus of its Key Issue *the need for continuous improvements in community well-being*. The Roundtable, excited by the potential of the scenario outlined in Box 7.2, considered developments in genetics and biotechnology promise much to assist human well-being and the advancement of knowledge, but they also raised a number of difficult ethical, legal and social issues.

Box 7.2. Scenario for 2010: Impact of research into the Human Genome and Environmental Impact on Health

The mapping of the human genome was completed by the year 2000 and despite attempts to patent this information, it is freely available.

In addition, the genetic origins have been established for the major causes of morbidity and mortality identified during the previous century. These conditions include asthma, diabetes, cancers (notably lung, bowel, breast and prostate), cardiovascular diseases and some diseases of the central nervous system such as Alzheimer's disease and the neurodegenerative disorders.

Major environmental factors impacting on health are better understood. These include climate, pollutants of air, water and food as well as lifestyle factors including exercise and stress. In addition, many foods are being tailored to reflect an individual's needs according to their age, gender, ethnic background and reproductive status. Moreover, the interactions between genes and the environment are major areas of health research in 2010.

As a result, society is in a position to modify its health by preventive strategies, aimed at those found to be at risk by gene testing. Such testing is carried out most commonly at key stages of life. For instance, couples wishing to start a family are able to choose to be screened for defective genes which are common. An example would be the gene for cystic fibrosis, which is carried by 5% of the Australian population. In addition, families with a family history of heritable diseases are strongly advised to undergo screening before conception. Couples at risk are able to utilise in vitro fertilisation procedures, selecting for implantation only those embryos not carrying the defective gene.

The practice of foetal screening is widespread. Abortion of foetuses with lethal genes, a procedure introduced in the 20th Century for conditions such as muscular dystrophy, are available for a much wider range of heritable diseases. However, society is still grappling with the ethical issues associated with aborting foetuses which carry genetic risk factors for treatable diseases such as diabetes.

At birth, irrespective of any previous genetic screening, the screening of every infant is strongly advised by the medical profession. Such screening has grown remarkably from the limited extent in the 20th Century for conditions such as phenylketonuria, with its requirements for subsequent modification of the diet. By 2010, screening reveals genes for common conditions such as asthma or diabetes, for which trigger factors later in life are known. Preventive measures can then be planned such as immunisation, restriction of diets or intervention to contain or avoid known trigger factors. At the age of consent, screening is available to the general public. As a result, individuals are able to know their predisposition to develop particular diseases. Some members of society choose to embrace the information and adjust their lives accordingly. For example, a predisposition to produce offspring with neural tube defects would indicate a need for dietary changes such as high folate intake. Other genes may be revealed for particular cancers. This presents the individual with choices such as changing their life style and avoiding trigger factors. Some individuals respond by demanding the right to excise the organ at risk by undergoing surgery. Still others seek to extend the length of their lives or that of their children by gene manipulation.

Others respond differently. Many are concerned at the potential to predict the disease from which they are likely to suffer and refuse testing. Others reject the role of genetics in health and reject the information. For very many others, the ability to respond is constrained by economic, educational and social disadvantage.

(cont'd)

Box 7.2. Scenario for 2010: Impact of research into the human genome and environmental impact on health (cont'd)

On a broader front, there is an ever growing debate about the social, legal and ethical implications of predictive genetic testing. In 2010, the information is available only to the individual concerned and those to whom they choose to disclose it. However, there are ongoing debates as to the potential use which could be made of these data. For example, should it be available to educators, health professionals, health and life insurance agencies or prospective employers? Many of these groups are actively seeking the information. If they gain access, what use might they make of it? For instance, might employment opportunities be limited by a susceptibility to disease?

As a result of a better understanding of the genetic origins of disease and of environmental impacts on health there is pressure on the health system to prioritise access to services. These services are increasingly over-stretched, as more diseases become treatable, while the positive benefits of new health measures have yet to impact on the number of people suffering disease.

There is debate as to whether priority can be given to individuals who do not comply with the restraints imposed by their genetic and/or environmental profiles. The dilemma extends that of the 20th Century as to whether smokers, or at the least those not prepared to stop smoking, were to be given equivalent priority to non-smokers. Other systems of prioritisation such as age or public expenditure capping are being debated. One consequence in this year 2010 is the recognition of the paramount need for health education and promotion programs at a much higher level than was available in 1995.

In summary, the new understanding of genetic origins of disease offers the possibility of improved health for many individuals in Australia in the world of 2010. However a host of ethical, legal and social issues remain unresolved.

Source: ASTEC 1995j

Opportunities include the earlier identification and treatment of human diseases and the related move from treatment based medicine to a health system based on prevention.

Challenges for these technologies include: equity; poverty, justice, health care; enhancing support for the aged: providing high quality food, water and air; and improving the quality of urban planning and community infrastructure.

The ASTEC Roundtables on *the need for a technologically literate society* and *the need to sustain our natural environment* also identified issues relating to genetics, including ethical and access issues, and the potential environmental impacts of the release of genetically modified organisms. S&T literacy discussions identified genetics as an S&T issue which graphically illustrated many problems of the S&T system. For example, the relationships between priority setting in research, community priorities and broader global needs: should funds be given to searching for genetic therapy for obesity or for widespread diseases, eg malaria? Also, there was concern about potential impacts of new biological technologies rendering us 'victims' of the S&T system.

While new biological technologies have the capacity to address long-term ethical issues for humanity, such as feeding the starving, they raise new problems and radically alter our perception of being human eg through the often costly extension of human life, or production of artificial and grown organs for xenotransplantation. Such a broader range of ethical issues may not have been adequately considered prior to the research being undertaken.

The Roundtable considered that wide-ranging community debate on such issues is not assisted by the media's focus on confrontation and the '10 second grab'.

However, concerns noted by ASTEC in the community about the impacts of genetic knowledge, potential changes in the distribution of health resources, and our increased responsibility to manage our own bodies, indicate that more debate is needed.

ASTEC's Roundtable on *the need to sustain our natural environment* revealed the need to balance the concerns and benefits of the new biology. It presents many new opportunities to manage the environment, control pollution, lessen the environmental impacts of agricultural production and enable greater control of weeds and ferals. But it also raises concerns about unintended consequences of releases and loss of biological and genetic diversity.

The study findings indicate the need to focus on improving impact assessment for the introduction of genetically modified organisms, and on communicating with the community. The Roundtable on *the need for a forward looking S&T system* also raised the need to examine the social context to work in this area.

Key Issue discussions of *Innovation and Globalisation* identified niche opportunities for biology-based businesses related to 'clean green' food, food processing, environmental monitoring and management, horticulture and other parts of agri-industry.

The theme of *Advances in Biological Technologies* was also important in a number of Partnership studies. As part of the ASTEC Health Partnership, a survey of the health community identified six major health issues for Australia to 2010: social/ policy issues; impact of clinical, pharmaceutical and scientific advances; aging of the Australian population; increasing/sustained impact of specific diseases/disorders; inequalities in availability of health services; and the impact of advances in communication, electronic transfer and information technology.

The potential contribution of S&T to addressing the six key health issues was seen to be in many different ways – one of which was genetics and molecular biology. The others include:

- improvement in detection – including screening, earlier diagnosis and diagnostic technologies (which might also involve genetics and molecular biology);
- information technology – telecommunication/computing;
- manufacturing and engineering, commercial product development; and
- reduction in cost of services and evaluation of costs and services.

In the main part of the *Health Partnership* study which focused on management of neurodegenerative disorders in older people to 2010, research in genetics and the use of new biological technologies were regarded as significant. The partnership heralded the 21st Century as the beginning of a new focus for health care delivery based on genetics and understanding of environmental factors. It suggested that the major diseases of the last two decades – for example, heart disease and cancer – will be replaced by neurodegenerative diseases as the technologies to prevent and manage the earlier diseases are more universally applied by the end of the 20th Century. A number of scenarios were developed to indicate the different types of health care delivery possible in 2010 (ASTEC 1995b).

The *Youth Partnership* reflected many of the concerns raised in the S&T Literacy Roundtable in relation to the social context for S&T, priorities and ethical issues. Genetics was one of three priority S&T topics identified by youth. Genetic engineering evoked strong feelings: as both an inevitable and desired technological progression but also as posing serious ethical considerations (eg parents deciding the sex of their children, cloning and genetic manipulation of the human germ line). It was seen as having applications such as fertility control and food production but applications like gender choice for babies were viewed as 'takeover technology'.

The *Urban Water Partnership* concluded that achieving ecologically sustainable urban water systems will require biology based S&T, in particular expertise in ecology, microbiology and epidemiology. Such expertise will allow accurate and timely water quality assessments, effluent and waste treatment.

7.3. The Significance of Advances in Biological Technologies to 2010

Biotechnology is based around two key technologies: firstly, cells of living organisms – such as plants, animals and bacteria – can be grown as tissue cultures; and, secondly, the genetic material that defines the nature of these cells can be isolated and genes can be moved from one cell to another. These two technologies are revolutionising biology and all its applications.

While the main impact is being felt in agriculture and medicine, applications in other diverse fields such as forensic science, security and mining are rapidly becoming commonplace. The potential for the interface of these technologies with I&CT is just starting to be realised; for example, biomolecular electronics using recombinant DNA technology for high density data storage have been suggested (US OSTP, NCTP 1995).

Box 7.3. Biotechnology – Some Key Prospects for Benefits

Technology	Prospects
DNA Technology	'Gene machines' to make new proteins Sequence banks for proteins and nucleic acids A complete map of the human genome Crime solving using DNA Complete maps of the genomes of economically important organisms
Gene detection	Specific DNA probes Detection of genetic health disorders
Gene/enzyme replacement	Gene therapy
Genetic and protein engineering/Transfer of new genes into organisms	Microbes: new antibiotics, new types of food, improved waste management, new fermentation processes, resource banks for rare human chemicals. Plants: new food products, disease and pest resistant strains, extension of habitat ranges. Animals: healthier farm stock, new types, new products, better growth
Cell culture	Plants: trees from single cells Animals: cultured cell products eg biochemicals and in vitro or in vivo grown organs, eg skin for grafting.
Monoclonal antibodies	Diagnostics, control of parasitic diseases, new anti-cancer drugs
Bio-sensors	Improved safety and monitoring in food and chemical industries and the environment.

Source: ASTEC

Particular applications of interest to industry include genetic modification of crops. Genes can now be transferred permanently between species by a number of methods. This transfer can alter a variety of properties of the plant, including resistance to disease and pests, or physical characteristics of fruits and seeds, including shelf-life etc. Plants might also be used as 'bio-reactors' to manufacture useful proteins or other materials for use as drugs or in industrial processes. Enzyme and protein engineering has many implications for industry eg in the food sector for cultures, fermentation and in speciality chemicals for bio-degradable polymers. Pollution prevention can be assisted by the use of biologically derived materials in production processes as alternatives to toxic materials. Bio-remediation, or the use of micro-organisms to break down hazardous wastes in able to replace many conventional methods. In medicine the Human Genome Project, a major project to map and sequence the human genome, is showing rapid progress, eg as the result of new physical mapping techniques such as 'yeast artificial chromosomes'. Ultimately, such developments may allow gene therapy where malfunctioning genes are replaced by normal ones. Also, many pharmaceutical drugs and vaccines are under development.

The two areas widely recognised as the most significant for biotechnology applications are agri-industry and health, which are outlined below.

a) Potential to Improve Agri-industry

The mid-1990s mark the start of a new phase in genetics and biological technology. In 1994, the first genetically engineered whole food – the 'Flavr Savr' tomato – was approved by the US Food and Drug Administration. Currently some 50 species of crop plants can be genetically modified, and engineered cotton, rice, oil seeds, sugar beet, alfalfa, potato and corn are expected to enter the market before 2000. We are entering a new phase in biotechnology – one of increasing commercialisation.

The global population is increasing exponentially, placing further pressure on the carrying capacity of the earth. The 'green revolution' of the 1950s was based on the application of Mendelian genetics; traditional plant breeding techniques to produce new high-yielding strains of the major plant crops and the use of chemical pesticides, herbicides and fertilisers to increase yields. However, the use of persistent chemicals has left a legacy of contamination in soils and water supplies so that many countries now have stringent targets for withdrawal of the use of certain chemicals, pesticides and fertilisers.

Box 7.4. Growing Potential for Crop Engineering

The ability to clone genes, to put them into plant cells and to regenerate plants from these cells, has bought technology to a stage where all our major food crops are being genetically engineered for traits such as pest resistance and particular commercial qualities.

Currently released crops are both commercially valuable and are technically the simplest to engineer. Tobacco is very easy to engineer and is mainly used as a model system to define methodologies. Tomato and potato are in the same plant family as tobacco and are also relatively easy to engineer.

Engineered fresh tomatoes are on sale in the US and tomato paste from engineered tomatoes is on sale in the UK. Engineered corn seed is being sold in the US. Cheese made with genetically engineered rennet is marketed in the UK as 'green cheese' as it does away with using rennet from the stomachs of calves. Perhaps the most valuable crops are rice and wheat, which have been quite difficult to engineer. Canola is both technically feasible to engineer and commercially valuable and has been the subject of most releases. Cotton is the subject of much research and a number of modifications have been made to confer disease and pesticide resistance.

Source: ASTEC

A major challenge is to find new ways to increase the food supply without further degrading our environment. Consequently there is world-wide major investment, particularly by the chemical companies, in applying the techniques of biotechnology to develop crop plants with their own in-built resistance to disease, insecticides and fertilisers. Similar techniques are used to create plants with high yields of particular components – for example, tomatoes with a high solids content, high amylose starch and so on.

Field releases of engineered plants in most countries are subject to government approval. OECD figures show a rapid increase in approved releases since 1987 with the USA leading the number of releases followed by Canada, UK, France and Belgium. Australia has approved several field releases with more applications awaiting approval.

The most commonly desired trait in modified crops is herbicide resistance, followed by insect and virus resistance. Chemical companies have focused on protecting the lucrative herbicide market by producing crops which tolerate herbicides, particularly herbicides which are not persistent (ie they are rapidly degraded in the soil to non-toxic products). Farmers plant the herbicide-resistant seed and spray with the corresponding herbicide to kill the weeds, but allow the seed crop to grow.

An exciting new area of biotechnology is 'biopharming'. Human pharmaceuticals such as interferon, for example, have been produced by transferring the gene for interferon into turnips. The pharmaceutical is then extracted from the turnips. Another development is the production of vaccines in bananas; genes for cholera and hepatitis B antigens are transferred into bananas so that children in developing countries can be immunised directly by eating the fruit.

In forestry, scientists are developing technologies for early screening of useful traits such as rapid growth, salt tolerance, etc. and scientists expect to engineer trees for properties relevant to pulp and paper making that will cause less environmental damage. Trees which specifically absorb certain metals through their roots, for example, are being developed for minesite rehabilitation. This new field of technology is termed phytoremediation.

b) Potential to Improve Human Health and Well-being

Over the last century, the world has moved from a complete lack of knowledge of the structure of human genes to a general understanding of the make-up of the human genome, its evolution and regulation. An important symbol of the genetics revolution is the Human Genome Project which seeks to map the entire human genome. The project promises to revolutionise medical practice and biological research in the 21st Century by allowing the accurate diagnosis of inherited diseases and by improving the understanding of gene function in health and disease.

By 2010 it is likely that information about our pre-dispositions to certain diseases will be available. We may also be able to purchase genetically modified food high in certain nutrients to prevent the onset of specific diseases, such as the scenario in Box 7.2.

Specific applications for biological technologies are also to be found in pharmaceuticals. Human drugs such as insulin for diabetics, growth hormones for individuals with pituitary dwarfism and tissue plasminogen activator for heart attack victims are being produced by the fermentation of transgenic bacteria.

Research backed by decision support systems leading to more effective prevention and therapies and minimising the need for long-term care will allow us to restrain costs while enhancing public health and health care. However one of the biggest issues to emerge from the study is genetic screening (Box 7.5 outlines some of the issues).

Some studies have suggested relatively positive community attitudes to the use of gene technology, with 63 per cent of respondents to a survey indicating that, over the next 20 years, the benefits of genetic engineering are likely to outweigh the risks. (DIST, 1995) This, appears to differ from the broad range of ethical concerns raised in ASTEC's consultations and particularly those related to genetic screening. However it does reflect, similar to ASTEC's Youth survey, the community's great hopes for S&T to resolve future problems.

Box 7.5. A Range of Issues Raised by Genetic Screening

Base-line questions are whether genetic testing is appropriate, and whether the community wants it or wishes to fund it. There needs to be greater discussion in the community about R&D priorities, the way that R&D funds are allocated and mechanisms to ensure genuine community participation and control. Important concerns about biotechnology focus on issues such as the access to information, particularly concerning privacy implications for employment, life insurance, mortgages, superannuation, health care, education.

There is a concern that in the future there might be pressure to search for the genetic basis of traits other than disease. Increasing interest in how people might be encouraged to modify their behaviour could lead to a search for the genetic basis of complex characteristics such as intelligence, personality, character and social behaviour. There might be demands for very detailed screening, beyond screening for abnormalities, to provide detailed descriptions' predictions and advice ('fate maps') – for those who can pay.

Some issues associated with genetic screening

- ***Access***
  People who are isolated may have less access to services than those living in the major communities.
- ***Pressure Groups***
  Rational decision making by governments is going to be a major problem in the face of demands by interest groups for resources to test for particular genetic diseases. This may require a national approach and an advisory body to oversee further developments such as the predictive testing and general screening of populations for a few common diseases ie we need to be strategic.
- ***Confidentiality***
  Extensive genetic testing raises issues of who should have access to this information, eg should it be available to insurance companies and employers, spouses, descendants?
- ***Quality Control***
  There is a need for quality control in the provision of genetic services at all levels. Safe guards in laboratory screening procedures and in counselling and clinical services are issues that the community, particularly the professional community, must address.
- ***Individual Choice***
  Wherever possible, individuals should decide whether they should undergo genetic testing and to whom the information would be made available.
- ***Protection of Individual Rights***
  This issue is highlighted by concerns that previously people were sterilised on the basis of their IQ test results: now genetic information might be similarly used. The 'eugenic' implications of this technology must be addressed.
- ***Cost***
  An important issue is whether feasible procedures and technology should be used regardless of cost.

(cont'd)

Box 7.5. A Range of Issues Raised by Genetic Screening (cont'd)

Other issues related to genetic screening which were raised at the ASTEC Roundtable on *the need for continuous improvement in community well-being* were:

a) Skill Base and Intellectual Property

The current conceptual model which crudely associates genetic predispositions and environmental factors will be inadequate. This was highlighted in ASTEC's health partnership study. Through an analysis of neurodegenerative diseases of older people, the study identified as central the coordinated advance of knowledge of both genetics and environmental triggers. Only through prolonged epidemiological and genetic studies could achievements be made.

Australia will need to generate a core of people who have the skills to put genetic technology into practice. Whilst most knowledge of genetic technology will be freely accessible in the public domain, a great deal will be covered by patents and not available commercially or diagnostically, without payment of royalties. Therefore Australia needs to be generating its own intellectual property to offset royalties that will have to paid overseas. An informed co-ordinating body will be needed to evaluate strategy.

b) Increasing Community Knowledge and Understanding

It is very important that the legal, ethical and social issues which arise out of the development of genetic knowledge be discussed. There needs to be informed public debate about issues – such as informed consent, privacy, choice regarding testing, discrimination, level of information provision, confidentiality, group versus individual good – to ensure decisions are made in the best interests of all members of society. There are currently very few forums actively discussing such issues and the general level of community education will need to rise if widespread rational community debate is to occur.

c) A National Co-ordinated Approach

Widespread delivery of DNA testing would require multi-disciplinary clinical genetic units and DNA diagnostic laboratories around Australia where scientists, counsellors and medical geneticists could interact. At present, clinical genetics is a largely ad hoc service in the various states. Currently there are different arrangements being made in different States. Some testing, for example, for particularly rare genetic disorders, is such that it can only be performed in one laboratory in the country. Therefore it would be sensible to have a nationally co-ordinated approach to genetic testing. Laboratories round the country could each test for common conditions along with a selected half dozen or so rare disorders to provide testing for the whole country. This would require an informed advisory body to co-ordinate genetic services and to oversee their rational growth.

d) Funding for Prevention

There is a concern that funding for prevention is not readily available and there are significant differences between the States. For example, serum screening for Down's Syndrome is available as a public health measure in South Australia, but is not available in a number of other States. It is difficult in this community to gain funding for preventive medicine as opposed to curative medicine, and much of the genetics in 2010 could involve prevention rather than treatment.

(cont'd)

Box 7.5. A Range of Issues Raised by Genetic Screening (cont'd)

e) Licensing

There will be a need for some type of licensing for tests to ensure: proper evaluation, field testing, valuation procedures and quality control (similar to drug trials). This would be necessary to ensure that facilities were not marketing procedures that did not provide valid test results. There will be a need to license laboratories where tests are conducted as well as the people who perform them. Moreover there is a need for a regulatory body to oversee the confidentiality and social implications of testing and for community-based ethics groups to be party to these decisions. Australia in the 1990s has been a minor stake holder in programs such as the Human Genome Project and as a result the expertise base for genetic testing and screening may be limited.

f) Testing for Whom?

Concerns were raised about the operation of clinical genetics laboratories and DNA diagnostic laboratories which focus on one-to-one counselling, diagnosis and not prevention. Unless great care is taken, such laboratories would be concerned with the acute, the rare, the interesting and the private instead of the common, the chronic, the uninteresting and the public. There was serious concern that professionals would concentrate on monogenic diseases, their screening and genetic counselling, rather than polygenic and late onset diseases and prevention.

Source: ASTEC

7.4. S&T Developments to 2010 Related to Biotechnology: Outcomes of International Foresight Studies

The results of International Foresight studies reaffirm the significance of biology-based S&T in the future. This section looks at outcomes from the Japanese Delphi study (1992) and its German reiteration (1994), US Critical technologies studies (eg US Department of Commerce 1990, OSTP, NCTP 1995) and the UK Technology Foresight study CEST (1994).

a) Japan

Topics in the Fifth Japanese Delphi survey suggest a fundamental change in medical science over the next twenty years or so: health care delivery will move from diagnosis and treatment to a preventative model for attaining improved health and avoiding diseases. Seventy five per cent of the Japanese survey respondents regarded 'predominance of preventative medicine in medical science' as very important and forecast its realisation by 2010. Respondents also expected that elucidation of the mechanism of disease onset for virtually all genetic diseases would occur by around 2010.

The Japanese Delphi survey identified seven areas of important future technology:

- progress in research into cancers, depending on further advances in *molecular biology*, particularly the elucidation of signal transduction in the carcinogenesis of cells and the identification of all cancer inhibiting genes;
- defining and analysing the entire primary structure of a genome;
- molecular mechanisms of development, differentiation and morphogenesis: there will be continued activity in seeking to discover the genes controlling development, maturation and aging;

- high level functions of brain-perception, memorisation, thinking: the development of non-invasive encephalometry technologies for analysing macro brain activities is a major priority;
- elucidation and high level modification of the functions of plants: foodstuffs are a major international area of concern and renewed efforts will be necessary to develop for food use new plants produced through gene manipulation and to enhance food production through improvement in the photosynthetic ability of plants;
- protein engineering: high priority is given to development of technologies that for designing and synthesising proteins; and
- *bio-informatics*: an important international task lies in the area of artificial intelligence applied to biological phenomenon, such as 'genetic algorithms' for the structure and creation.

Box 7.6 shows the Japanese Delphi scenario for Cancer Research. The survey also forecast that technology for genetic testing will be cheaper and simpler with widely distributed means to provide individual genetic descriptions ranging from results for screening of various kinds, such as screening for genetic abnormalities, to quite detailed descriptions and predictions and advice based on them. For example, it will be possible to predict whether an individual is at risk for cancers (for example lung, bowel, breast and prostate), adult onset neurodegenerative conditions, common multi-factorial problems such as ischaemic heart disease, asthma, diabetes and hypertension. However, this facility may be limited to those who are able and prepared to pay for it.

Box 7.6. Delphi Scenario for Cancer Research

Year	Development
2001	practical use of diagnostic technology for cancer by using three dimensional images
2001	development of sensitive techniques for simple and early cancer diagnosis using blood serum
2003	enhancement of a secondary cancer prevention (early detection) system and social awareness of its importance, resulting in an average survival rate exceeding 70 per cent five years after the outbreak of all types of cancer
2004	practical use of early diagnosis of cancer risk based on gene analysis and cytological means
2007	elucidation of the whole aspect of signal transduction in the carcinogenesis of cells
2007	practical use of effective means to prevent metastasis of cancer
2013	medicines that prevent the development of cancer
2015	common use of medicines for dysdifferentiating carcinogenic cells

Source: NISTEP FhG ISI 1994

Current indications are that professionals are going to understand the genetic basis of disease in greater breadth and depth than ever before. There will be the ability to screen far more extensively for genetic risk, understand gene-environment interactions, and intervene to modify them. Increased knowledge will allow public health measures to be quite focused. Specific tests will become available to screen and ascertain high risk groups within the whole population in terms of genetic profile and environmental influences. This information would allow individuals to undergo interventions before triggering factors take effect and thus avoid onset of the disease. The approach would allow for prevention of disease and also development of less complex, cheaper therapy by intervening pre-symptomatically.

While there will have been success in terms of identifying the genetic basis of some diseases, particularly monogenic traits, continuous progress is not certain and may founder as the research emphasis turns to multiple gene causation, the nature of triggers, how genes interact and detailed causal chains of complicated gene-gene and gene-trigger interactions.

b) USA

In 1990, the Department of Commerce identified 12 'emerging' technologies where research had progressed far enough to indicate a high probability of technical success for new products and applications that might have substantial markets by the Year 2000 (ASTEC, 1994c). These technologies were seen to have the potential to create new products and industries with markets of substantial size. They would provide large advances in productivity, significant improvements in the quality of products produced by existing industries which supply large, important markets, or they would drive the next generation of R&D and produce spin-off applications (Box 7.7). This work considered the underlying S&T needs of these technologies, the potential markets and impediments such as engineering barriers.

The 1995 US Critical Technologies Panel biennial report identified Living Systems as a critical technology area. The Living Systems technology category includes four critical technology areas: biotechnology, medical technology, agriculture and food technology and human systems. Within these areas many specific technologies and applications were identified. For example, in medical technology, sub-areas included integrated information systems, functional diagnostic imaging, biocompatible materials and the rapid identification of bacteria and viral infectious agents and medical devices and equipment.

Box 7.7. US Critical Technologies in Life Sciences and their applications

Emerging technology	Major technology elements	Underlying Science	Engineering Barriers	Likely Markets
Biotechnology	Bioprocessing Drug design Genetic engineering Bioelectronics	Genetic engineering, molecular biology, chemical engineering, biochemistry biophysics	Difficulty in controlling processes in large scale bioreactors and making economical large scale separations. lack of measurement tool, data and knowledge to control cellular processes and to elucidate protein structure/function relationships for intelligent product and process design.	Pharmaceutical and related products: foods, flavours and fragrances, agri-chemicals, commodities and fuels, pollution abatement.

Box 7.7. US Critical Technologies in Life Sciences and their applications (cont'd)

Emerging technology	Major technology elements	Underlying Science	Engineering Barriers	Likely Markets
Medical devices and Diagnostics	Cellular-level sensors Medical imaging In-vitro and in-vivo analysis Targeted pharmaceuticals Fibre optic probes	Immunology, microbiology biology, electronics engineering	Need to design instruments for little or no invasion of the human body. Cellular level devices and diagnostics will require miniaturisation, capabilities not presently available.	Health-care, instru-mentation, pharmaceutical medicine.

Source: US Department of Commerce 1990

c) United Kingdom

The recent UK Technology Foresight study argued that work to identify genetic risk factors and their interaction with lifestyle and environment may revolutionise medicine, allowing for individual measures of risk, tailored prevention plans and better informed choice of treatment. The UK report 'Health and Life Sciences' noted that it might be possible to target sectors of the population at risk to enhance preventative measures.

A recent UK study provided an overview of perceived opportunities in the field of plant biology (CEST, 1994). A matrix using commercial attraction and S&T status as the criteria to rank technologies was developed (Box 7.8).

Group D includes the two 'core' technologies of genetic markers and hybrid production. Hybrid production and male sterility have the prospect of making genetically engineered plants more profitable for seed companies and safer for the environment. This is a science-driven sector of enormous importance in the light of the major increase in world populations and the likely increase in quality of life aspirations. It will also be important in response to the growth in demand generated by chronic and degenerative disease in the world's aging populations. The foresight study report noted that the UK will need to exploit opportunities offered by molecular genetics and bioinformatics generated by the science base in the UK and overseas.

Health and dietary considerations in the Food and Drink sector indicate probable demand for a range of new products, new ingredients and new modes of food processing. Particular priorities for the sector include: enhanced understanding of the links between diet and health; exploiting biotechnology in relation to agricultural and food products; better understanding of the impacts of food processing; the application of multivariate modelling and information systems in the organisation of production.

Box 7.8. Plant Biotechnology Groupings

Technology 'Cluster'	Technologies
A: Technically available but high competition and low consumer acceptance	3: Herbicide resistance, Viral disease resistance, Insect resistance (food crops)
B: Technically valid but consumer acceptance uncertain	5: Oils (different composition or higher content), Insect resistance (non-food crops), Starch & Sugar (different composition or higher content), Protein quality (amino acids, bread making etc.), Fruit (ripening, quality, frost resistance)
C: High research investment required and uncertain commercial value, characterised as 'Why bother?'	3: Flavours and Fragrances, Bacterial disease resistance, Fungal resistance
D: 'Core technologies'	2: Genetic markers in breeding – for efficient breeding and rapid gene identification, Hybrid production (self incompatibility and male sterility) – for commercial importance to safeguard germplasm and eliminate farm saved seed
E: High crop yield technologies and specialty products and applications requiring a high level of R&D investment, characterised as 'Dreams of future profits'	9: Photosynthesis efficiency improvement, Fibres (timber, textile), Flowers (structure, colour, brightness, timing, aging), Drought, flood and salt tolerance, Structure (height, branching, leaves, roots), Nitrogen fixation and nutrient uptake (Nitrogen, Phosphorus, Potassium, Sulphur and micro-nutrients), Specialty Enzymes, compounds and medicines, Cold/heat resistance, Heavy metal uptake and accumulation (bioremediation)

Source: CEST, 1994.

There is growing interest in very small scale 'nano-technology' and its use in the production on 'bio-electronic' devices. These have potential as bio-sensors for detecting clinical parameters, or pollutants, or in monitoring industrial processes including food production, and rapid progress in development is expected in the next five years. However, nano-technology is not expected to have a major impact on mainstream electronics until around 2010.

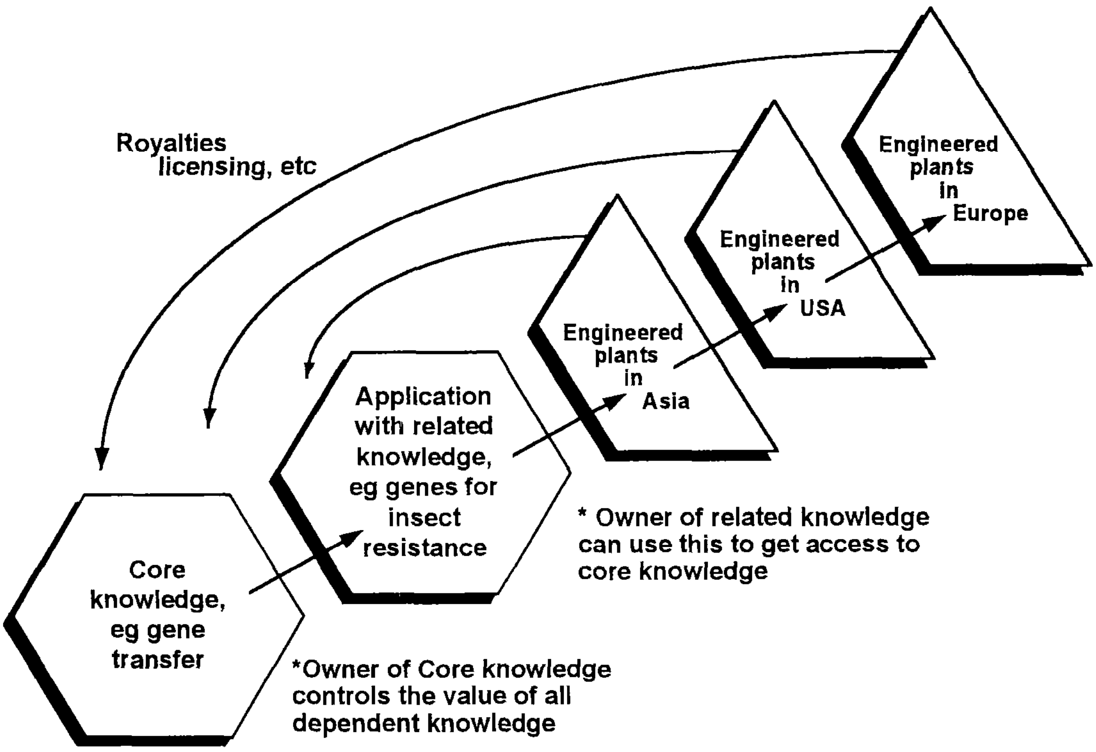
7.5. A Key Target for Australia to 2010: Finding our Place in an Emerging Global Industry

What is Australia's position in this global revolution in S&T related to biology? While Australia is a nation with a relatively small economy and cannot expect to be a leader in all areas of S&T, it must be positioned to take advantage of developments of potential value where it has recognised strengths.

Australia has significant strength in its biotechnology science base as revealed in a bibliometric analysis (Bourke and Butler, 1995). While in overall terms we are very small players in the global scene Australia accounts for 2-4% of all new knowledge in this area – a relatively high proportion. We have the scientific capabilities within the CSIRO, higher education institutions and some fledgling companies to be among the world leaders in a few targeted areas. Clearly, it is important that Australia realises opportunities provided through such high quality scientific expertise and knowledge.

ASTEC identified one major concern a ownership of the current work in this area. Do we have appropriate structures in place to maintain control over the technology we do develop? While the long-term strategic importance of control of our own technology is not immediately apparent, in biotechnology whoever owns (eg through patents) the core biotechnologies has effective control over all applications (Box 7.9).

Box 7.9. Biotechnology Related Knowledge and Core Knowledge



Source: Clarke 1995

Techniques for transferring genes into plant or animal cells are regarded as core technologies as every new engineering application requires a licence from the owner of gene transfer technology and the terms of the licence are of course set by the owner. If Australia owns neither any part of the core technologies (eg gene transfer) nor the genes to be transferred, we have to licence all the knowledge. This may be a disadvantage in the rapidly evolving early commercialisation stage of these technologies that is underway. Effective control over some key technologies will help to guarantee access to other technologies, including those that complement Australian technology. This will lead to greater possibilities for the development of an internationally competitive biotechnology sector in the longer term.

At present ownership of some of the technologies is being fought through the courts in both the US and Europe in disputes involving the major international chemical companies. The intensity and scale of these disputes indicates the importance the companies place on rights to the technologies.

Australian biotechnology is developed usually through a multi-national company or through small start-ups. Outside the mining sector there are very few substantial Australian-controlled entities with an in-house R&D capability, even fewer with an interest in biotechnology. With multi-national companies headquartered outside Australia, it is important to retain control of ownership of our inventions and work towards mutually beneficial agreements.

As in many other knowledge-intensive areas, Australia must develop strategies to provide direct control by Australians of at least some of our new discoveries in the field of biotechnology. This will help to ensure that we have a 'place at the table' and a bargaining position to provide access to related technologies on reasonable terms. It can be argued that this will allow us to derive benefits from technologies we own and which are used by firms in other countries through multiplier effects.

Ownership of core biological technologies is particularly important to Australia's continuing future as a major exporter of agricultural products. Failure to own key emerging technologies may restrict the value that Australia can derive from its agriculture base and thus exert control over our future development.

7.6. Conclusions

Technologies capable of allowing humans to alter biological systems are growing rapidly; they have important potential benefits commercially and for our quality of life. Yet they present many challenges and possibly potential dangers.

Issues of ownership are critical to creating a long-term future for Australia in this dynamic and important global industry. Australia needs to develop and retain fundamental intellectual property in technology. This will be a big challenge given the structure of Australian industry.

The Human Genome Project has the potential to provide valuable information for the detection and treatment of medical disorders. It is important that Australia be involved in such leading-edge international projects to gain and maintain access to the associated intellectual property. Recent initiatives for Australian participation in the Human Genome project will contribute to this.

Australia has considerable research strength in genetic and biological science areas. It is important to build on this strength by developing a capacity to commercialise the results of research. The Australian industry is small and fragmented, and networking of businesses and research should be encouraged to help build productive new collaborations. Current efforts to achieve this should be continued.

However, genetic and biological technologies challenge many fundamental aspects of the relationship between individuals, society and the environment. The widespread concerns expressed to ASTEC by people across Australia reflect this.

The way in which such technologies are developed and introduced must attend to such concerns if we are to realise the potential of these technologies in the longer term.

Commonly presented arguments in favour of fast development focused on the areas of communication between science and industry, and the public, and on means to develop an informed public 'acceptance' of the new technologies.

But, as illustrated by ASTEC's consultations, the community expects much more. There is a fundamental need to open up the processes and consequences of advances in biological technologies to public scrutiny. In particular there is a perceived need for open and ethical processes for decision making and experimentation.

For example, young people consulted by ASTEC were one of the groups most strongly aware of the potential hazards. However, they may not be aware of the safety provisions for publicly funded scientific research under the voluntary Genetic Manipulation Advisory Committee arrangements.

The S&T system needs to take community concerns into account as a long-term issue. Two-way, rather than one-way communication needs to be the focus. Australia needs to ensure that it develops the basis for practical implementation and use of the new technologies in the long-term. This requires addressing not only technical issues but also social, ethical and environmental questions.

There are high potential costs if we do not looking ahead in these areas. For example, years of research resources could be wasted if an eventual application is unlikely to be approved for ethical reasons. Further, looking to future scenarios, as more genetically modified organisms are released into the environment, the probability of accidental and unforeseen consequences, such as severe environmental impacts, may rise. If such events do occur they will further reduce the community's trust of S&T experts and the technologies. In the extreme, reactions against such events may halt the realisation of many potential benefits from the technologies.

The biological revolution will take many decades to mature and community fears are expected to continue, it is therefore more efficient and less divisive for our society to face these issues 'head on'. A key future need is for the S&T community to build and enjoy the trust of our whole society in the long-term.

An important element of building this trust is to address ethical issues in an accountable way and treat them as an equal priority to S&T developments in areas such as human genetic screening and eventual treatment. Australia needs a consistent framework within which to do this. It might be appropriate, for example, to consider the inclusion of a compulsory ethics component in biology-based S&T university programs.

Much of the current regulation and rules of conduct are based on voluntary codes and ethical decisions made by small groups of experts. Others provide different entitlements for Australians in different states. A perception was expressed that these processes are too separate from broader society, which has had only a limited ability to influence them, so they have the required level of security and trust has not yet been built.

A Parliamentary inquiry into the development, use and release of genetically manipulated plants, animals and micro-organisms recommended a mandatory, legislated, regulatory regime, with a wide range of penalties for breaches. This might include uniform State and Federal legislation (HoR 1992c).

ASTEC considers that Australia needs to develop a national regime for genetic and biological technologies that is, and will remain in the longer term, 'world best practice' in its ability to take account of the breadth of issues. This should be supported by appropriate Government legislation and regulatory guidelines or controls.

Area for Action:
Advances in Biological Technologies

ASTEC considers it necessary to continue building on Australia's international position in genetic and biological technologies, by developing a coherent strategy and regime for the purposeful development and application of these technologies.

This will require an integrated national strategic approach to the development and use of biological technologies in the private and public sectors, and requires the involvement of Commonwealth and State governments in close consultation with industry, scientists and the broader community.

Priority Action for the Commonwealth Government – 3

ASTEC recommends that as a priority the Ministers for Science and Technology, Health and Family Services, and the Environment, in conjunction with State governments and other relevant Agencies take action to:

- as a matter of urgency, establish a Task Group to coordinate the development of national guidelines related to ethical, environmental and equity issues arising from biotechnology developments and, in particular, for genetic testing and eventual treatment of humans and the use of personal genetic information;
- ensure the efficient development of new markets for biologically engineered products, by developing agreed national safety regulations and procedures, including product labelling, and seek to establish a suitable regulatory environment across all States and Territories;
- develop and implement temporary support for the creation of effective commercially-oriented networks within the Australian biotechnology research and industry sectors, with a view to identifying and removing impediments to the development and commercialisation of Australian technology; and
- ensure ongoing support for Australian participation in high priority international initiatives, eg the Human Genome Project, and for the development of S&T and biological industry links within the Asia-Pacific region.

Part C: Impacts of the Key Forces for Change

ASTEC identified four Key Forces for Change for Australia to 2010 – *Global Integration, Applying I&CT, Environmental Sustainability* and *Advances in Biological Technologies*. What are the implications of these for Australia? How might they interact to produce new drivers for change? How can S&T contribute to shaping an effective response?

- Will there be changing rules of competitiveness for Australian industry?
- What will governments need to do to shape this new world?
- What will be the impacts on the Australian community and how can S&T build a stronger, more equitable community?

The following four chapters consider how the combined impacts of these forces could shape the future in profound ways and explores how S&T can contribute to responses from three points of view – government, industry and the broader community. They examine the interplay between the forces for change and how they can be managed in a constructive way.

Chapter 8 takes a sectoral approach to innovation and the changing rules of competitiveness. It identifies some of the drivers, long-term issues and constraints to innovation and growth. S&T will be an integral part of effective strategies to manage the changes ahead and it is important to consider the specific ways it can contribute to the achievement of goals.

Chapter 9 investigates export opportunities, particularly in the Asia-Pacific, and identifies a range of longer term challenges for industry which suggest it will be critical to develop targeted strategies to detect, respond to, and shape the four Key Forces for Change.

Government responses to Key Forces for Change highlight the need to adapt to changing roles to meet the challenges of the 21st Century (Chapter 10). And broader community concern need to explore how S&T can reduce inequities between various groups in Australian society (Chapter 11).

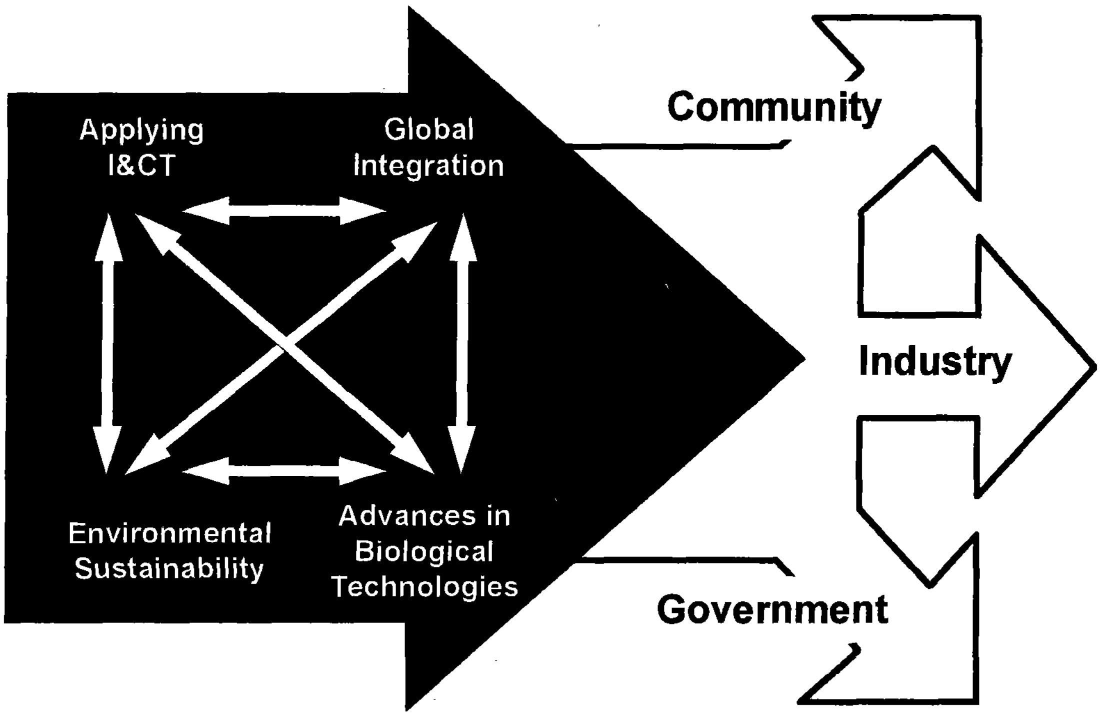
The Key Forces for Change are a useful tool to consider the future from many different perspectives. Readers may wish to consider how this information could be used to help manage the future of their organisation more successfully.

Chapter 8.
Impacts for Industry – Changing Rules of Competitiveness

8.1. Introduction

The combined impacts of the Key Forces for Change will pervade industry, government and the broader community. However, the importance and uncertainty of specific impacts will vary according to one's viewpoint (Box 8.1).

Box 8.1. Combined Impacts of the Key Forces for Change



Source: ASTEC

This chapter explores some of these combined impacts from the viewpoint of specific industry sectors. It examines the role of innovation and foresight in meeting future challenges and reviews long-term issues, constraints and drivers for particular sectors identified by international foresight experience.

In emphasising four Key Forces for Change ASTEC sought to simplify major issues as an aid to approaching the uncertainty of many possible futures. This helps to build an understanding of the directions of change and allows the identification of indicators, or weak signals of change. Such forces can become major elements in the construction of scenarios. Scenario planning, however, requires a focal issue or decision. This chapter, taking industry sectors as a focal point, highlights the potential value of foresight for industry, in particular industry associations and groups.

8.2. Foresight Complements Innovation

Managing the future requires managing uncertainty over time. Winners in the 21st Century will be those who find ways to manage risks and cope with uncertainty. This applies to individuals and small firms as much as it does to governments and global companies. Yet recent reports suggest Australians are not good at risk management. The Karpin Task Force noted one study of Asian businessmen rated Australians worst amongst a group of key countries in entrepreneurial and risk management skills (Karpin, 1995).

Innovation is a crucial yet uncertain process. An innovator needs to be willing to look ahead with confidence to make strategic choices and investments today in anticipation of uncertain future returns. Foresight can be of value to innovators by exploring critical uncertainties and possible developments in key variables. This helps develop strategies to cope with divergent outcomes and sensitise an organisation to recognise signals of possible changes in the world, thus enabling quick and appropriate responses. Foresight methods can help articulate the different pathways that might exist to the future and identify appropriate actions for each path.

Responding to new needs and opportunities requires innovation and entrepreneurship. ASTEC identified the need for innovation and entrepreneurship as a Key Issue for 2010 and strongly supports government action in this area.

ASTEC's discussion paper for the June 1995 Prime Minister's Science and Engineering Council considered options for government action to deliver Australia's future through innovation (ASTEC 1995g). It identified a series of emerging challenges for Australia's national innovation capacity to 2010 to:

- shape Australia's long-term opportunities;
- manage risk and uncertainty to grow new businesses;
- support the technologies of tomorrow;
- create infrastructure for national and global networks;
- enhance R&D in government enterprises;
- educate innovative managers for the 21st Century; and
- deliver on regional leadership in 2010.

Views of innovation, and innovation processes themselves, are evolving. New technological developments and new concepts for managing S&T are augmenting and changing the practices of successful innovators.

Innovation is a profoundly disruptive and uncertain process. Changing techno-economic paradigms such as that being wrought by the key force of Applying I&CT are genuinely 'revolutionary'. The immense social and economic transformations which occur during each new techno-economic paradigm, described by Freeman and Perez (1988), involve:

- a new 'best-practice' form of organisation in the firm and at the plant level;
- a new skill profile of the workforce, affecting both quality and quantity of labour and corresponding patterns of income distribution;
- a new product mix, with new technologies representing a growing proportion of Gross Domestic Product;
- new trends in innovation (both incremental and radical) as substitution of the new factors occurs;

- a new pattern of location of investment both nationally and internationally as the new factors change comparative advantages;
- a new wave of infrastructure investment to encourage diffusion of new technologies;
- a new wave of entrepreneurship and small, start-up firms in new technologies and industries;
- a tendency for large firms to concentrate – by means of growth or diversification – in the new factors; and
- a new pattern of consumption of goods and services and new types of distribution and consumer behaviour.

Just as these transformations have occurred in the past, they are strongly in evidence at present. These changes might be expected to characterise many of the new businesses at the beginning of the 21st Century. Indeed, firms that don't adapt to these new patterns may not survive.

Rothwell suggests the passage of several 'generations' of innovation relates to changes in concepts underlying the thinking of innovators and the practices they use (Rothwell, 1994). We are now seeing the emergence of a 'fifth generation' innovation process and expect wider use of this model by successful innovators over the next 15 years. The characteristics of this process largely reflect the paradigm shift driven by the Key Force of applying I&CT. They reflect the tighter integration of information management and systems with innovation (Box 8.2).

Box 8.2. The Fifth Generation Innovation Process – Systems Integration and Networking

Underlying Strategy Elements:

- time-based strategy (faster more efficient product development);
- development focus on quality and other non-price factors;
- emphasis on corporate flexibility and responsiveness;
- customer focus at the forefront of strategy;
- strategic integration with primary suppliers;
- strategies for horizontal technological collaboration;
- electronic data processing strategies; and
- policy of total quality control.

Primary Enabling Features:

- greater overall organisational and systems integration,
  - — cross-functional links, involvement of suppliers and leading edge customers in product development, appropriate horizontal collaborations;
- flatter more flexible organisational structure for rapid and effective decision-making,
  - — empowerment of project leaders and lower level managers;
- fully developed internal databases,
  - — linked computer-aided design (CAD) and engineering systems, effective data sharing, computer assisted product development; and
- effective external data links,
  - — co-development to suppliers linked CAD, CAD at customer interface, data links to R&D collaborators.

Source: Rothwell 1994

An important characteristic of the fifth generation innovation process is the emphasis on interacting through efficient networks and linkages. This is now a criterion for high achieving firms, so that the most innovative new firms have well developed linkages with leading edge customers, suppliers, R&D providers and other firms in their industry (AMC/McKinsey, 1993).

Few small and medium-sized enterprises (SMEs) have the resources to seek out and understand the many technological developments of direct relevance to their business. SMEs can benefit from becoming involved in processes to develop networks where information is shared. A key aspect of the development of linkages, particularly relevant to Australia, is the quality of links between the public and private sectors. We have many world-class researchers in the public sector. But to fully develop our innovation potential we need to open up communication and exchange between research providers and users.

Linkages will also become more common across national borders. The emerging global nature of technology issues and the phenomenon of 'techno-globalism' create a need to consider 'new rules of the game'. Increasingly, localised concentrations of competitive companies lead to networks of sub-contractors supplying specialised labour or components.

Developing perspectives on the future can help identify potential innovation opportunities at the heart of an enterprise's future. Astute investments and creative changes today are required to sustain and develop tomorrow's business success. Organisations are often focused on the day-to-day and in this mindset new technology is limited to problem solving objectives. But innovation is more than problem solving. In a culture of innovation people perceive future possibilities and bring about concerted action to make their ideas and visions a reality.

The strategic approach of looking outward and forward, and thinking about what customers and clients might need tomorrow, is critical. While external forces such as the Key Forces for Change, are not the sole drivers of innovation, they often stimulate novel responses.

The perspective of foresight, like that of innovation, is of the future. It provides a vehicle for people to see new possibilities, to share ideas about possible futures, acting as a catalyst to break the cycle of short-term thinking and enrich the mental maps of participants and managers. Foresight also provides a framework against which innovation-based investment decisions can be assessed. It provides systematic methods to help people perceive the potential of new technical developments and develop a greater understanding of market needs and potential demands. It explicitly highlights uncertainties and novel ideas and brings people together in potentially highly productive combinations. Importantly, the use of scenarios allows innovators to assess their innovations in a number of possible future market and technology contexts. This can provide for more flexible approaches, including, at one extreme, the option of withdrawing from a project to avoid costly mistakes.

ASTEC's initial consideration of innovation took a cross-sectoral approach (ASTEC 1995g). However, international foresight exercises have emphasised that long-term science and technology issues and constraints have considerable variation between sectors. The issues are complex and impinge on the strategies and possibilities for innovation, the adoption and use of technology and long-term competitiveness.

This study emphasises over-arching Key Forces for Change, but it is important to recognise the finer levels of concern in foresight analysis. There are variations in the impacts of driving forces between sectors, and firms, which have specific products, will take an even more detailed view. Using foresight methods as a means of enhancing competitiveness requires detailed understandings of the specific technologies and operations within individual firms or industry sectors, and of their markets. The development of 'industry foresight' in Australia has great potential to assist innovative projects by providing the framework for strategies that compete *for* the future (Box 8.3).

Box 8.3. 'Seeing the Future First' – The Quest for Industry Foresight

Hamel and Prahalad suggested that managers spend far too little energy, perhaps only one or two per cent of effort, looking outward and forward and forging a long-term well-tested view of the future of their industry.

Industry foresight can be considered as a race to get to the future first, by gaining an understanding, deeper that competitors, of the trends and discontinuities – technological, demographic, regulatory, or lifestyle – that could be used to transform industry boundaries and create new competitive space.

Contrary to current management fashion, they point to dangers in being too customer-led, because it hinders identifying unserved customers or unarticulated customer needs. They suggest that 'customer-leading' strategies are critical to future competitiveness – leading customers where they want to go but don't know it yet.

However, developing industry foresight is not a trivial or short term project, it requires effort measured in weeks and months, not hours and days. It requires managers to reconceive their firm and the industries within which it competes.

Source: Hamel and Prahalad 1994

Foresight can contribute to competitiveness by its attempt to capture the dynamics of change and placing today's decisions into a context that includes the possible developments of tomorrow. The Key Forces for Change are four key dimensions of uncertainty that firms will need to manage towards 2010.

8.3. Sectoral Variations in Key Forces for Change

Key Forces for Change will have different impact on various sectors. For example, large physical scale industrial activities, including some based on natural resources, are likely to be more strongly influenced by the need for environmental sustainability. That is, a greater impact on mining, agriculture and large scale manufacturing (eg petrochemicals). Of these, biology-based technologies might be more important for Australia's food and fibre based production and value added sectors, whereas improvements in I&CT leading to advanced management systems could have great impact on larger enterprises regardless of whether they are resource based. I&CT will also facilitate the development of networks among small and medium-sized enterprises (SMEs) and the diffusion of best practice.

Long-term issues facing particular sectors were reviewed by the UK Technology Foresight exercise. The following analysis compares each of the ASTEC Key Forces for Change with the long-term issues identified for various sectors in the UK study. The long-term issues which emerged in the UK study are broadly similar to those identified in the Australian consultations. They are a starting point to assess which of the Key Forces for Change might be most important to particular sectors as they provide a focus on broad trends.

Global integration has brought a profound shift in the paradigm governing international competitiveness through shifts in trade and production patterns. It is changing the competitive environment for industry creating long-term issues for more industry sectors than any other Key Force for Change (Box 8.4).

Box 8.4. UK Technology Foresight Long-term Issues – Strong Links to Global Integration

Sector	Long-term Issues identified for the UK
Agriculture, Natural Resources and Environment	• Food imports from ever-widening sources: increasing world competition in agriculture
Chemicals	• Meeting the challenges of a global market and global competition
Construction	• Cost reduction and international competitiveness: responding to world demographic change
Energy	• Environmental concern – emissions, global warming, nuclear risk, renewables, waste
Manufacturing, Production and Business Processes	• Continuing internationalisation of business • Increasing rate of improvement to catch up with foreign competition
Transport	• Export opportunities for UK solutions
Communications	• Regulatory regime and barriers to trade
Financial Services	• Greater choice of financial products
Information Technology and Electronics	• Maintaining or increasing the UK's share of global markets • Attracting investment to the UK in competition with the Pacific Rim countries
Leisure and Learning	• The regulatory framework in relation to product market changes
Retail and Distribution	• The expansion of global retailing
Defence and Aerospace	• Uncertainty about global security developments

Source: UK OST 1995b

Applying I&CT is driving and enabling many changes in the organisational and work structures and culture of Australian businesses. Such is the ubiquitous nature of I&CT that applications can be found not only within the I&CT sector eg in developing creative and competitive software, but also in developing services and in 'smarter' manufacturing. Important long-term issues identified in the UK (Box 8.5) emphasise the emerging impacts of I&CT across a large number of sectors.

Box 8.5. UK Technology Foresight Long-term Issues – Strong Links to Applying I&CT

Sector	Long-term Issues identified for the UK
Transport	• Impact of information technology (IT) and telecommunications on transport market
Communications	• IT literacy of the UK population and the technical skills base for the communications industry • Technology advances in the key areas of digitalisation, broad-band networks, mobility and intelligent networks
Financial Services	• Impact of multimedia • More sophisticated customer profiling by advanced computing • Cheques replaced by smart cards and electronic cash
Information Technology and Electronics	• Capitalising on the UK's artistic and creative strengths in the content-based information industries • Raising the IT awareness and proficiency of students and teaching staff • Retaining access to leading edge technologies, eg displays and silicon
Leisure and Learning	• Development of hybrid technic-artistic-commercial skills • Impact of new technology on education and informational leisure markets • Equal access to educational distance learning hardware and software
Retail and Distribution	• The expansion of remote retailing over the information Superhighway • The merging of leisure with retailing and retailing with financial services • The impact of IT on the further de-humanisation of retailing
Food and drink	• Further use of IT, computer modelling and automation, in production and distribution • Communication of technological risks and benefits to consumers
Health and Life Sciences	• IT in medicine and the life sciences

Source: UK OST (1995b)

Demands for environmental sustainability will have an impact on product design and other aspects of marketing, but they will also impact on the internal operations of firms through the introduction of cleaner production processes. Community pressure for tighter environmental regulations are likely to alter the competitive environment for firms. The UK Foresight study reveals long-term environment issues are particularly important in the 'Agriculture, Natural Resources and Environment' sector but also affect a number of other sectors (Box 8.6).

Box 8.6. UK Technology Foresight Long-term Issues – Strong Links to Environmental Sustainability

Sector	Long-term Issues identified for the UK
Agriculture, Natural Resources and Environment	• Increasing diversity of farm production and farming activities (Non-food farms) • Legislation promoting pollution control and sustainable use of the environment will affect all economic and leisure activity • Continued growth in 'Environmental industries' (treatment plants, clean processes, monitoring and consultancy) • Environmental drivers for reusable, recyclable materials and products)
Chemicals	• Meeting environmental requirements and taking advantage of environmental opportunities
Construction	• Environmental and social trends and pressures
Energy	• Environmental concern – emissions, global warming, nuclear risk, renewables, waste • Energy efficiency – public attitude
Manufacturing, Production and Business Processes	• Increasing influence of regulation and legislation
Transport	• Environmental regulation • Business access and mobility with transport capacity and environmental constraints

Source: UK OST (1995b)

The next 15 years will see an increasing exploitation of biological processes to develop new products for, among other things: human and animal health, agriculture, food and nutrition, energy-efficient processes, biomass energy and environmental conservation and rehabilitation. Some estimate that the biotechnology industry will reach sales of $50 billion in the US by 2000. Developing the conditions for profitable adoption and development of biological technologies will require significant investments in new capital, both human and equipment. Long-term issues linked to genetic and biological technologies identified in the UK foresight program related mainly to the 'Food and Drink; and 'Health and Life Sciences' sectors (Box 8.7).

Box 8.7. UK Technology Foresight Long-term Issues – Strong Links to Genetics and Biological Technology

Sector	Long-term Issues identified for the UK
Food and drink	• Exploiting food raw materials and ingredients from novel sources and by advanced biotechnology
Health and Life Sciences	• Aging populations • Exploiting the opportunities offered by molecular genetics

Source: UK OST (1995b)

8.4. Linkages between Key Forces for Change

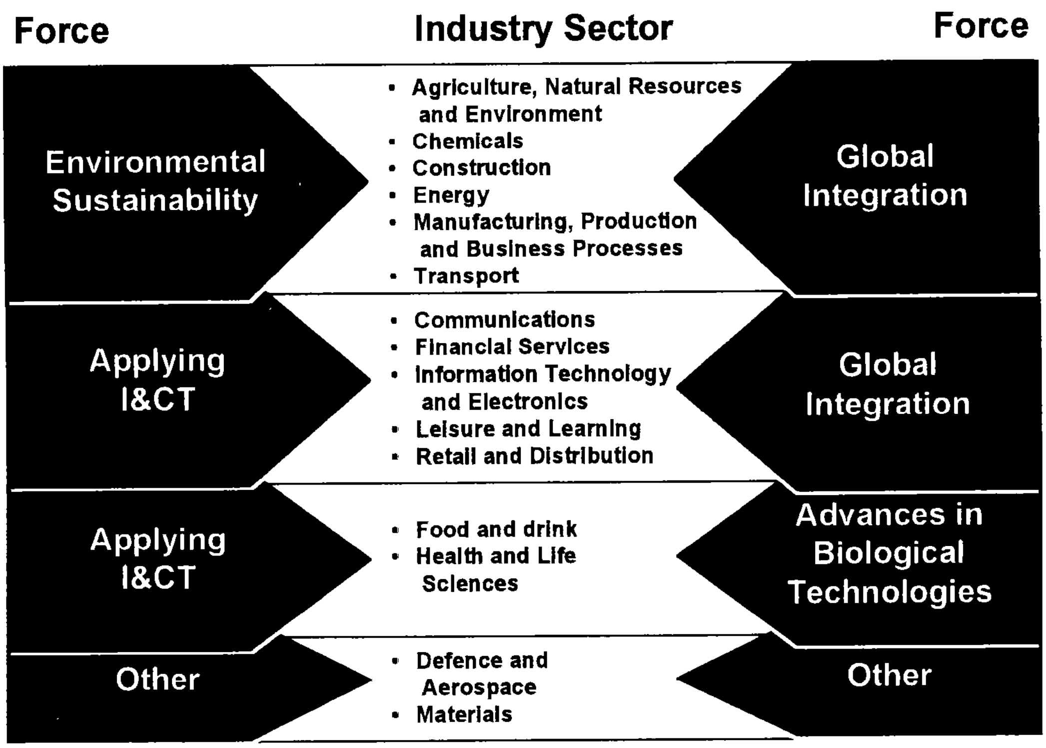
The Key Forces for Change are not four distinct dimensions: they are interlinked. It is their interaction which is likely to shape the future in profound ways. For example:

- global exchanges, experienced through increased international tourism and higher levels of trade increases the risk of exotic organisms entering Australia and impacting on our unique Australian environment. I&CT is a major tool to track such movements and develop management strategies, and biotechnology is already being used to respond to some historic problems in this area;
- improved information infrastructures can contribute to a reduction in environmental damage by reducing the use of paper, reducing traffic through teleworking, and increasing the efficiency of traffic flows through the use of traffic information systems;
- global linkages and I&CT help to create new forms of business organisation, where production processes can be integrated across national boundaries through networks that influence how businesses interact with their markets, suppliers and competitors. greater precision in managing resources allows organisations to be more efficient, thereby reducing impacts on the environment; and
- global knowledge in biotechnology and I&CT can be combined to produce new developments in bio-sensors and bio-electronics.

ASTEC identified four broad groups strongly influenced by the combination of two Key Forces for Change (Box 8.8). The most significant combined impact of *Environmental Sustainability* and *Global Integration* are on sectors related to primary production and manufacturing; whereas *Applying I&CT* and *Global Integration* are likely to have greatest impact on the services sector; and *Applying I&CT* and *Advances in Biological Technologies* on food and drink, and health and life sciences sectors. The analysis of long-term issues did not identify any sectors in the UK study which were particularly impacted on by the combination of *Environmental Sustainability* and *Advances in Biological Technologies*, although it is possible to conceive of activities for which these two forces would be the fundamental drivers.

Long-term issues related to the sectors of Defence and Aerospace and Materials did not relate directly to ASTEC's Key Forces, of course, these industries are very limited in Australia. For example, in the Defence and Aerospace sector, major long-term issues were defence procurement policy, business process re-engineering employed as a competitive weapon, and competitive funding of R&D.

Box 8.8. Key Forces for Change Influencing Long-term Sectoral Issues



Source: ASTEC

8.5. Key Sectoral Drivers and Constraints to Future Developments

The UK foresight study explored, for each of 15 different sectors, drivers for change and constraints on development. These two give some idea of the 'push' and 'pull' on various sectors which, although not totally transferable to the Australian situation, provide an excellent starting point.

There are likely to be many similarities between the UK findings and the Australian situation. Global markets and the similarities between the technological requirements of sectors (eg as measured by R&D intensity) indicate that many essential sectoral features will be shared around the world. A summary of the UK analysis of sectoral drivers and constraints is provided here to demonstrate how sectors differ in their receptivity and response to change.

a) Sectoral Innovation Drivers

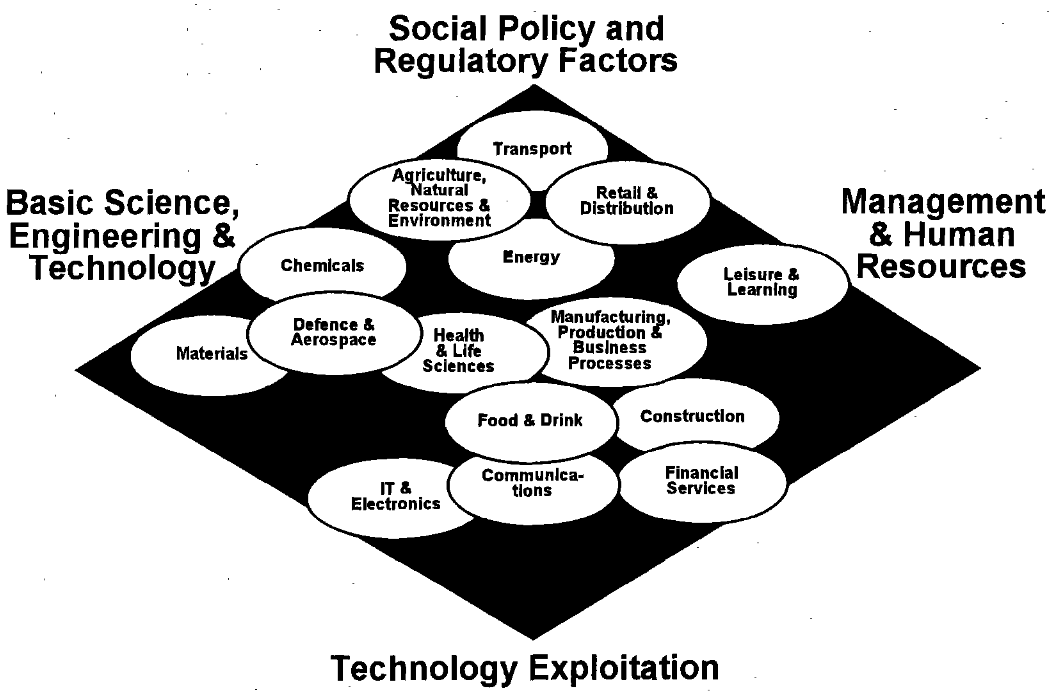
New advances in science, technology and engineering are important to all sectors; but all sectors have other important drivers. In Agriculture, Natural Resources and Environment for example while regulatory, social and economic policy factors are likely to be the main drivers, advances in scientific understanding of the processes of environmental change will be fundamental.

The UK foresight study identified four broad groups of sectors – defined according to where the principal, although not exclusive, sectoral drivers to international competitiveness operate. This framework helps to identify where the main strategic thrust for each sector lies. It is not intended to oversimplify the range of actions required (Box 8.9).

The four groupings of sectors are:

- *Chemicals, Materials, Defence and Aerospace*, and *Health and Life Sciences* driven mainly by advances and investment in basic science, engineering and technology;
- *Information technology (IT) & Electronics*, *Communications*, *Food and Drink* and *Financial Services* driven mainly by an ability to exploit already foreseeable advances in S&T and secure pull-through into internationally competitive products and services;
- *Transport, Energy, Retail and Distribution*, and *Agriculture, Natural Resources and Environment* driven mainly by the stimulus provided by political, social and regulatory environments; and
- *Manufacturing, Construction and Leisure and Learning* driven mainly by investment in human resources – developing new skills and deepening understanding of business processes and consumer preferences eg by investment in relevant areas of science, engineering and technology.

Box 8.9. UK Foresight: Sectoral Drivers



Source: UK OST 1995b

b) *Sectoral Innovation Constraints*

Identifying constraints is an important feature of foresight work. It is most formalised in the Delphi technology 'forecast' survey process. In these surveys views are sought, among other things, on the relative importance of constraints to the realisation of the prospective innovations (also known as topic statements) listed.

The two most recent Delphi surveys, UK (UK OST 1995 various) and Japanese (NISTEP 1992), differ slightly in their categories of constraints, however there are broad similarities.

Both these Delphi foresight studies consider social, technological, economic, institutional and educational constraints, but explore slightly different aspects. This depends on cultural factors and the specific objectives of the foresight study which influence the type of information being gathered. For example, the Japanese category of 'Economic constraints: Market competitiveness' was expanded in the UK study to two categories: 'Economic viability' and 'Industrial / Commercial factors inhibiting development'. A comparison of the UK and Japanese Delphi survey constraint categories is shown in Box 8.10.

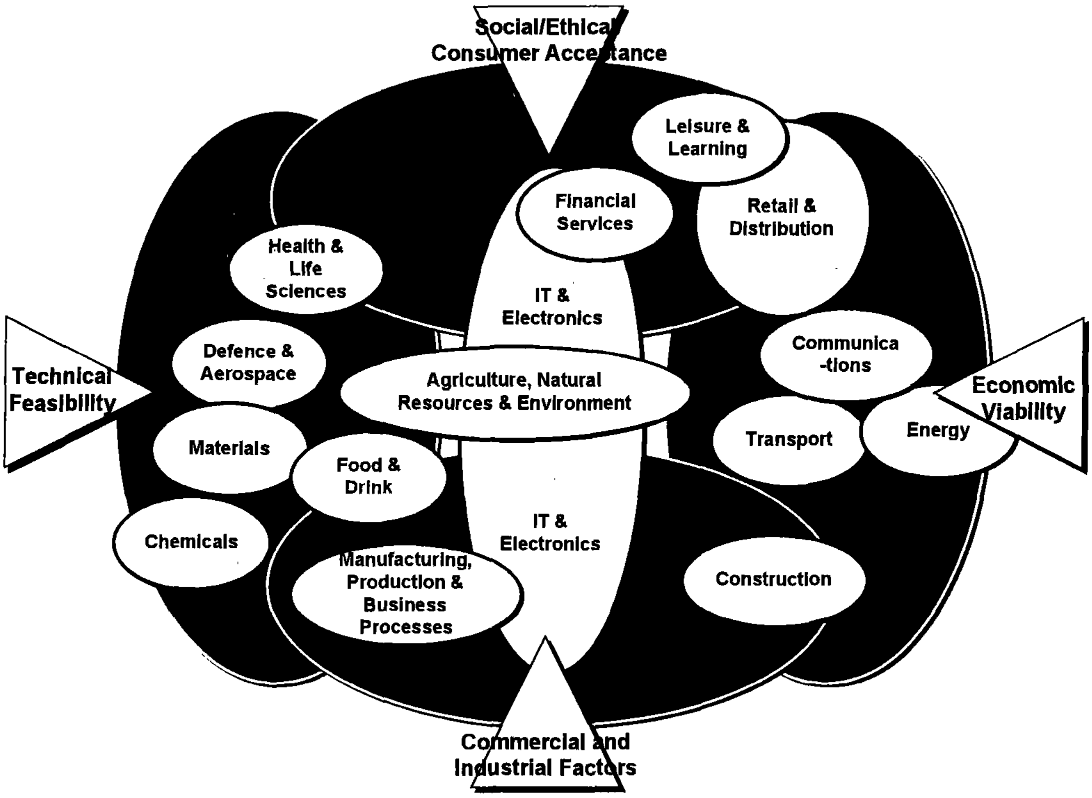
Box 8.10. UK and Japanese Delphi Survey Constraints

Category Area	UK Technology Foresight	1992 NISTEP Delphi
Social	Social / Ethical acceptability: including cultural constraints and constraints arising from general public attitudes or pressure groups	Cultural: including the sense of values of society, cultural and climate factors
Technological	Technological feasibility: the technology is theoretically possible, but development is likely to prove difficult or risky	Technical: various technological factors are difficult to resolve
		R&D system: including interactive cooperation between research organisations or researchers
Economic	Lack of funding: availability of investment capital or research funds	Funding: insufficient funding
	Economic viability: unsatisfactory return on investment	Cost: including costs for reinforcing market competitiveness or for opening up markets
	Industrial / Commercial: includes the possibility that competitive circumstances (eg dominant producers, attractive substitutes) inhibit development	
Institutional	Regulatory / Policy / Standards: includes the establishment of international and national standards, intellectual property rights and measurement policies	Institutional: including restrictions placed by law and regulations or unimproved standards
Education	Educational / Skill base: the practical and professional skills required to adapt and develop technology and markets	Fostering/securing human resources
		Others

Source: ASTEC

The UK study rated the relative importance of the categories of constraints listed above for all sectors. It found that institutional and educational constraints were not prominent for any sectors. Four constraints emerged as particularly significant: Economic viability; Technical feasibility; Social/Ethical/Consumer acceptance; and Commercial and industrial factors (Box 8.11). Two of these – Economic viability and Commercial and industrial factors – relate to economic variables which were clustered together in the Japanese Delphi survey.

Box 8.11. UK Foresight: Broad Constraints on Sectoral Development



Source: UK OST 1995b

The UK study reveals considerable variations in the predominant constraints for particular sectors. While most sectors are strongly influenced by one set of constraints, three sectors – Retail and Distribution, Construction and IT and Electronics – fall within two groups. One sector – Agriculture, Natural Resources and Environment – does not correlate strongly with any group, but falls within 'technical feasibility constraints' more than any other.

Group 1 – Economic Viability

Energy, Communications, Retail and Distribution, Construction and Transport face strong economic viability constraints, with the realisation of Delphi topics mainly constrained by economic viability, or unsatisfactory return on investment.

Costs were considered to have a decisive impact on these sectors, which involve major infrastructure investments and large scale 'replication' of technologies. The UK study suggested that research in these sectors might therefore focus on reducing the cost of major investments and of widely replicated technologies. These sectors are also strongly influenced by Regulatory / Policy / Standards constraints, especially communications and energy, for example by affecting the likely return on investment and the environmental standards they must meet.

Group 2 – Technical Feasibility

Chemicals, Health and Life Sciences, Defence and Aerospace, Materials, Food and Drink, and Agriculture, Natural Resources and Environment face strong technical feasibility constraints, or the level of technical risk and difficulty, to the realisation of the innovations suggested in the survey.

The UK Steering Committee considered that these sectors have a number of common characteristics: many diverse products, comparatively small investments in standardised infrastructure, and competitive advantage in new technology products. The diversity of products leads to a heavy demand for applied research; and because of the competitive advantage provided by technology these sectors are important exploiters of a wide range of basic research results. In these sectors technical networks between industry, academia and government laboratories are important to provide the advanced techniques and knowledge to solve complex technical problems. Technology 'demonstrators' were suggested as a way to reduce technical risk in these sectors.

Group 3 – Social and Ethical Acceptance

Leisure and Learning, Retail and Distribution, Financial Services, and Information Technology and Electronics face strong social / ethical acceptability constraints from cultural attitudes and pressure groups where the 'social and ethical acceptability' were considered particularly important.

It was suggested that this type of constraint requires research to innovate and understand the potential social value of future products and services, especially to assess the likely social benefits and costs. In these sectors I&CT is a pervasive driver of change: there is an abundance of new information technology, but the issues are primarily how to exploit it, and what further technology is needed to make 'information' more useful.

The UK study suggested that research in these sectors should be aimed at understanding the human dimension of information technology. For example, how information will be used, how to make its use easier, more attractive and more effective. The use of pilot projects will be valuable to understand and demonstrate new information-based products and services, to understand cultural and artistic issues, nationally and internationally, and to develop user acceptance. Constraints from Regulatory / Policy / Standards were also significant (especially in Financial Services) and governments need to ensure that regulation anticipates change, avoids creating inertia and influences regulation and standards in other countries.

Group 4 – Commercial and Industrial Factors

Information Technology and Electronics, Manufacturing, Production and Business Processes, and Construction face strong industrial and commercial opportunity constraints where competitive circumstances might inhibit the realisation of the Delphi topics.

In these sectors, market structures were considered important. There are companies with leadership positions in markets, technology or manufacturing leadership who are able to control and shape future markets and products. There may also be strongly entrenched technologies and substitutes that inhibit the success of new products.

The UK foresight study suggested that research needs to be positioned carefully so that it is not pursuing a 'lost cause'. Research also needs to be coupled strongly and pragmatically into product development. This is particularly true for Manufacturing, Production and Business Processes, which differs from other sectors in that its Delphi survey developments had a predicted time to realisation of only about 5 years on average compared with 8-10 years for other sectors.

In addition, a fifth group of sectors was identified. 'Lack of funding', either for investment capital or research funds, was considered a significant constraint to the realisation of Delphi topics for *Defence and Aerospace, Materials, Health and Life Science, and Transport*. The UK study considered that for these sectors there is a danger of spreading research too thinly and not achieving effective exploitation. To avoid duplication of effort and to exploit world technology a narrower range of research would have to be done in the UK. It considered that where possible, UK research should be focused where it generates powerful 'core competence' with good leverage. Academic research is important for these sectors in strengthening the scientific networks coupling the UK to world wide research.

This type of analysis can be undertaken to provide a broad context for considering the future of a particular sector. For example, we are able to conclude from the UK study, that for the 'Leisure and Learning' sector:

- the dominant Key Forces for Change will be *Applying I&CT* and *Global Integration*;
- the long-term issues will be the regulatory framework in relation to product market changes; development of hybrid technic-artistic-commercial skills; impact of new technology on education and informational leisure markets; and equal access to educational distance learning hardware and software;
- the main sectoral drivers will be the investment in skills and human resources; and
- the main sectoral constraints will be social, ethical and consumer acceptance.

Such information may also be useful to Australian businesses, given our large Services sector.

At a detailed level, the importance of other issues will be evident, emphasising that Key Forces for Change must be viewed as additional information in strategic planning, rather than as a replacement for existing knowledge. This, however, provides an excellent starting point for organisations in this sector to consider their own foresight exercise.

Detailed sectoral foresight information is reflected in the ASTEC study through the sectoral Partnership studies. The analysis in these studies suggested a number of recommendations, which need to acknowledged and responded to.

8.6. Conclusion

The linking of information on sectoral constraints with ASTEC's Key Forces for Change indicates many strategic issues for Australian industry. These forces will impact in combination and with a variety of emphases. International foresight indicates that the nature of drivers and constraints for innovation also vary according to sector.

For example, innovation in response to *Applying I&CT* is constrained not only by industrial and commercial opportunities (from markets dominated by a few companies), but importantly there are social and cultural constraints. For Australia, where hardware production is limited to niche segments, it is important for software and content developers to heed the UK advice to research to innovate and understand potential social value of future products and services and to assess the likely social benefits and costs. It is the usefulness of I&CT to people that will be significant in the exploitation of the technology. This view is also supported by the ASTEC's I&CT Partnership which considered that 'consumer value' was the most important and most uncertain factor influencing the future of broadband 'full service networks' (ASTEC 1995d).

A forward-looking approach which recognises the critical links between foresight and innovation may be able to reduce some of the risks of innovation. Foresight can help develop a better understanding of potential changes over time in external and internal factors affecting innovation. This is one objective of foresight. It is not intended to replace more traditional methods of analysis, but to add a new dimension to our long-term strategic thinking.

Area for Action:
Developing Forward-looking Innovation Programs

ASTEC considers that building competitive Australian businesses into the 21st Century will require a world-class innovation capacity. A long-term perspective on differences between industry drivers and constraints indicates the value of a sectoral industry-driven approach to innovation policy.

It is necessary to develop coherent sectoral strategies for encouraging technological innovation and S&T based competitiveness in Australian industry. Actions that might be considered include industry sector consultative boards to initiate 'critical technology' reviews and ensure that relevant organisations across Australia in the private and public sectors have access to outcomes of national and international studies on new and emerging technologies, including foresight studies. Such initiatives might be used to identify strengths, weaknesses and critical gaps in Australia and help develop a strategic framework to investigate and respond to impediments to Australia's future competitiveness and build links between Australian and overseas organisations and industries.

ASTEC also suggests a need to acknowledge and respond to the recommendations of the ASTEC sectoral Partnership studies.

Chapter 9. Impacts for Industry – New Opportunities

9.1. Introduction

This Chapter explores some of the implications of ASTEC's four Key Forces for Change for Australian industry, which in this context, includes both private and public sector businesses – from agriculture and mining, to manufacturing and services. It focuses on a number of potential export opportunities which emerged from the study.

The chapter also considers the potential commercial value to industry of taking a long-term view on the use of scientific and technological knowledge and the contribution of S&T to industry and economic growth over the next 15 years.

There is growing evidence that industry can use science and technology (S&T) to help create competitive advantage, whether from innovation in new or improved products, processes and services, the creation of new markets, or from lowering costs and increasing productivity. Competitiveness into the 21st Century will require firms to invest in knowledge and skill development, product and process technology and R&D. Firms, particularly small and medium-sized enterprises will need an effective capacity to adopt, develop and exploit S&T.

This chapter was based mainly on a series of interviews with selected industry leaders, Key Issue discussions of 'Globalisation' and 'Innovation' and a consultancy on the relationship between S&T and economic growth (Sheehan, 1995). However issues emerging from other consultations have also been included as appropriate.

There is a significant difference in the role of science vis-a-vis technology in industry. Science is applied mainly through the adoption of a scientific approach, whereas technology, which is the creation of artefacts, is embodied in products and the processes and the machinery to make them. Some have argued that technology is really only engineering – and that it is the emphasis on engineering which is more important to commerce.

If, as suggested in this study, the future in 2010 will be one of more pervasive and sophisticated technology, then this places additional demands on Australia's engineering base and our national capacity for technology transfer. Changing rules of competitiveness will force Australian companies to work harder to survive into the future – thus placing greater demands on their engineering skills. By contrast South and East Asian countries have benefited in the last decade from their strong engineering base. They currently produce 6% of the world's engineering publications, positioning them well for a more technological future.

The Japanese, US and UK foresight exercise found engineering to be very important. Two of the six generic priorities in the UK foresight study related specifically to engineering – 'precision and control in management' and 'new materials'. This emphasis did not emerge in the Australian study. While this may be partly explained as a factor of study design, it also appears to reflect a lower overall priority given to engineering in Australia. Also, as noted in the previous Chapter, the most important or 'critical' technological force will vary according to sector. There is no doubt that new materials and advanced manufacturing technologies will be critical in materials production and fabrication sectors, for example, Motor Vehicles or Ship Building.

9.2. The Contribution of S&T to Australian Industry and Economic Growth by 2010

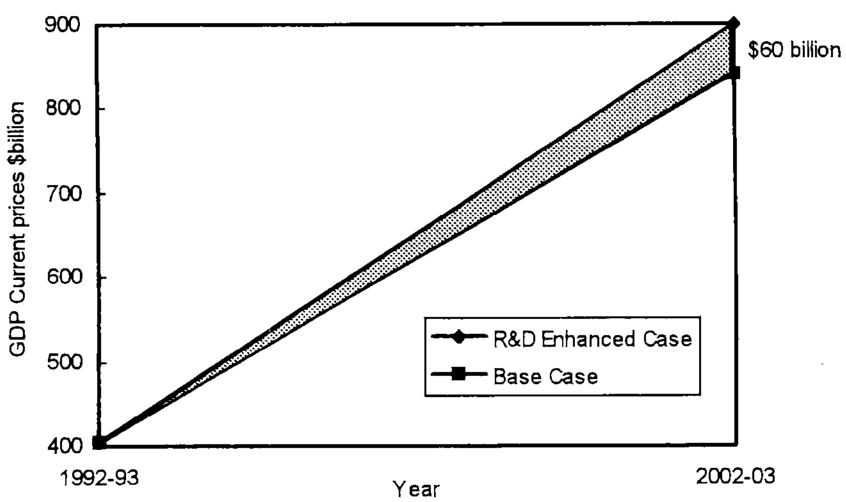
It is generally accepted that measuring the relationship between technological innovation and economic growth is difficult because of data inadequacies and the complexity of innovation itself (it is not a 'discrete' activity, but rather involves a number of organisations/economic actors over a lengthy period). Nevertheless, we do know that R&D expenditure and patenting activity are positively associated with growth in productivity and exports, and that the use of advanced manufacturing technology is linked to increased employment, higher wages and more secure jobs (Fagerberg, 1987; US Department of Commerce, 1994).

As part of this study ASTEC considered the role of S&T in wealth creation and whether economic growth could be lifted through additional investment in R&D. Sheehan, for ASTEC, tested the hypothesis, based on new growth theory, that there is the potential to boost Australia's economic growth through government policy initiatives which facilitate scientific R&D and the transfer of new technology.

Sheehan (1995) found that the ratios of exports to production, and R&D to value added, have increased strongly in the past decade in high technology sectors of the economy. He concludes that the strong association between the rises in these two measures provide strong *prima facie* evidence of an important causal link of increased R&D in Australia's strong performance in 'high-technology' exports.

Accordingly, if Australia were, through a variety of policies, to immediately increase expenditure on R&D as a proportion of GDP from 1.7 per cent to 2.5 per cent, by the year 2002-03 the additional resulting increment to GDP would be $60 billion in current prices ($37 billion in 1994-95 prices). This would imply an industrial base for the Australian economy radically different from that of 1995 and has vast implications for the economy as a whole (Box 9.1).

Box 9.1. Incremental Impact of Research and Development on the Limits to Economic Growth



Source: Sheehan et al. 1995

The growth to 2.5 per cent represents an increase of at least 0.5 per cent more than the current quite high growth rate will achieve in that time. Changes to the economy achieved through increased levels of R&D (eg strengthened 'high-tech' industries), would allow higher levels of economic growth to be sustained than are possible at present.

Sheehan does not suggest that the contribution of Australian industry to economic growth can rise only due to factors associated with R&D and notes this increase will come primarily from industry rather than government sponsored research. He also points to the importance of growth in the Asia-Pacific for achieving higher levels of economic growth in Australia.

Three lessons seem especially relevant to the present study:

- while world merchandise trade is likely to continue to expand at a good pace, the nature of that trade is shifting towards R&D intensive commodities, with trade in these commodities growing much more rapidly than merchandise trade as a whole;
- services exports are now growing more rapidly than goods exports, with particularly high rates of growth in travel services and in the increasingly knowledge intensive other non-official services; and
- much growth over the next 15 years will be in areas managed by government today – health, education, environment and infrastructure.

Economies which are able to expand their level of economic activity and exports in high technology (R&D intensive) goods and in knowledge intensive services are likely to be best placed in the emerging global economy. It is therefore vitally important for Australia to participate fully in the rapidly growing world trade in these two areas as they account for an increasing proportion of world trade.

Nevertheless, markets for other traded goods and services are so substantial and are continuing to grow at such significant rates, that it would be unwise for any country to ignore other specific opportunities available to it. For Australia this means in particular agricultural and mining products and their value added derivatives in the manufacturing sector, such as processed food, fibres, metals and energy products.

Australia has achieved substantial gains over the past decade in applying S&T to generate economic growth. While Australia's innovation system is far from adequate to support the transformation of the economy into one able to compete successfully in a range of knowledge intensive industries, good progress has been made in this direction.

Commonwealth government policies which have contributed to this success are: powerful incentives for private business to undertake R&D, the strong focus on the commercialisation of public sector research results, continuing support from the Commonwealth budget for R&D, and industry policies specifically encouraging R&D, such as the 'Partnerships for Development' program and the 'factor (f)' pharmaceutical industry program.

Enhanced measures were recommended by Sheehan (1995) in each of these areas, together with three new policies to achieve increased levels of economic growth. The new initiatives are: incentives for public businesses to undertake R&D relating to their business needs, a technology foresight program, and a new emphasis on the internationalism of Australia's R&D base.

9.3. Potential Opportunities to 2010

Adam (1992), suggests that by the year 2000 growth in Australia will come from three different categories of companies. He proposes the need for 10 new $1 billion companies (to act as the strategic business units of the future which will probably come from existing resource companies); 100 new $100 million companies (growing from existing smaller companies); and 1000 new $10 million companies (from start-up ventures).

Using this framework, the following list was derived from ASTEC's consultations. It indicates some of industry's current ideas on potential long-term opportunities for Australia:

- *$1 Billion businesses*

  Clean green food; cable delivered information and entertainment services; health services training and delivery; transportation equipment; integrated transport services into Asia; applications of mobile telephony; major aircraft maintenance; mineral processing eg magnesium; gas conversion; services and engineering needs of mining companies; remote sensing; waste management.

- *$100 Million businesses*

  Health technology – products, equipment, screening services; specialised high speed shipbuilding; sporting equipment – technology, facilities design, services, testing, etc.; support services for tourism – software, equipment, training, etc.; Interscan; Membrane filtration; design and manufacture of special packaging, controlled atmosphere containers; food processing equipment; taste – texture- flavour control for food.

- *$10 Million businesses*

  Specialised foods – natural, natives, exotics; specialised software; specialised horticulture; new personal home centred services for affluent people.

Our consultations showed that there is a strong emphasis on opportunities in Asia, reflecting a widely held view that the next 15 years will see a maturing of our place in the region. It was noted that broadly 'constraints' on growth in the Asia-Pacific region might represent potential opportunities for Australia. Many are in current areas of Australian strengths including: human capital and skills; infrastructure; resources, energy and its efficient use; and continuing access to developed markets, eg European Union.

ASTEC grouped potential export opportunities for Australian industry, which may emerge over the next 15 years, into four broad, and overlapping, categories of:

- 'people-linked' business including: Travel and Tourism, Engineering infrastructure, knowledge based services and cultural exports;
- 'infrastructure-linked' business including: Education Facilities and Service, Health Facilities and Services, Medical Research and Transportation;
- 'resource- and environment-linked' business including: Agri-industry, Value-added mineral products, Environment Management, Renewable and other energy; and
- manufacturing business – including: I&CT, Pharmaceuticals and emerging flexible structures for 21st Century manufacturing systems.

The rest of this chapter explores these potential opportunities. It is important to critically evaluate their viability. Some potential opportunities, such as 'clean-green food', were raised consistently, often by people with little detailed knowledge of Australia's strengths and weaknesses in this area, yet some experts suggest that clean-green food may be a difficult opportunity for Australian industry to capture in current circumstances.

It is critical that those opportunities which have been identified are tested further to assess their real potential and Australian industry needs for 2010. The opportunities outlined below should be regarded as part of a 'possible future' – to capture them will require careful thought, detailed planning and investment.

a) *Opportunities for People-linked Business*

One of Australia's chief resources is her people, their knowledge, skills and culture. Australia also has many unique social institutions, which might present opportunities for growth in Australia and in interaction with the rest of the world. Important areas of people-linked business include knowledge-based services; cultural exports; and tourism and travel.

In addition to the opportunities outlined below, Australia has a variety of social institutions, experience and skills which can be used as potential models for developing nations. Establishing and adapting such services in other nations, eg in employment services, could provide additional opportunities for Australia.

The UK foresight study suggested that services and knowledge/culture-based sectors will be most affected by global integration and I&CT. It is therefore important to review the international and I&CT strategies of the following opportunity areas and to explore how S&T might assist in responding most effectively to the challenges ahead for these areas.

i) *Knowledge-based services*

The Asian region will need enormous developments in services which comprise a wide array of economic activities. It is the knowledge-based services, such as professional and technical services, information technology services, banking and insurance, travel, modern health care and education, that constitute the dynamic edge of the services economy today. Services at $US934 billion in 1993, accounted for 22 per cent of world trade.

A key trend from the increasingly knowledge intensive nature of production is the rapid expansion and growing tradability of knowledge-based services, partially reflected by an increasing R&D intensity in services (Box 9.2).

Box 9.2. Service Sector R&D, Business Enterprises Selected Countries, 1976-1992

	Level			Share of Total Business R&D			Share of GDP
	1984	1992 ($US million)	Annual % Change 1984-1992	1976 (%)	1984 (%)	1992 (%)	1992 (%)
Australia	**93**	**564**	**25.3**	**10.3**	**14.7**	**27.3**	**0.14**
Canada	503	1461	14.3	14.3	21.5	33.3	0.18
Denmark	90	267	15.3	17.0	22.1	27.6	0.16
France	477	1478	15.2	5.7	5.6	9.3	0.06
Germany	531	714	3.8	3.4	3.8	3.0	0.02
Italy	368	1118	14.9	14.1	10.3	14.4	0.08
Japan	874	1955	10.9	4.5	3.8	3.9	0.03
Sweden	197	340	7.0	11.2	10.6	11.5	0.08
UK	375	1330	17.2	7.9	4.4	10.6	0.06
USA	4905	10918	10.5	3.1	6.6	na	0.07
OECD				**7.2**	**6.7**	**9.6**	

Notes: Levels and shares of GDP are calculated in US dollars, using purchasing power parities; shares of R&D are calculated in domestic currencies.
Source: Sheehan et al 1995

There is a continuing transformation of developed countries from industry-dominated to service-dominated economies. In common with other developed countries, Australia has a services-based economy (70 per cent of GDP, 80 per cent of employment). Between 1960 and 1993, the average share of services in industrialised countries rose from 42 to 65 per cent, while their share of GDP rose from 53 to 61 per cent. This structural shift is likely to continue, but at a slower rate with average employment in services reaching 75 per cent by 2010.

The continuing structural shift towards services in developed countries has important implications for their trade with developing countries. As services grow more important to their economies and the service intensity of their output increases, there will be a progressive shift in the structure of their exports towards services and service-intensive goods. One example is customised manufactured products that require continuous interaction between producers and consumers. For developing countries, these structural shifts increase the potential opportunities for exports of traditional manufactures.

While it remains useful to distinguish between goods and services and between the corresponding sectors of the economy, it is important to recognise that these distinctions are becoming increasingly blurred in the modern economy. Thus the manufacturing industry sector is a major purchaser of information technology services, while the industry itself provides a range of service, advice and support components which are a significant contributor to receipts. Indeed, these components may be the dominant elements in determining export performance.

ii) 'Cultural' exports

A note of confidence was expressed in Australia's ability to add to global cultural development particularly in providing global media content, multi-media content and education services, once customer needs are identified. Australian content development industries already generate domestic revenues in the order of $8.4 billion.

The development of specialist content for broadband services delivery will require S&T support through skills and knowledge. By the end of the decade, Australia's domestic interactive multi-media market could be worth $2-3 billion, with exports expected to be worth more than $200 million by 1997-98. (Ref: Creative Nation 1994). This requires a high general education level and effective infrastructure for business eg a substantial optic-fibre network.

During the 1980s Australia built up a strong international presence in contemporary music despite our small domestic market. Australia has become the third largest supplier of new English repertoire to the international market with our share estimated at $206 million a year. (Creative Nation 1994).

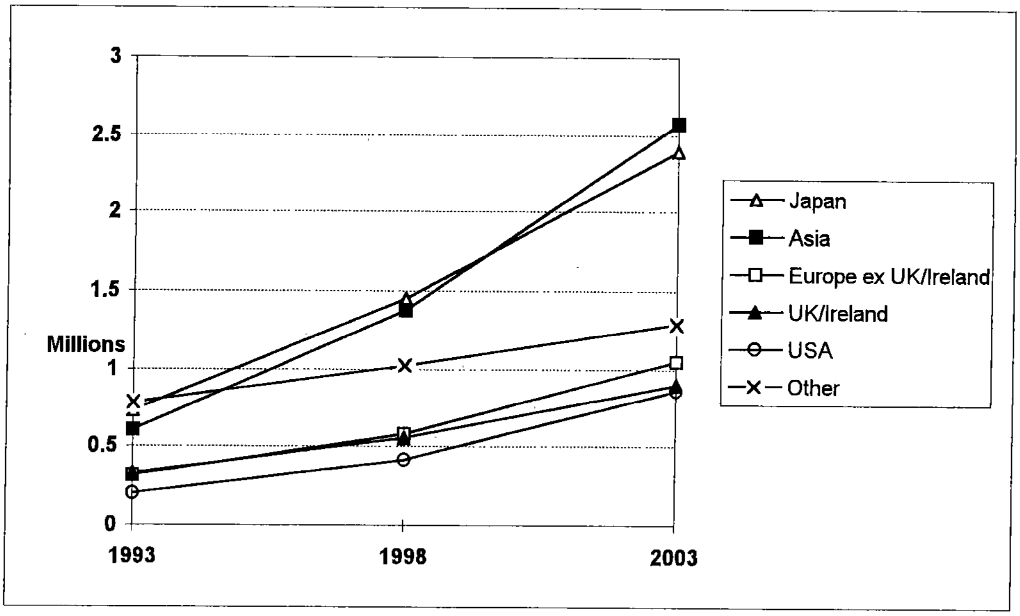
Australia's natural environment and culture place it well to provide leisure time activities for people of the Asia-Pacific region. Less well acknowledged opportunities could include gambling and sport drug testing.

iii) Tourism and travel

The largest industry in the world is now tourism and travel, with a turnover of roughly $US270 billion and employing 204 million people world-wide (10.6 per cent of the global workforce). This figure is expected to grow to 348 million by 2005, with the major growth occurring in the Asia-Pacific region (112 million jobs).

Australia is a relatively new destination for international travellers and currently receives less than 0.5 per cent of global international travel. While it is predicted that Asia/Oceania's share of the world market will increase from 14.6 per cent in 1989 to 21.9 per cent in 2000, Australia's share of the growth will still be relatively small. The Australian Tourist Commission predictions for tourists to Australia to 2003 point to the growing importance of the East Asian market (Box 9.4). International tourist numbers in Australia are expected to reach 8.8 million a year in 2005, an average of 8.9 per cent annual growth from 1995.

Box 9.4. Tourists to Australia by origin (millions)



Source: Australian Tourist Commission, 1992

The contribution of tourism to the Australian economy is significant. In 1990-91, tourism contributed $7.2 billion to the economy through international tourism expenditure (Box 9.5). This contribution is highly significant when compared to earnings from coal ($6.5 bill), meat ($3.2 bill) and wool ($2.8 bill). On current projections this relativity will be maintained into the 21st Century, with tourism export earnings expected to reach $31 billion a year in 2005.

Given that one new job is generated for every 17 international tourists and one for every 200 domestic tourists, it is expected that tourism will generate 200 000 new jobs in Australia over the next decade and generate between $20 and 30 billion in additional overseas income a year beyond 2000 (Tegart, 1995).

Box 9.5. Contribution of Tourism to the Australian Economy

Tourism expenditure ($bn.)	**1990-91**	**1991-92**
International	7.2	8.2
Domestic	17.9	18.4
Total	25.1	26.6
Contribution to GDP(%)		
International	1.6	1.8
Domestic	3.8	3.8
Total	5.4	5.6
Employment generated ('000s)		
International	130	144
Domestic	320	322
Total	450	466

Source: Australian Tourism Commission

Tourism is an information-rich industry, which has complex links to many other sectors. For example, it links economic sectors such as transport to restaurants, retail to services and hotels, and other accommodation to commercial development. Major developments in I&CT and other infrastructure will be needed to cope with the projected increases in travellers, eg new airports, transport systems, hotels, travel planning. The World Bank calculated that in developed countries 2.5 other jobs are generated from every job created by tourism, so that potential employment of another 500 000 people is possible in Australia over the next decade.

The international travel market is changing. Increased spending power per capita, greater leisure time, a better travelled and more discerning public and major socio-demographic changes in the developed world point to a substantially different travel market in the 1990s. Demand is increasing for even greater variety in types of tourism and a need to tailor packages to specific market segments.

Special interest travel will be a major factor in the expansion of tourism that will dominate the industry in the next decade. Adventure travel now accounts for 10 per cent of the domestic market in the USA while eco-tourism, educational travel, arts and heritage travel are rapidly expanding. Australia is already developing many of these options but they will need to be expanded to cope with predicted growth, particularly amongst Asian travellers. Many potential futures and new S&T needs are implied by such an expansion (Box 9.6)

Box 9.6. A Scenario: Ecotourism in 2010

This scenario, developed by ASTEC as part of the Roundtable to explore the Key Issue *the need to sustain our environment to 2010* explores a future in which tourism developments are required to be 'more environmentally friendly'.

The development is located on an island adjacent to the Great Barrier Reef Marine Park. In 2010 areas of high conservation value have been identified and placed on a central national register. They also have a rating which indicates the level of protection required. Category 2, which is the rating of the island where the tourist accommodation is proposed, is the second highest rating. Areas in this category are allowed to contain some development or economic activity. However such developments must have:

- *stringent impact assessment at nationally agreed standards with high level of ongoing monitoring;*
- *very high insurance to ensure finance is available to remedy any problems which arise;*
- *conditions in the lease which guarantee no damaging impact on the environment, from the establishment, operation and decommissioning of the development.*

These conditions are backed up by legally enforceable, and regularly enforced, sanctions eg orders to cease activity which can have immediate effect; fines which are based on percentages of independently audited company value or development turnover and criminal sanctions which include custodial sentences for serious intentional breaches.

The rating system is well understood by people staying at accommodation. As a result it can be used in advertising and patrons, willing to pay high prices because they value the pristine nature of the area they are visiting, are likely to complain to the combined industry/government board if they suspect breaches in environmental standards.

The tourism operation must be 'closed cycle' in terms of outputs. This means no liquid or solid waste, minimal noise or energy loss and minimal impact on the surrounding marine or terrestrial environments. All waste must be dealt with on location, and transport to and from the development is minimised to contain damage to the surrounding marine environment. All environmental costs are reflected in pricing of the services at the tourism site.

Source: ASTEC

Cultural tourism is also expected to expand. According to a recent survey, there is considerable interest in cultural tourism opportunities in Australia. For example, forty-eight percent of international tourists were interested in seeing and learning about Aboriginal and Torres Strait Island culture. The value of purchases of Aboriginal and Torres Strait Islander art and souvenirs by international visitors is increasing rapidly – rising from $30 million in 1990 by almost 50 per cent to an estimated $46 million in 1991, (DOCA, 1994).

Expanding tourism opportunities raise environmental issues for Australia, eg preservation of wilderness areas, protection of land and water resources, which have to be faced at an early stage. Equally it offers opportunities for development and application of environmental management techniques that are potentially exportable.

There are significant opportunities to train people for jobs in the tourism industry, both in Australia and overseas. A wide range of semi-skilled and skilled people are needed and academic institutions in Australia are moving to recognise tourism as a major discipline. Apart from training overseas people in Australia, there is potential for setting-up offshore training institutions in hotel management, etc., again drawing on the language skills and cultural background of the multi-cultural Australian population. These opportunities are already being exploited by East Asian airlines and hotel groups in creating niches in industrial country markets and by supplying neighbouring developing countries.

b) Opportunities for Infrastructure-linked Business

Closely allied to people-linked business are other opportunities founded on Australia's infrastructure strengths. These include: infrastructure development; integrated systems; medical facilities; and educational facilities. As with the opportunities in people-linked businesses, I&CT and global integration are expected to play a major role over the next 15 years.

i) Infrastructure development

Australia has a well developed infrastructure basis to leverage export opportunities involving many organisations and sectors not conventionally associated with 'exporting'. A variety of Government instrumentalities have an ability to market infrastructure development services to other countries including through collaborative agreements. Australia may be able to export its expertise in areas such as urban transport solutions, home ownership, energy efficiency and conservation, drainage and air conditioning.

The growing population in Asia coupled with increasing per capita income and trade liberalisation implies a need for large scale development of infrastructure such as energy, educational and medical facilities, telecommunications and transportation. Estimates of East Asian infrastructure investment levels by the year 2000 range between $US1–2 trillion. Much of this will be spent on energy, telecommunications and transportation (Box 9.7).

Box 9.7. East Asian expenditure on infrastructure to 2000 ($USbn)

	Transportation	Power	Telecom	Other
ASEAN	74	64	21	63
China	968	54	25	-
Hong Kong	23	13	1	30
Korea	132	48	32	146
Taiwan	124	29	10	84

Source: Asia-Pacific Economics Group (1995).

The region's needs are so vast and demands on resources so great that government have had difficulty in financing them. The needs in China are greatest because of its sheer size, population and recent pace of economic growth.

Australian engineering infrastructure and skills in transportation provide a basis for competitive development. Specialist consulting services, for example in Engineering and Construction offer opportunities for Australia particularly in infrastructure development.

ii) Integrated systems

An increasingly important trend to 2010 is the development and trade of 'integrated systems'. This refers to the widespread implementation of integrated economic activities. For example, manufacturing and services, including government services can be 'sold' as an integrated package.

Many opportunities have been identified in the services sector in systems management of both public and private sector organisations. This includes the integrated provision of information systems, involving both goods and services, to an increasingly affluent Asia. This might include infrastructure projects associated with Australian 'government' agencies, such as municipal services, efficient government services (tax, social security, customs), mail sorting, mobile telephony, emergency services, customs, mail, environmental standards etc. Australia can also build upon strengths and expertise in security. These are areas which can be adapted to the needs of the rapidly changing social and economic structures of countries in the region.

In the private sector, stock exchanges, banks, betting systems, film and television offer opportunities as living standards and disposable incomes increase in the region. Australian stock exchanges are excellent by world standards and the screen-based trading system 'SEATS' is considered to be world class. The present settlement system has been independently ranked as second only to the US. There is a $US130 million guarantee fund which offers investors probably the best protection in the world against default in the market. The market information systems are efficient and comprehensive.

The Australian securities market is creating an Asian sector to obtain primary listings of Asian companies on the Australian market. This will enhance Australia's position as a regional financial centre and make Australia a conduit for investment for other countries into Asia. Better integration of Australian capital markets to regional markets, eg developing Australia as a regional capital manager may require the development of new market mechanisms to promote capital access. Related opportunities may be in financial services and banking technology.

Our knowledge and skills provide a potential for Australia to become a base for regional R&D services which DIST is seeking to promote internationally. S&T project management also provides an export opportunity.

iii) Educational facilities

The demand for education at all levels, but particularly for children, offers opportunities in the Asian region. Australia's multi-cultural society provides an excellent base of English speakers from a wide variety of backgrounds, to provide education services and facilities.

Australian universities and other institutions have already developed a number of bilateral links into the region. The Department of Employment, Education, Training and Youth Affairs (DEETYA) is developing a co-ordinated approach with the Australian International Education Foundation and the International Strategic Training/Education Partnerships Program, but more needs to be done.

Tegart (1995) suggests there is an opportunity to supply fully equipped educational institutions from buildings through equipment to teaching staff. This requires a new mindset in government and the educational institutions themselves which, he argues, will come from newer institutions rather than older universities pre-occupied with traditional links to Europe, US and Japan.

By using modern design and building techniques and adapting these to local materials and conditions, there is an opportunity to construct university buildings to meet local requirements. Australian architects are already operating widely in Asia and the enormous Muang Thong Tani satellite city project in Bangkok is a prime example of Australian architectural skills which could be applied to constructing a range of educational institutions.

There is a precedent for Australian supply of educational equipment and instruments into the region through the operations of the Sydney-based Vocational and Technical Training Corporation (VTTC) operating in Indonesia. Over the past 12 years VTTC has won contracts worth more than $100 million supplying products from over 100 Australian firms.

The provision of trained staff for programs targeted at particular countries could be facilitated by strong links between Australia's multi-cultural society and the region. The market needs to be defined but, as an example, recent discussions in Thailand suggest that 20 new universities will be needed there by the early 21st Century to cope with the expanding population and the need for trained personnel (Tegart, 1995). Major opportunities exist for new universities in the border area of Laos, Thailand and Cambodia which is a potentially rapid growth area linking China to Vietnam.

Currently the World Bank is preparing to fund a project on higher education consolidation and reform in Vietnam. AusAID is providing funds for consultants to participate in working groups, but the effort is fragmented.

An important factor in the success or otherwise in the supply of 'turn-key' universities is the question of project management. Australia generally has a good record in large projects in the region, eg large resource development projects, construction consortia, transport development etc. This will require a partnership of government, academia and industry in education facilities in a form not seen previously in this country.

iv) Medical facilities

Australia's multi-cultural society, coupled with our high standard of medical practice and research, can help to capture opportunities in the medical area. This includes health care delivery, telemedicine, re-engineering hospitals, as well as medical and legal education.

One area of potential opportunity is the delivery of a 'package' of a fully equipped medical facilities from buildings through equipment to staff. Tegart (1995) argues that hospitals are essentially hotels with specialised facilities and Australia's existing architectural and construction technologies provide a basis for the development of customised modular hospitals for different countries, including the design of laboratories and operating theatres.

A step in this direction is the formation of the Australian Medical and Services Export Group of about 25 companies covering a range of products and services, from hospital furniture to paging systems. Project management skills are a potential asset in the construction and setting-up phase while management skills developed as a result of recent hospital reforms in Australia will be invaluable in the operational phase.

There are niche opportunities for specific aspects of medical facilities and services which could be used in a culturally sensitive way to develop local medical facilities able to address the needs of local communities. Given the range of needs in the region there is clearly a case to develop a spectrum of products and services appropriate for local circumstances – from relatively simple village or town hospitals to regional centres and major sophisticated urban hospitals.

A relatively recent development are specialised 'fly-in, fly-out' hospitals, eg for heart transplant patients in Sydney. The concept can be extended to tropical medicine and specialised cancer treatments.

The development of sophisticated interactive communication systems offers the opportunity for telemedicine ie remote diagnosis of patients. Such systems have already been trialed overseas for evaluation of ultrasound images between North America, Africa and the Middle East. Recently Australia announced a telemedicine joint venture in Melbourne linking city and rural hospitals with evaluation of 3D images from X-ray scanning and magnetic resonance imaging, together with a feasibility study in Perth for a National Telemedicine Centre. The latter would service remote Australian communities as well as exporting services. Thus patients in other countries could be examined in local hospital systems, referred to specialists in Australia and then be treated locally or flown to Australia for specialised treatments.

c) Opportunities in Resource- and Environment-linked Business

Australia is both a resource and knowledge-rich country. This presents opportunities in the supply of raw materials and value-added resource-based products, supported by services and technology for their use. Our previous analysis suggested that these industries need to take particular account of Global Integration and Environmental Sustainability. This section explores how three different sectors – Agriculture, Coal and Environmental Management – are responding to these forces, in particular the drive for environmental sustainability.

i) Clean coal technology

Energy requirements in developing countries are predicted to escalate over the next 15 years, particularly in the Asia-Pacific. This energy demand will need to be met by constructing a variety of systems against the background of the need to limit greenhouse gas emissions.

Currently there is a niche area in remote area power supplies, particularly to islands and for communities unable to be linked to national grids, eg in remote mountain areas. Australia has been at the forefront of developing such systems based on solar and wind power together with hybrids incorporating diesel power. We should be in a strong position to capitalise on this experience.

In the case of photovoltaics, Australia is already a world leader in R&D in this field and is a major manufacturer of solar cells, exporting half its production. Both Indonesia and India have expressed interest in large scale application of photovoltaics and, in the latter case, the US has already committed some $50 million in co-operative agreements. There appears to be a need for a formal group to focus Australian firms and institutions operating in this area on market development in the Asia-Pacific.

However, it is clear that fossil fuels, namely coal and gas, will continue to be the major energy source to 2010. While coal has been identified as an area of potential opportunity over the next 15 years, concerns about greenhouse enhanced climate change suggest limits to its longer term potential.

Australia is a large producer, exporter and consumer of coal and makes use of highly efficient and technically sophisticated equipment and techniques in all parts of its coal industry. The countries of south and east Asia, particularly China and India, are also large producers and consumers of coal. Together with Australia, these countries, excluding the large coal importers of Japan, South Korea and Taiwan, currently account for between 35 and 40 per cent of both production and consumption of coal in the world. What is more, current energy sector plans anticipate that coal will increase its share of total primary energy in most of the developing countries of Asia (DPIE, 1994).

A study of the Asia-Pacific region reveals how important coal is to economic development in this region. Only 4 per cent of the world's oil reserves and 6 per cent of the world's natural gas reserves are found in the region. While the region contains 31 per cent of the world's reserves of anthracitic and bituminous coal, these are concentrated in China (83 per cent of regional total) and Australia (16 per cent of regional total). About 52 per cent of coal consumed in the Asia-Pacific region (excluding China) is imported and Australia is the major coal supplier to the region. It provides about 55 per cent of Japan's coal imports, 33 per cent of Taiwan's and 30 per cent of Hong Kong's coal imports. Net coal imports to the region are forecast to grow from 156 Mt in 1990 to 355 Mt in 2010.

Official plans call for coal fired plant to provide the majority of the required new capacity in China, India and Indonesia, and to play an important role in Thailand and the Philippines. Coal is projected to be less important in meeting growing electricity demand in other Asian countries.

Increasing the efficiency with which coal is produced and used has been widely recognised as an important means of reducing the growth of greenhouse gas emissions in Asia. Supplying modern, efficient coal technologies to developing countries is consistent with Australia's obligations, as a party to the Framework Convention on Climate Change.

De-regulation and privatisation of energy production and distribution systems in Asia will present a range of opportunities for Australian energy industries. Australia is a world leader in the construction and operation of black coal and lignite fired power stations. Over the past 15 years Australia has constructed and commissioned more than 20 black coal and lignite fired units of 500 MW or more when new capacity installation in the USA, Canada, Germany, France, Italy, Britain and Japan has been negligible,

Australia also has the advantage of recent experience in building small to medium sized coal fired power stations for smaller electric utilities and large industrial users, often extractive and process industries located in remote areas. This experience is likely to be particularly relevant in Asian countries, where current electricity demand and system capacities are too small to be able to support large (500 MW and above) units.

Eight broad areas of coal related technology and activity identified as opportunities for Australia are:

- use of high grade Australian coal in power stations;
- more efficient production of indigenous coal;
- beneficiation of indigenous coal;
- improved efficiency of coal fired power stations;
- improved efficiency of other coal fired plant by various measures, including improved coal quality, improved efficiency of industrial boilers, co-generation, and improved efficiency of brick and cement kilns;
- coal bed methane drainage;
- design, construction and operation of new coal fired power stations; and
- technical training in the operation of coal fired plant.

Relevant expertise in these areas is located in a wide range of organisations, including consultants, contractors, manufacturers, fabricators, trading houses, electricity and gas utilities, financiers, research institutions and educational institutions. Austenergy, the

Australian energy sector exporters group provides a focus for capturing opportunities in the energy area.

ii) Environmentally-friendly technologies

The emergence of new Australian environment management industries is a development holding considerable promise. Many companies are producing leading edge technologies capable of solving serious environmental problems.

Markets for environmental goods and services are growing rapidly in Australia and the Asia-Pacific region. More than $3 billion is being spent each year on the environment industry in Australia. Estimates put the size of the Asia-Pacific market at more than $US60 billion by 1998 and opportunities for Australian manufacturers in this market are excellent.

Clean production techniques, environmental management services, water treatment, air pollution control, solid waste treatment and recycling are likely to continue to be high growth areas into the 21st Century.

Australia is well-placed to take a leading role in environmental technology in the Asia-Pacific region. Such technologies for a cleaner environment include:

- sewage treatment with magnetite particles;
- continuous micro-filtration in water and sewage applications;
- sludge disposal through low temperature conversion and conditioning;
- heavy metal recovery techniques;
- hybrid, high rate anaerobic reactor for waste water; and
- thermal gas destruction of hazardous waste.

The ability to apply such 'clean' technologies may be the limiting factor in developing industry sectors in Asia in the future and application of Australian expertise may provide a significant competitive edge. Currently the extremely rapid development of industry in many Asian countries is leading to major air pollution and water quality problems. This is particularly severe in urban areas and is exacerbated by the explosive growth of numbers of cars and trucks. For example Tegart (1995) raises the considerable pollution problems such as acid rain posed for Korea by China's industry development and suggests Australia could investigate tri-partite solutions with China and Korea.

iii) Agriculture

ASTEC identified agriculture as a sector undergoing extensive change from all four Key Forces over the next 15 years. The demand for increasing amounts of agricultural products to feed and clothe a growing global population is universally accepted, as is Australia's unique location on the doorstep of rapidly growing markets of middle-class consumers in Asia. Such consumers will have the disposable incomes to purchase high value agricultural products and food-based brands Australians would like to produce.

Opportunities for agricultural exports are seen as particularly strong in Asian markets, although a focus is needed on customer needs and tastes. China is finding it increasingly difficult to increase grain production consistent with its growing population and one prediction is that by 2010 there will be a shortfall of over 50 million tonnes of grain. Dairy, beef and grain-based products and brands present many opportunities for exports, as does agricultural technology.

However there is significant cause for concern about the present condition and future prospects of Australia's agricultural resource base and fundamental and far-reaching changes are necessary to put Australia's production and natural resource management systems on a sustainable basis. (PMSEC, 1995a)

ASTEC, through its consultations, identified a number of important issues for agri-food sector, that need to be addressed in the longer term (Box 9.8).

Box 9.8. Issues in capturing Australian Agri-food opportunities to 2010

Through its consultations ASTEC identified a number of long-term issues to be addressed in capturing opportunities in Australian agri-food sector. These include:

- environmental concerns about farming on marginal lands;
- full pricing of water, energy;
- financial institution's growing concern about sustainability of farms;
- questions about viability of most Australian farms;
- corporatisation of farming – the loss of family farms;
- trends from extensive to intensive farming, eg feedlots;
- information and communications technology, in production – monitoring soil to shelf, and for consumer awareness of contamination, modification etc.;
- growing concerns about the impact of single product farming;
- high level of foreign ownership in the food processing industry;
- climate change including an enhanced greenhouse effect;
- genetically modified plants and impacts on pests;
- skill levels of farmers and readiness to embrace change;
- indigenous farming – control of intellectual property and knowledge;
- consumer trends eg to vegetarianism and away from wool;
- APEC and the inclusion of agricultural trade; and
- Aquaculture – a key uncertainty.

Source: ASTEC

If the agricultural sector does not achieve environmental sustainability over the next decade it could harm our economy, as agricultural exports constitute one third of all Australia's commodity exports. It could impact on the physical health of many Australians, and many species of plants and animals, with consequences for biodiversity.

Estimates of losses due to land degradation range upwards from $600 million a year. As the then Prime Minister was advised in June 1995 there is every possibility that we will soon reach the point 'if we have not already, where the cost to manage the impact of agriculture, both on-farm and off-farm will exceed the net worth of the industry'. (PMSEC, 1995a)

Global integration has caused major changes in Australia's farming sector. There has been an ongoing decline in producer's terms of trade combined with high exposure to subsidised competition and trade barriers. Some Australian farmers incomes rank close to third world levels and current assessments suggest that less than 30% of our farms are currently economically viable if government subsidies were withdrawn.

A strategy for prosperity in the 21st Century is high quality, high value, niche market farming, 'clean-green food and fibre', but it is hard to market Australian agriculture as clean and green when the international press reports a thousand kilometres of toxic blue-green blooms on the Darling River. (PMSEC, 1995a)

I&CT presents opportunities for the agricultural sector. It provides a mechanism to gain a marketing advantage by monitoring agriculture from 'soil to shelf'. I&CT also enables farmers to access the latest in management information systems and use farm management models to make decisions on stocking levels, fertilisers etc. enables industries to monitor crops and pastures to make real-time assessments of yield and quality, and allows land managers and farmers to monitor emerging drought conditions.

Biotechnology is seen as potentially providing a second 'green revolution' for agriculture – increasing yields and quality to new levels. It offers biological control of pests and weeds over vast regions at little further cost to the landholder, however, initial research is expensive and long-term.

Australian agriculture is land extensive, and although it recorded the highest rate of growth of land productivity (output per unit of land) of any OECD country over the three decades to 1990, its land productivity remains the lowest in the OECD. To the extent that the terms of trade for agriculture are determined to a considerable extent by rates of technological change in agriculture overseas, the survival of Australian agriculture is dependent on its achieving an internationally competitive rate of progress in implementing and managing new technologies. (PMSEC, 1995a).

Fundamental to change is the need to recognise land as a key farm asset that must be valued accordingly. ASTEC explored the implications of altered environmental valuations for S&T in a number of ways including though a scenario for agriculture in the Kimberley (Box 9.9). This is an area of much current interest, eg Australian banks are attempting to develop I&CT-based tools to measure environmental degradation to use in determining loans to the farming sector.

Box 9.9. Agriculture in the Kimberley – A scenario for 2010

Part of ASTEC's study considered the issue of land-use management in the Kimberleys under a 2010 scenario of full environmental costing. The Kimberleys were chosen as a model for the purposes of the Roundtable, to offer participants a diverse yet challenging scenario.

The developed scenario showed the future for agriculture was one of quality production in a mosaic of agricultural and aquacultural land and water uses. The scenario included using a range of plants and animals including: genetically modified species; Australian native products and animals, introduced animals such as crocodiles, cows and prawns; pockets and niches of land and water; and significantly improved management of herbivores. Poly-culture would dominate with different forms of agriculture mixed together in ways which suited both the resources and the ability to handle wastes.

S&T priorities identified for this scenario included the need for greater local knowledge and expertise to manage local ecosystems, infrastructure which takes account of the climate, and better landscape management, including of bushfires and restoring degraded lands. Gaps in the current system were identified as: environmental costing and impact evaluation; management of hot, arid ecosystems; the policy process, involving consultation within the region and clear decision-making based on the parameters of ecologically sustainable development; and policies which recognised the interface between the market and the environment and the capacity to produce incremental change over the next 15 years.

Source: ASTEC 1995i

A significant number of farmers (including the 30 per cent of broadacre farmers who belong to Landcare groups) are beginning to change their practices towards sustainable management. However more needs to be done so that all land users, not just an elite few, manage their land sustainably and reduce off-site impacts. Declining yields and product quality will eventually bring about change, however, there may be a long lead time between deterioration of the natural resource base and declining yields, a forward-looking approach is therefore needed.

Long-term issues for agriculture require Australians to develop strategies addressing issues that include:

- diversification into new enterprises and niche markets;
- upgrading management skills in all sectors to help agriculture remain competitive in the face of declining terms of trade; including ensuring educational and training opportunities for existing land holders in land management;
- developing a framework for governments to ensure rational decisions on issues such as the degree and nature of government intervention, acceptable levels of managed resource degradation and the application of new technologies;
- facilitating major investments in changed land use systems. These include those from the resources of existing businesses and those using government contributions where the public benefit:cost ratio justifies it;
- implementing improved and integrated data collection systems for monitoring trends in resource condition and other sustainability indicators, and how to ensure this information is used effectively by policy decision-makers; and
- addressing difficult issues such as de-stocking of degraded rangelands, reclaiming and revegetating degraded areas to prevent outbreaks of weeds and feral animals.

In summary, the future of agriculture towards 2010 requires us to re-assess national landuse patterns. The nature and condition of Australia's land resources are a fundamental determinant of the national quality of life, and landuse and management are critical considerations in all planning for the future.

From a large set of potential futures, Graetz (1995), developed a set of four plausible scenarios based on the manner in which Australian society might deals with the interconnected set of environmental problems it faces now. These four scenarios are briefly described in Box 9.10.

Graetz considers that 'Australia's national perspective was, until 25 years ago, close to that described for the Lucky Country. In the last 25 years, the national perspective is moving towards the brighter future of either Libertarian or Beautopia'.

The achievement of these possible futures, and the benefits they imply, will require widespread and on-going commitment and a recognition of the positive role of S&T.

Box 9.10. The Futures of a Wide Brown Land: Thriving or Surviving

The use of scenarios can help establish the contexts for decision making in Agriculture and help define the range of possible futures for our farm lands. Graetz, of CSIRO, has offered challenging personal perspectives on futures for Australian landuse to 2020. He considers that the future of Australia is strongly determined by the contribution of S&T to the national cultural perspective, so the application of S&T, which differs within these four scenarios, largely determines their characteristics.

Scenario 1: 'Lucky Country' – 'Most apparent problems are exaggerated'

There is little intervention in the course of events, reacting only to serious threats not opportunities, thereby practicing 'crisis management'. This leads to changes such as an expansion of the area of agricultural lands along the margins in response to enlarging export opportunities, a focus on quantity not quality, and extensification not intensification. Such a future will lead to cycles of land degradation.

Scenario 2: 'Dystopia' – 'things are going from bad to worse'

Landuse change is dominated by the potential for growth in agricultural exports as in the past with a tendency to use simple 'tried and true' solutions for complex problems. Nature (the environment) is considered perverse and in need of regulating while risk is (reluctantly) accepted. As in the 'Lucky Country' scenario, the focus was on quantity not quality, extensification not intensification, because the latter required inputs of information and technology. New but familiar cycles of land degradation began again, with high levels of social hardship. The consequences of the reactionary strategy of land management are significant as intensive pastoralism, extensive and intensive cropping diminishes productive capacity and value.

Scenario 3: 'Libertarian' – 'the future will be better than the present or the past'

There is a desire for more than survival – to do as well as possible. There is a recognition of the positive role of S&T in current progress and an attribution of current problems to the misuse or abuse of S&T. There is a focus on change within the system, but not change of the system itself. The environment is seen as a 'skill-controlled cornucopia'. Translated into landuse policy the Individualist perspective seizes the GATT potential, but in contrast to the two previous scenarios, the focus is on quality, not quantity – achieved though intensification. There is a retreat from unsustainable margins, and more attention is given to enriching profitable agricultural enterprise with information and technology. The emphasis is on – 'not high-tech, not low-tech, but just right-tech!'

Scenario 4: 'Beautopia' – 'A desirable future can be created'

There is an increased ability to design and control our destinies to reach a preferred goal. Coupled to this is a recognition that accelerating rates of environmental, technological and social change requires adaptive management. An articulated national aim is to increase by 50% the export of the highest quality, value-added produce that attracts premium prices in a competitive world. The national landscape characteristics – clean and green – are used to distinguish the Australian produce. Increased agricultural demand is met though intensification, not extensification. The production focus is on distinctive quality. The emphasis is on increasing information rather than energy or material inputs.

Source: Based on Graetz in Eckersley and Jeans 1994

9.4. *Manufacturing and 'High Technology'*

The future holds many opportunities for Australia in manufacturing. In specific niches we can produce high technology goods and services for the world. In others, competitive advantage will come from applying and adapting imported high technology and in developing a deeper S&T knowledge within traditional sectors. There are many strategies for using S&T knowledge, and global competition will increasingly focus attention on our management ability and how we make best use of emerging flexible structures and systems.

The growth in manufacturing world-wide presents an opportunity. Manufacturing has been a significant area of international trade and industrial growth over the past decade, the fastest growing component being the so-called high technology sectors of Aerospace, Computers, Electronics (including communications equipment) and Pharmaceuticals. These sectors have a high 'R&D intensity', or requirement for R&D as an input to business (ie an average ratio of R&D: Production of above 1:10).

If world 'high tech' export growth rates achieved over the 1985-1992 period continued to 2002, exports would amount to about 24% of world manufacturing exports. This growth reflects a fundamental shift in the world economy to an increased dependency on goods and services embodying knowledge (Box 9.11).

Box 9.11. World Manufacturing Exports, by R&D Intensity – 1985-2002 $US billion

Technology Level	1985	1992	1993	2002[1]
High	183.2	505.2	532.4	1768
Medium High	406.0	876.9	865.1	2026
Medium Low	395.5	751.0	729.2	1451
Low	424.2	911.7	871.1	1958
Total manufactures[2]	1414.6	3053.9	3007.1	7220
Total manufactures excluding high tech	1231.4	2548.7	2474.7	5452
High tech share of total	**12.9%**	**16.5%**	**17.7%**	**24.5%**

Notes:
1. Figures are based on continuation of 1985-1992 growth rates.
2. Total manufactures includes minor items not covered by technology classification.
Source: Sheehan, 1995, table 1.1, p 4

Australia has many advantages for manufacturing. We are located in the world's fastest growing market region for manufactured goods. We have a multicultural population base, which could allow us to interact effectively in strategic alliances throughout the Pacific Rim. We have a S&T infrastructure that can provide a competitive advantage in the new world order of manufacturing, with its expertise harnessed effectively to a changing and expanding industry base (DIST, 1995).

Australian high- and medium-high technology production account for a smaller proportion of our economy than most other OECD countries and the level of R&D expenditure is also relatively low (DIST, 1996). These sectors have, on average, high levels of technology inputs (as measured by R&D as a proportion of value-added). Australia's low presence in these high R&D intensive industries is particularly marked in the electronics sector, however, in pharmaceuticals Australia has a stronger relative presence.

However, there are niches of expertise and opportunity in all high-technology areas and Australia has produced a number of specific examples of successful innovative products in aerospace, computers and electronics, and pharmaceuticals.

Given a relatively low level of high-technology production it is important to look at how outputs from high technology might potentially be applied in other lower-technology sectors – in which Australia has a larger industrial base.

Such sectors are closely linked to the processing of traditional natural resources, eg Food, drink and tobacco, Ferrous and Non-ferrous metals, Paper and printing. While they have a relatively low 'R&D intensity', the absolute amounts of money spent on R&D can be quite large due to the large scale of operations. The value of 'knowledge' in their processes should not be underestimated. For example, CRA and BHP are among Australia's top five R&D performers.

There are many opportunities for increasing the 'knowledge' intensiveness of production. This diffusion of technological knowledge can be undertaken by as applying I&CT technologies to increase productivity, product quality or to generate new products, etc. Such potential opportunities require careful consideration in the context of an individual enterprise. An illustration of a company seeking to identify areas of high potential for new I&CT technologies over the next 10-15 years is provided by the resource-linked Australian company BHP (Box 9.12).

Box 9.12. An Industry Foresight Project: Advanced Computing Applications Project.

BHP Research has begun a 3 year corporately funded project to develop a world-class capability in the identification and exploitation of advanced computing technologies in BHP's business operations. Such computational technologies would primarily be assessed on the basis of their long-term potential to substantially transform or revolutionise aspects of our business. The actual project statement is 'to identify and evaluate 3 to 4 applications of emerging computer technologies that have the potential to revolutionise BHP's core businesses and BHP Research within 15 years.'

The objectives of the project are to:

1. Identify: Develop and apply the processes for ongoing identification of business impacts and emerging or embryonic computing technologies.
2. Evaluate: Assess the potential for applying or tailoring the identified technologies to impact BHP core businesses and BHP Research.
3. Alert: Communicate relevant technologies and associated business opportunities early, to maximise competitive advantage.
4. Transfer: Facilitate transfer of successfully demonstrated technologies to core businesses.

As part of the project, BHP plans to review the results of other foresighting projects around the world and also perform some scenario analyses of breakthroughs in computing related technologies which could impact on BHP.

Source: BHP

In addition to applying high technology to develop new business, S&T can be applied as a tool to achieve competitive advantage through developing deep strengths in the knowledge base underlying a business. An example of this is a prominent Australian company which is looking closely at the S&T underlying its future progress (see Box 9.13).

Box 9.13. An Australian Company Looking to the Future

A prominent Australian company in the packaging industry has a large commitment to research and fosters a climate where R&D have become an integral part of keeping ahead of competitors. The company's research capability, built over many years, is particularly strong in areas of S&T relevant to packaging, including fibres and surface chemistry.

Looking to the future the company sees increased demand and an expansion of the world's trade in paper and pulp assisted by trade liberalisation under GATT. Increased demand arises from many areas including: developing nations (eg an expected doubling of paper consumption in Asia by 2010 to equal the demand in the US); demand for printing paper and newsprint despite the growth of the electronics industry; growth in the use of paper in packaging suitable for safe recycling; and the use of composites. This will lead to increased demand for wood and pulp, which in turn requires sound forestry practices. Other future pressures will include moves towards efficient recycling processes to conserve raw materials, reductions in waste disposal and land fill; and higher standards of efficiency, particularly in energy, including energy self-sufficiency. However, a 'closed system' in fibre may not be self-sustaining and there will be ongoing demand for the infusion of virgin fibre.

Critical technologies for competitiveness include the following areas:

1. Materials: renewable materials, composites for severe environments, amorphous materials, photoactive materials;
2. Manufacturing: intelligent processing equipment, robotics, design and simulation technology, quality and reliability technology, processing for extreme environments, laser technology, shaping, joining and assembly technology, non-contact and digital printing technology;
3. I&CT: computer simulation and modelling, machine intelligence/robotics computerised image and voice technology, optical storage, advanced metrology and analysis sensors;
4. Biotechnology and Life Sciences: materials and processes (enzymes, plant cell engineering, genetic engineering, biotechnology based agri-industrial research, biodegradability);
5. Energy and Environment: pollution minimisation, control and clean up technology, waste management, renewable energy, modelling energy & environment, life cycle analysis; and
6. Health and Safety: environment/lifestyle, industrial.

Most promising fields of research in this sector include: recycling wastepaper, eg sensors for sorting qualities for processing and incineration, prevention of virgin fibre degradation in processing, low or zero effluent mills through biodegradability, membrane technology and evaporation, low cost energy, lighter weight high performance packaging structure, eg 'smart' packaging with less material, paper surfaces (including coating and additives) for better computer graphics printing.

Australia's strengths in the pulp and paper industry are in six areas: clean environment, space for development, plentiful resources (energy and fibre), Australia's place in the Asia-Pacific region – including culture and lifestyle, strong industrial R&D base in paper industry, and our strong culture of innovation in paper industry.

Areas where significant achievements are expected include: growing fresh food, eg for Asian markets, supported by an integrated packaging and marketing approach, including: ultra-lightweight high performance packaging structures (paper and composites); and 'active packaging' with specific application atmospheres.

(cont'd)

Box 9.13. An Australian Company Looking to the Future (cont'd)

Significant achievements are expected in very high quality printing and graphics: sharper, high quality coloured imagery, non-impact printing, coatings/additives, paper sheet structure. Another area is in life-cycle analysis to obtain the right balance in such areas as: virgin and renewable materials, environment and energy, and costs and social wants. Significant achievements by the company which can address important needs in Australian economy include: maintaining a clean environment, value-adding to natural resources, increasing exports to improve Australia's balance of payments and assisting to satisfy employment needs for Australians.

Special requirements for success over the next 15 years include: policies for encouraging international joint ventures, cooperative research programs, commercial development, R&D incentives and foreign investment policy in Australia.

Uncertainties and unresolved tensions include: Australia's lack of population policy, APEC and tariffs (Australia and Asia), electronics versus paper, and environmental resources policy. Critical issues to ensure that optimistic achievements are met include: Australian population and immigration policy, collaborative research on an international scale and trade liberalisation developments.

Source: ASTEC industry interviews

9.5. New Business Processes

The role of S&T in business processes, and the potential opportunities for 'high technology', can take many forms. Technology strategies and opportunities over the next 15 years will be transitory and contingent upon many technological and market factors.

This view is reinforced by technology 'lifecycle' and growth wave theories, which suggest that technological needs and the strategic orientation of research vary throughout the lifecycle of a technology. An initial focus on rapid product cycles and a diversity of technical approaches gives way to phases of growth, maturity and standardisation, with innovation related to cost reduction and process efficiency.

Changes will occur in the nature of the products and processes of industry over the next 15 years. Adam (CSIRO, 1995) suggests:

> *'Industrial structures do not change rapidly, but over periods of time there are both incremental and step changes. The trends were already clear in the 1990s to define the nature of manufacturing over the next 25 to 30 years. To understand these trends and changes it is necessary to appreciate the continually evolving philosophy of manufacturing.'*

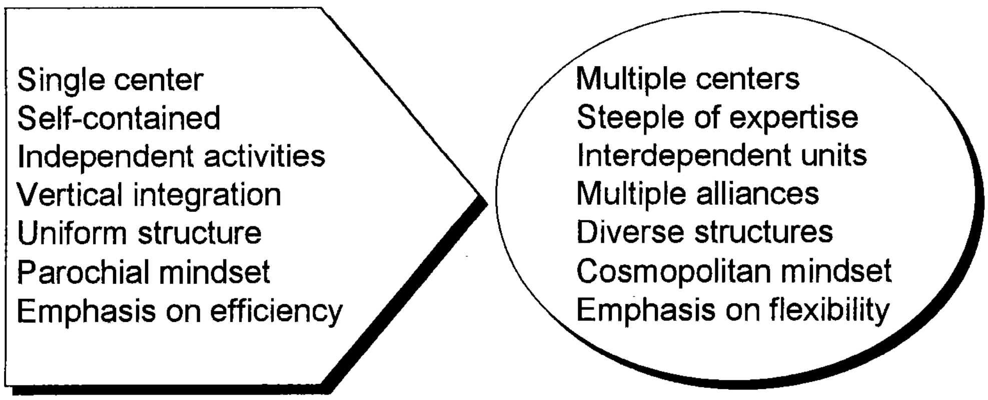
Adam considers that manufacturing will be characterised by capital intensive, small business units closely integrated with suppliers and customers through multi-purpose communication links. These highly automated and integrated units will stress information and knowledge in readily assimilable forms which can be acted upon in real-time.

New opportunities in manufacturing will be very diverse and rapidly changing. Managing change and adapting early stage technology developments, as well as the applying maturing technologies such as I&CT, requires adaptable approaches. This, combined with fierce competition around the world and demanding customers, is bringing about a rethinking of business organisation. One trend suggested in response to these forces is the emergence of a 'flexible organisation' model (Box 9.14).

Visions of highly integrated and flexible manufacturing ventures suggest many other far reaching changes in business organisation and operation, including work practices and skills. Some suggestions of changes that will be needed to realise such visions of global, smart and agile operations include a higher level of 'entrepreneurial-ownership' by all participants in the enterprise. Participants in manufacturing operations might be on-call for 24 hours a day, seven days a week, with their workplace to become more socially oriented. Small multi-skilled teams may become the core of such ventures, so that un-skilled and semi-skilled jobs virtually disappear. There may not be an increase in overall employment levels, despite increases in output.

Box 9.14. The Emerging Flexible Organisation

Traditional Firm **Emerging Flexible Model**



Source: After, Bahrami 1992.

Another important future trend is the greater integration of service and manufacturing. It is increasingly common to see manufacturing firms as driven by excellence in certain specific services activities, often to do with specific knowledge bases, technological expertise or management skills. In this view, the critical management task is to maintain, enhance and develop those core competencies in particular service activities and to plan the development of the business around those core competencies (eg Hamel and Prahalad 1994).

In practice, many manufacturers provide a range of advisory, support and back-up services in relation to products sold, and in many cases the value of these services may approach or exceed the value of goods sold. In some industries, such as the computing and communications industries, the dominant element in export contracts may be the services, advice and support components, with the goods element being a secondary component. This trend is likely to continue, and to spread to other industries, in the future.

The development of new manufacturing technology will clearly be an important area over the next 15 years. Australia is involved in a program seeking to investigate the new possibilities of the technology, the Intelligent Manufacturing Systems (IMS) program (eg Box 9.15).

Box 9.15. A Case Study: Intelligent Manufacturing Systems

New forms of global industry structures are possible given the combined improvements in I&CT and increasing globalisation. One current international program that gives us a glimpse of this future is the Intelligent Manufacturing Systems (IMS) program, which explores many of the potential changes to the internal operation of firms, how they are linked to each other and to their suppliers and customers.

The 'virtual global enterprise' sees 21st Century manufacturing enterprises as dynamic, global, virtual enterprises made up of work units operating autonomously, but cooperatively and networked together by a variety of transactions. These transitory networks form and re-form around particular business ventures. Any given business unit may be participating in several virtual enterprises concurrently, all supported by the same human resource, knowledge and infrastructure.

The IMS program has also developed a vision of the characteristics of such global manufacturing systems of the future. Key Characteristics of 'Next Generation Manufacturing Systems' are:

- customer focused, business oriented;
- reconfigurable, adaptable, flexible;
- modular to support distribution and autonomy;
- support for global design and production;
- human intelligence rich;
- cooperative to support enterprise goals;
- support for virtual enterprise;
- information and knowledge based; and
- environmentally aware.

Such enterprise integration requires the development of an appropriate infrastructure for efficient interactions to take place, particularly through the use of ICT. Systems integration through the development of technologies such as Computer-aided Acquisition and Logistic Support (CALS) can provide a means to develop the necessary infrastructure.

Source: IMS

9.6. *Conclusions*

This chapter explored some potential opportunities for Australia in the 21st Century which were identified through this study. The Key Forces for Change bring opportunities for industry and present problems to be overcome. Innovation, and the productivity improvements generated are, and will remain, a key part of the process of economic growth and technological competitiveness.

The 1980s and 1990s have drawn attention to a small set of industries and technologies marked by a high R&D intensity which are dominated by transnational corporations (the world's 600 largest technologically active companies account nearly 50 per cent of patenting). Australian firms have to find their place in global 'high-technology' markets.

Leaders in innovation in 2010 will be more systematic in their use of innovative techniques. The trend for many will be toward enhanced development, speed and efficiency. This will be assisted by changes in strategy and organisation, including networking between suppliers, customers and collaborators, and integrated data systems such as 'electronic toolkits' to aid design and development.

A wide range of current industry programs are available, but often they do not have a focus on particular components of a business system in the context of longer term needs and opportunities. To succeed in innovation Australian firms need a holistic approach to industry program delivery, including a cross-portfolio coordinated client focus.

Markets and technologies are changing relative costs and pricing. Technologies will change the boundaries of the activities of firms. These shifting boundaries present opportunities for growth and dangers for those not taking a strategic longer term view. Foresight and longer term thinking needs to be encouraged in industry and in financial markets.

To improve Australia's strengths in engineering and provide the knowledge base for the expansion of economic activity in areas such as elaborately transformed manufactures and exporting engineering services will require substantial improvements in the overall performance of university engineering departments, both at the undergraduate level and in research and research training.

It was suggested to ASTEC that we have a relative weakness in engineering education and that there is a need for specific centres of excellence.

The establishment of a small number of world-class engineering schools, capable of producing the high quality graduates, might require the Minister for Employment, Education, Training and Youth Affairs to enter into discussions with State and Territory counterparts and the Australian Vice-Chancellors' Committee.

A specific study looking at engineering in the 21st Century, conducted in partnership with industry may be needed to consider how best to position Australia into the 21st Century.

The current discipline review of engineering education is a valuable step in establishing detailed base-line data from which to plan improvements and to recommend actions.

The evolving nature of business at the beginning of the 21st Century indicates that business needs vary and will change. It is important to ensure that the many Commonwealth and State policies and programs addressing industry, eg those of AusIndustry, recognise the varying needs of business, especially those which are small or medium-sized. In the future, there will be an even greater need to look at specific and targeted advice and assistance.

It is critical that those opportunities which have been identified are tested further to assess their potential and Australian industry needs for 2010.

Area for Action:
Developing S&T-based Businesses for the 21st Century

ASTEC considers that there are a range of potential new businesses and markets for the 21st Century that have a significant science, technology and engineering base. There is a need to ensure that Australian businesses are able to effectively use S&T as an integral part of company operations as a means to establish core business growth in future years. A knowledge of international S&T developments and trends in new applications is important to developing long-term business strategies in all sectors.

While it is for the private sector to identify and pursue business opportunities, there is a significant role for governments to provide information about emerging industry and technology developments and to facilitate the exploration of opportunities; and to develop incentives for public sector organisations to undertake R&D and make the best use of S&T.

ASTEC considers that relevant S&T Agencies and industry organisations might consider actions to collect and disseminate information on emerging characteristics of new businesses and industries, including information on the complex relationships between S&T and economic growth in specific sectors; the development and application of S&T to underpin the export growth in service industries.

Chapter 10. Impacts for Government

10.1. Introduction

ASTEC's four Key Forces for Change – Global Integration, Environmental Sustainability, Applying I&CT and Reshaping Biology – will combine together to produce unforseen pressures on governments at all levels in Australia and across the world.

This chapter explores how these forces could, separately and combined, impact on Australian governments over the next 15 years. It considers how S&T might contribute to a more effective response in a number of areas including: the provision of urban water, changes to defence R&D, national policies for I&CT and medical research related to aging. The chapter emphasises government's role as a user, rather than as a provider, of S&T.

Perhaps the most significant change to national government to 2010 will be from Global Integration. The history of the late 19th and early 20th centuries was one of nationalisation: smaller regional economies being converted into national economies and local and regional governments being amalgamated into national states. There is now a similar process of internationalisation of national economies and nation states as a result of the new global technologies of telecommunications and computerisation. These changes create new challenges for the nation state because they challenge its territorial basis.

Concerns about environmental issues are driving bilateral, regional and international agreements on issues from air pollution to climate change and forest management. Responses to these issues go to the heart of a nation's economic activity targeting industrial production in areas such as energy, transport, mining and waste management. Global agreements on environment issues require countries to specify national action plans and contribute resources to global programs. They may involve international agencies as well as regional institutions.

Large global companies could reduce the power of national governments to influence global commercial interests. There will be new ways to circumvent government authority by, for example, taking certain activities offshore. This raises concerns about governments ability to fund their ongoing services and the Australian Taxation Office is currently examining these issues. If large companies are able to circumvent national taxation laws this may seriously impact on government revenue and further weaken the capacity of a national governments to stand up to large global companies.

The revolution in biotechnology sets new tasks for government, such as how to protect yet benefit from Australia's unique biota. How much control is appropriate? This will require sophisticated risk management strategies and improvements in community decision making.

10.2. Governments' Changing Role

In the last quarter of the 20th Century, international relations have been dominated by several emerging inter-related political trends: the collapse of communism; revival of nationalism; growth of regionalism and greater emphasis on the value of market forces. The world is currently in transition from a relatively stable 'Cold War' situation to one that is less predictable.

Currently the United States is the only superpower, but by 2010 their unique position may be rivalled by China. As US dominance declines, other developed countries must decide whether and how they should take greater responsibility for world stability.

Global organisations, often under the umbrella of the United Nations, are increasingly fulfilling some of the functions previously the preserve of national governments. This expansion of international organisations in response to a range of regional and global threats is leading to a strengthening of the UN system. This could lead to: expansion of the Security Council to include Japan, the creation of a permanent UN peacekeeping force and creation of an international monitoring agency under UN auspices to monitor governments compliance in areas such as arms control agreements, regional military restraints and environmental standards. It could also lead to the establishment of an electoral monitoring agency, the creation of a Human Rights Court and the establishment of a new Environmental Council

Regionalisation is seen as a preliminary to the fuller introduction of globalisation. (Ruthven, 1994). Certainly there is a rapid acceleration in the establishment of regional economies and trading blocs leading to de facto regional government. This does not necessarily imply the end of national decision-making, but there is no doubt that a higher tier of government is being added.

The European Community (EC) has developed to the point where the aim of establishing a single European market without barriers to the movement of goods, people and capital between member states is virtually a reality. Equally important is the North American Free Trade Agreement (NAFTA) between the United States, Canada and Mexico.

The internationalisation process continues with the formation as recently as July 1993 of the East Asia Economic Caucus (WEAEC), which will operate as a caucus within the wider Asia Pacific Economic Cooperation (APEC) forum, which also includes all NAFTA members.

In the Middle East, the Organisation of Arab Petroleum Exporting Countries (OAPEC), the Gulf Cooperation Council and the Arab League combine economic and security interests which may have the potential to form the basis of regional government. In Africa, the Organisation for African Unity (OAU) includes all African states except South Africa, Western Sahara and Morocco.

At the same time there has been a rise in local conflicts including hostility towards ethnic and religious minorities following the break-up of the Soviet empire and conflict in the former Yugoslavia. Large flows of cross–border migration in central and eastern Europe raise concerns by some that 'ethnic cleansing' may spread more widely. There are flash points in southern Africa and parts of Asia and it is possible that India may divide again.

In many developed countries the State has been shedding commercial functions: this trend to privatise nationalised industries may continue. Ideas about the appropriate size of the public sector may shift further down, with governments increasingly expected to achieve their aims by regulation, not provision. What remains within the public sector is likely to be much more subject to market discipline than at present. Box 10.1 puts forward four scenarios for state government in to the 21st Century.

Taxation levels are predicted to remain an issue, particularly in Europe, as demographic changes increase the cost of benefits. During the 1990s the State appeared willing to try to influence social behaviours which have high social and economic costs such as drink driving: Will societies in the 21st Century go even further in this direction?

Governments around the world, on both sides of politics, are seeking to foster the 'knowledge sector' of the economy. It has been suggested that as knowledge and information become the key factors of production, politics will fracture along a new fault line between the 'haves' and the 'have nots' in the knowledge sector (BCA, 1995).

A number of global trends could be reflected in domestic Australian politics. For example environmental issues could lead to the emergence of one or more 'new' parties. Changes to employment, such as reductions in the percentage of full-time employees, could challenge the natural constituency of the Labour Party. Australian governments could be led by minority parties, with a more volatile, less predictable situation as alliances change during a governments term of office. Women's perception of the practical commitment of political parties' to increasing the participation of women in the political process at all levels may cut across these factors.

Box 10.1. Four Scenarios for State Governments in 2010

The following four scenarios were developed for the US in the 21st Century. However they can be used as indicators of possible changes to the role of state governments in the Australian system. They range from an optimistic extrapolation of recent ideas about how to reinvent government to a gloomy image of a future where state governments are small, beleaguered, overwhelmed by responsibilities and severely under-financed.

SCENARIO ONE: THE ENTREPRENEURIAL STATE	MACRO ELEMENTS
State governments have become lean and efficient. Most agencies and programs have clear missions and priorities. Accountability measures have been developed that focus on both social benefits (effectiveness) and program costs (efficiency). State governments use various strategies to improve their performance and the quality of services: privatisation, decentralised management, market-based incentives and user fees, and broadly dispersed technology. Many health and social service programs are contracted to community-based organisations with clear performance-based standards; traditional business services and economic development programs are provided by voluntary associations (such as, industrial networks) on a fee-for-service basis; and new market-based incentives and pollution taxes achieve environmental protection with greater efficiency and public benefits. Former civil service systems have been abolished or radically transformed: satisfactory job performance is required to ensure job security for state employees and the only work rules that remain relate to public health and safety concerns. Substantial resources are invested in training and retraining workers to assume new responsibilities and shift to different jobs.	ECONOMY • Slow in 1990s, better in 2000s • Restructuring improves productivity PUBLIC ATTITUDES • Demand for accountability • Support for innovation FEDERAL ROLE • Level funding to states • Greater cooperation in innovation • Reduced regulation STATE ELEMENTS: SCALE • Like 1994 NATURE • Lean and efficient • Clearer missions and priorities • 'Reinventing Government' • Emphasise on training

SCENARIO TWO: THE WITHERING STATE	MACRO ELEMENTS
State governments have become much smaller than they were during the 1980s. They retain direct responsibility for the criminal justice system, transportation and public health: but they provide relatively few direct services and often not of high quality. State governments resemble holding companies: formula grants to localities constitute most of their budgets they also contract with providers, communities and non profit organisations to provide services. Careers in state government are neither adequately compensated nor highly regraded. Federal regulations for categorical programs narrowly limit the discretion of managers. The growing dissatisfaction with government and increasing tax revolts have kept resources modest and constrained the opportunity to design any new initiatives. The public has little confidence in any level of government but state and local governments are rated lower than the federal government in public opinion surveys.	ECONOMY • Moderate growth • Top twenty do best PUBLIC ATTITUDES • Loss of faith in state government • Turn from 'public goods' to 'privatisation' FEDERAL ROLE • Reduced funding STATE ELEMENTS: SCALE • Much reduced – only transportation, justice, public health NATURE • 'Holding Company' • Low innovation • Job insecurity, low pay and status
SCENARIO THREE: THE RESTRUCTURED STATE	**MACRO ELEMENTS**
State governments in the year 2010 have primary responsibility for education, health services, housing, community and economic development, employment and training, social services, airports and roads. Moreover, they are excelling at assuming these broad responsibilities, demonstrating high levels of planning, coordination and management. Additional public resources combined with the elimination of federal regulations for hundreds of categorical programs have given state officials and managers tremendous flexibility and autonomy in shaping domestic policy and in designing programs creatively. The federal government had gradually withdrawn from these policy areas, beginning with the Reagan administration, and had accelerated its withdrawal in the late 1990s and early 2000s after the Common Shared Taxes plan began to provide additional federal resources to states. As part of this restructuring, the federal government assumed full responsibility for income support (including welfare) and medical care programs.	ECONOMY • Moderate to good growth • Productivity surge PUBLIC ATTITUDES • Demand for rationalisation • Environmental concern • Stronger communities FEDERAL ROLE • Ample funding • Federal withdrawal STATE ELEMENTS: SCALE • Larger size, more roles NATURE • Good planning, management • 'Reinventing government' • New technologies for training, cooperation, services

SCENARIO FOUR: THE BELEAGUERED STATE	MACRO ELEMENTS
State governments are small, beleaguered, overwhelmed by responsibilities and severely under financed. They have relatively few highly skilled professionals and much of their work force is marginally productive. Two decades of effort to reform and liberate the civil service system have produced meagre results. This is particularly evident in states with large, politically active public service unions. State governments are still bogged down by the tedious regulations that govern the few remaining federal categorical programs. They receive little federal support in 2010 because so many of the domestic programs established before 1980 had either been eliminated or drastically reduced during the 1990s and 2000s. Furthermore, the revenue bases for state governments are much smaller in 2010 because of the frequent tax cuts made by conservative governors and state legislators during this period.	ECONOMY • Poor PUBLIC ATTITUDES • Frustration, cynicism, anger toward government FEDERAL ROLE • Minimal influence, no resources STATE ELEMENTS: SCALE • Truncated NATURE • Most states flounder • Some innovate • Employees resist change, training declines

Source: Bonnett and Olson 1994.

This section explores four of the many trends that government might have to face in the 21st Century. It is not a comprehensive analysis, rather it illustrates four possible areas of change.

a) A Stronger International Focus for Federal Government with a Need to Redefine National Sovereignty

Australia will benefit from a growing Asia in part because of its long history of being able to deliver political stability. However as national borders become less important, bilateral and multilateral alliances with other countries become more important. Australia has long developed ties with New Zealand, Papua New Guinea, our neighbours in the Pacific and more recently with Asian countries through the APEC forum.

With each of these associations, national sovereignty is traded for the positive benefits of group membership. This requires a new look at what is best for Australia. ASTEC suggests the need for a national dialogue on the role of national sovereignty into the 21st Century as an essential part of the current 'republic debate'.

Nation states are now locked in fiercely competitive struggles to attract international investment with this competition focused on labour, infrastructure and regulatory costs. Yet, increasingly governments of industrialised countries are reducing their involvement in financing and provision of public infrastructure.

The culture of smaller countries such as Australia is seen to be under threat from new developments in I&CT and the Prime Minister's Culture Statement in 1994 identified the retention of a unique Australian culture as a high priority. Australians are concerned that the flood of new information will be poor quality homogenised global culture and see an important role for government over the next 15 years to protect Australia's unique values and heritage.

Managing the changing 'domestic-international' interface will be an increasingly complex area of policy development. Governments will need S&T to support their own knowledge systems and to ensure they have appropriate, reliable information to inform decisions across a broad spectrum of areas.

Increasingly international conventions will require S&T expertise. This may be an area where Australia wants to provide additional support, eg for S&T experts to participate in secretariats to Conventions and international institutions. Extra leverage, networks and international experience comes from such collaborations. Over the next 15 years it will be important for Australia to argue well informed national positions on many issues: this will require S&T experts who comprehend political processes.

b) Changing Roles of Commonwealth, State and Local Governments

The division of powers between the Commonwealth and states agreed one hundred years ago may not be appropriate in a world where decision making is increasingly at a supra national level. State and federal governments will need to work together in reconstructing our economic, political and social institutions to meet the challenges of the 21st Century.

It has been suggested that merging of the roles between Commonwealth and States is likely to be focused around current mechanisms such as Ministerial Councils and COAG (the Council of Australian Governments). There is a need to ensure that all such mechanisms, including new institutions, consider the changing needs for S&T in their areas of responsibility.

Trends towards regionalisation may grow in significance as a result of a number of developments. Environmental issues may impose limits on larger cities such as Sydney. New capacities in I&CT will allow workers to be situated far away from base companies. There could be community reactions to the enormity of globalisation resulting in a strong preference to be treated as local communities. Local councils, currently unable to afford the infrastructure necessary to meet new requirements in waste management and other areas, are grouping together to form regional councils. This new and more powerful level of government, particularly suited to communities located away from major cities, may bring new demands for regional development.

Urban water is an example of one issue where action at all levels of government will be critical. The ASTEC study of this matter concluded urban water should be considered in an holistic way and that all governments must recognise the importance of efficient urban water systems, and assist the establishment of collaborations in urban water matters.

c) Differences in the Way Governments Interact with People

Fifty years ago the community elected political parties to govern for a set period on their behalf. However I&CT has improved the capacity for professional lobby groups and even ad hoc community groups to demand immediate government action on specific issues. Some have argued this trend, combined with developments in I&CT, will allow citizen based referenda where people can vote from home on issues expecting an immediate government response.

It has been suggested that the next 15 years will see the rise of very strong consumer organisations. Advances in I&CT will allow people to group together to form powerful lobby groups to change decisions in governments and industry. This greater consumer power would lead to changes in industry and government processes and policies. S&T could provide important constructive input to new decision making processes. However for this to occur the community will need to become more expert in S&T issues.

d) Relations with Industry

Traditional regulatory instruments employed by national governments will not be adequate to policing this new world and nation states are starting to cooperate in the creation of international institutions of governance. In Europe the competition policy of the European Union is leading to the creation of a supranational electricity industry with regulatory power increasingly moving out of the hands of national governments up to the regional level. While this final upwards shift in the electricity industry is unlikely to take place in Australia it is likely that Australia might become subject to international reporting on its public services such as electricity.

Governments use regulation for a variety of purposes, including the promotion of economic well-being and the protection of consumers, investors and employees. The regulatory framework in areas such as telecommunications, financial services and environmental protection is a major determinant of competitiveness. In some areas, advances in technology may challenge existing regulatory arrangements. Those frameworks which anticipate the dynamics of an industry or which help to force the pace in reaching decisions about standards, are among the ways in which nations can bid for competitive advantage.

National and supra-national Governmental bodies need to provide frameworks that move in sympathy with the rapid pace of technological change. New technology creates difficult challenges for regulators, eg in the field of new electronic media where copyright and intellectual property issues spotlight the need for novel forms of protection.

Governments which can establish effective and competitive new partnerships with the private sector might have an edge in the global market place. This includes the provision of a much wider range of public services on a non-territorial basis. For example, contract prison services and waste management in Australia are increasingly in the domain of trans-national corporations with high investments in technology.

By world standards, and particularly by the standards of the Asia-Pacific region, Australia has an exceptionally well-developed public sector. The capacity to create entirely new industries by exporting these services in partnership with the private sector is immense. However the growth of Australia as a vibrant node in the Asia-Pacific requires governments ensure adequate attention is given to S&T education and infrastructure.

10.3. Case Studies for Government S&T Businesses in the 21st Century

Challenges for government related to S&T over the next 15 years will be in many areas. The following discussion explores four of these. It looks at the challenge for Australian governments to work together to provide high quality water for Australian cities that is based on a shared understanding and detailed knowledge of ecological processes in the urban water lifecycle. The Chapter also looks at the challenge for national governments to maximise the benefits to their country from global developments in I&CT.

Defence is another area of turmoil. It has traditionally played a major role in supporting S&T developments, particularly in the US. How will this change over the next 15 years and what will be the most appropriate policies for Australia in these circumstances? Another critical issue for governments of developed economies is their aging populations and how to the challenge of handle neurodegenerative disorders and aging. This issue raises social questions about quality of life and euthanasia. How can S&T help governments prepare an appropriate response to these issues?

There is an important role for the public sector in promoting S&T in Australia, indeed Australian S&T is dependent on government for the environment in which it can grow. It will be critical to maximise this over the next 15 years.

a) *The Urban Water System*

The urban water system in Australia is undergoing profound change due to a widespread recognition that there is a limit to available water in Australia. Environmental sustainability is the main challenge to current operations in the urban water system, although globalisation will also bring many changes in the 21st Century.

As part of this study ASTEC gathered a group of organisations representing all aspects of the urban water system to assess the contribution of S&T to issues in the urban water system over the next 50 years and test the use of foresighting techniques for long-term planning.

Four plausible, possible futures for Australia were developed at workshops in Adelaide, Brisbane, Sydney and Perth:

- *Market World* – The Australian public sector has been fully privatised. Water is provided by a large number of retail suppliers drawing from a common 'spine' supply that is fed by various water sources and producers. In this scenario rampant privatisation of the urban water system required government legislation to guarantee minimum access for needy consumers. Environmental and health concerns are minimised and addressed through market-based mechanisms. Data secrecy acts as a limit on S&T. Innovation is directed towards cost reduction and ownership by global companies neither guarantees 'public good research' or that research will be done in Australia.
- *Eco-Event* – The steady build-up of ecological problems and crises worldwide has driven dramatic change. In Australia, all infrastructure projects are required to follow ecologically sustainable development principles. While this may act as a catalyst to a range of innovation in the urban water system with long-term benefits for Australia, water is not the only environmental product that has been badly affected. The disasters lead to the full internalisation of environmental costs: the price of water has risen but this is offset by successful demand management and innovative technology for water re-use. Innovation is targeted to meet rising environmental standards with lower priority for economic, social and health concerns.
- *Public Health Crisis* – There are overriding concerns about threats to public health, including the emergence of new pathogens, the drug resistance of existing pathogens and the exposure of people through air travel to increasingly frequent international epidemics. This future is driven by the rapid spread of epidemics globally and a perception that public health problems are out of control. Whilst this scenario focuses innovation in health related S&T, it would be a trade-off against national environmental quality. This scenario also proposes heavy social restrictions eg on pets and recreation.
- *Slow Deterioration* – The current system is in decay. A future in which there are no overriding events to force change and little public money is available for maintenance and repairs to the existing system. Lack of public finance and no particular crisis to force change lead to a continuation of current thinking and slow spiralling down of services for Australian communities. S&T is kept to the lowest level.

The four scenarios are all plausible, but they are not predictions of the future, nor are they statements of desired visions or goals.

The partnership agreed that the main drivers of change in the urban water system will be the demand for new services. There is the greatest uncertainty about where this demand will come from. Will it be from privatised water companies, environmental demands, or health concerns?

Each of these requires different priorities for S&T. From an analysis of these scenarios the Partnership was able to identify priorities for S&T which are described in Box 10.2.

Analysis of the scenarios led the Partnership to agree that the present strategy of splitting the urban water cycle into a whole range of different elements has now outlived its usefulness. There is a need to develop a whole system or life cycle approach to encourage thinking in a more systematic way. This will require governments at all levels to work more closely together, and with the S&T system, in a fuller appreciation of the complex ecology of the urban water lifecycle.

Box 10.2. Priorities for S&T in the Urban Water System

ASTEC's Partnership on Urban Water identified a number of S&T priorities for the industry.

i) The Urban Water Lifecycle

Studies of the whole urban water lifecycle are necessary to quantify the water valance and the mass balances of pollutants. There is considerable knowledge of individual components of the cycle, such as water use in the home, but when all the information is collated gaps appear. Modelling of the whole lifecycle will allow all the implications and interactions of any management initiatives to be evaluated. Similarly mass balances of pollutants will allow better targeting of pollution reduction programs.

ii) Aquatic Ecology

The ability to divert fresh water from the environment for consumptive use, and the ability to return treated effluent to the environment in a sustainable way depends on knowledge of the particular freshwater or marine ecology. The ability to measure the ecological health of modified environments and develop strategies for improving their health is critically dependent on ecological knowledge. Numerical models of particular freshwater and marine environments should be developed so that predictions of future behaviour can be made.

iii) Stormwater

In the past flooding and drainage were the focus of stormwater studies. Water quality and yield have been neglected until relatively recently and the long-term data that is required to understand catchment behaviour is often absent. Studies of the sources and behaviour of material as they move down the catchment is required.

iv) Form of Urban Development

Current studies of the costs of urban development indicate that innovation in the design of urban environments has the greatest potential to improve both environmental sustainability and cost effectiveness in providing water supply, wastewater and drainage services. The layout of housing can effect the ability to construct settling ponds, retarding basins and storages to harvest stormwater. Layout also impacts on the cost of both water and sewer reticulation. Recycling and dual reticulation of different qualities of water is more feasible if considered as part of the overall design of urban development.

v) Technology of Water Using Appliances

Systems for managing human waste that use considerably less water or no water at all exist and initiatives such as more water efficient toilets have already yielded significant benefits. The application of 21st Century technology to the problem could make significant improvements. Innovation in all forms of domestic water use, dishwashing, clothes washing, showers and garden irrigation could yield more efficient services at lower cost.

(cont'd)

Box 10.2. Priorities for S&T in the Urban Water System (cont'd)

vi) Smaller Scale Wastewater Treatment Systems

If more distributed wastewater treatment systems with consequent increased opportunity for recycling are to become cost competitive with the large treatment systems a sharp reduction in unit cost will be necessary. Investment in small scale technology (neighbourhood scale) could yield technology that would give a lot more options to the designers of urban water systems with consequent benefits to sustainability.

vii) Smart Operational Technology

Given the massive investment in water distribution and sewage collection systems improvements in the efficiency of operation can yield significant benefits. Balancing the load on sewage treatment plants to make optimum use of total plant capacity is a good example. Surveillance, control and data acquisition systems are becoming more cost effective and there are rapid developments in the technology. Application of this technology to water and wastewater systems has great potential to improve the cost effectiveness of operations if properly targeted. Smart metering even of individual customers is becoming more feasible as the information Superhighway gathers momentum.

viii) Reducing the Replacement Costs of Pipes

Sewage reticulation is a massive investment: about half the investment required for the provision of wastewater services. These progressively increasing costs of pipe replacement will become a major driving force in innovation. Water reticulation makes up about a third of the investment required to provide water supply. There are opportunities to further develop trenchless technology to replace sewers in situ and innovation to reduce the replacement costs of small pipelines has considerable potential benefits. Reduction in the leakage from both systems will also improve environmental sustainability.

ix) Epidemiological Studies relating Water Quality to Public Health

As detection techniques for micro contaminants in water improve, and community concern about exotic diseases, cancer, Alzheimer's Disease, etc. grows, there is a need to relate drinking water quality to public health through epidemiological study.

x) Water Treatment and Disinfectant Technology

Concerns expressed about the possible long-term effects of chlorine, alum, etc. increase the need to develop disinfection systems that are less dependent on chemicals or do not require chemicals to be effective. Given the massive expenditure on this field internationally careful thought would have to be put into how Australian effort could best be organised.

Source: ASTEC 1995c

b) I&CT

A recent area of government attention, that will set many new challenges for national policies over the next 15 years is I&CT – a global technology. Balancing national benefits in a global framework, where technologies are constantly changing and national borders are increasingly difficult to enforce will present new challenges for Australian governments at all levels. A summary of the state of the Australian I&CT industry is provided in Box 10.3.

Box 10.3. Australia's Information and Communications Industry – a Summary

Information technology is a widely accepted part of Australians daily lives, with 23 per cent of households frequently using a computer at home. Also, 4.4 per cent of homes have a fax machine and 3 per cent have a CD-ROM (ABS survey Household use of IT). Mobile telephony has been very rapidly adopted. Estimates by the BTCE suggest that by 2010 there will be 4.5 million PCs in Australian homes. Australia, with its sophisticated technology market, is seen as a testing ground for products from European and Japanese vendors providing Australia with early access to the latest technology. Australia is also viewed as a useful base from which to enter the growing Asia-Pacific market. The information technology industry in Australia in 1992-93 was dominated by low-profit, small and medium enterprise firms. For example, it included: 9500 businesses; 7200 specialist businesses employing 137,000; $30 billion gross income — 88 per cent with less than $100,000 operating profit; 88 per cent of specialist businesses employed less than 10 people, only 1 per cent have more than 100 employees (Australian Bureau of Statistics, 1995, 'Information Technology in Australia'). The majority of Australia's top 10 ten IT companies are local operations of multinational companies.

The Australian telecommunications sector has undergone a substantial growth and transition from a domestic orientation to a much more export-oriented industry. Export grew from $160 million in 1989 to $468 in 1992-93, accompanied by a large investment in manufacturing technologies. Australia imports much more information technology than it produces leading to a substantial trade deficit particularly in hardware – imports $5.5 billion (hardware $3.7 billion), exports $1.8 billion (hardware $820 million). Business R&D expenditure on 'Information and Telecommunications Technology' in 1992-93 was $930 million, 50 per cent of the total R&D expenditure of manufacturing industry. $635 million of this was for computer software R&D.

Strengths

- political and economic stability
- innovative and creative people, particularly in software
- educated workforce, substantial skills and knowledge base
- well developed transport, services and research infrastructure
- solid grounding in telecommunications expertise and sophisticated users such as the finance sector
- proximity to, and experience in dealing with, growing markets in Asia
- lower wages for skilled employees, such as engineers, relative to other advanced economies
- low cost of living, lower executive salaries and office rentals compared with other corporate headquarter sites in Hong Kong, Singapore and Tokyo

Weaknesses

- small local market and distance from markets
- difficulties in obtaining finance
- limited domestic supply of components
- occasional skill shortages
- small scale of many businesses

Source: Industry Commission, 1995b

Governments are interested in fostering the developing information infrastructures and must also address access and equity issues. They have a role in developing standards, determining privacy issues, developing legislation on security and considering cultural issues, and censorship. They must also consider their own role as an information provider. Some of the issues which must be dealt with are identified below.

In general, OECD countries consider the financing of information infrastructures to be the responsibility of the private sector. It is thought that by introducing or expanding competition private investment will be stimulated thus ensuring cost-effectiveness, lower prices as well as improved and widened services. However, governments can stimulate private investment by providing tax incentives, and loan guarantees; and additional public funding can be provided for commercially non-attractive projects in rural areas or specific facilities for the disabled and the elderly. Achieving the 'right mix' will be a difficult challenge given constantly improving technologies. An outline of how some governments are approaching these challenges is given in Box 10.4.

Experience shows that competition is important in reducing prices. However, a recent OECD report suggested that existing telecommunication tariff structures for access and use of information infrastructures, especially in monopoly markets, hinder the development of dynamic markets. Even in markets that have recently liberalised, prices do not appear to be low enough to stimulate new applications. The issue of tariffs is an important issue requiring further examination in national information infrastructure policies.

The relationship between the different institutional needs of both the private and public sector must be defined clearly to address issues such as open and equal access and competitive interconnection, including for developing nations. Particularly important is the need for harmonisation of international rules for security, privacy and intellectual property rights. Encryption policy is currently a major issue in the US and Europe and multi-lateral dialogue is needed. Involvement in international policy is being headed in Australia by the Attorney-General.

To maximise the potential provided by information infrastructures, interoperability of networks must be attained on a national and an international level. Standardisation is essential to achieve interconnection and interoperability. Being aware that setting standards can provide a competitive advantage, governments want to co-operate more closely with industry and standardisation agencies. Australia will need to increase its involvement in international debate on the harmonisation of international regulations for security, privacy and intellectual property rights.

Box 10.4. Information and Communications Policies in Different Countries – a Summary

Governments are supporting the development of information and communications industries through a variety of policy initiatives, including the provision of incentives for large multinational IT&T companies to establish local operations, funding skills transfer (including R&D, product development, manufacturing, management and marketing) and research collaboration. Governments themselves as major purchasers of information technology and communications products and services can significantly affect the growth of small firms through their purchasing policies, eg US defence related purchasing. Below is a summary of activities in a number of countries which are designed to ensure effective infrastructure development to support new information flows.

The **United States** National Information Infrastructure (NII) galvanised world attention on the 'information super highway'. A Information Infrastructure Task Force has been established to articulate and implement the NII vision.

(cont'd)

Box 10.4. Information and Communications Policies in Different Countries – a Summary (cont'd)

The **Canadian** government is developing an Information Highway strategy with an Advisory Council. Policy objectives include: creation of employment through innovation and investment in Canada; reinforce Canadian sovereignty and cultural identity; and, ensure universal access at reasonable cost. The strategy's operating principles are: an interconnected and interoperable network of networks; collaborative public and private sector development; competition in facilities, products and services; and, privacy protection and network security.

The **United Kingdom** Technology Foresight program identified two key priorities for the information and communications sector: encourage investment to support the direct growth of the industry in line with global expansion, ie to 10% of GDP by 2005; and develop capabilities in particular technologies pertinent to growth of existing and new businesses to provide an additional contribution of 2 per cent to GDP. It also recommended the creation of a national 'Information Super Highway Initiative' to secure the UK's position as one of the top three players in the construction and exploitation of the emerging highway.

The **European Commission** has endorsed further liberalisation of the telecommunications sector to enable a European 'single market' by 1998 and advocates a new form of public-private sector partnership to implement the recommended action plan. The report identifies the needs for action on several issues including standards to facilitate interoperability, protection of intellectual property rights, data security and competition policy. Such actions can help support the development of 'demonstration' applications to jump-start initial supply and demand, including: teleworking, distance learning, university and research networks, networks for SMEs, road traffic management, air traffic control, health care, electronic tendering, trans-European administration network and connection of households to multi-media services. The European Commission has begun a three year Imprimatur program to achieve agreements on identification data numbers for electronic intellectual property rights, similar to the ISBN identification numbers.

Denmark's *An Info-Society 2000* report has been released. The principal aim is for the public sector to work with the private sector on a proactive strategy for Denmark's development towards the information society; the public sector is to lead in efficient use of information technology.

Major **Japanese** developments include establishment of a optical fibre network (trunk lines to be completed by 2010) and the development and diffusion of public services based on multi-media applications. It has been estimated that by building a nation-wide fibre optic network for broadband (fibre-to-the-home), the multimedia market plus regular telecom market will attain a level of approximately 123 trillion yen ($US1,230 billion) in 2010. There are challenges are being faced in how to finance the proposal.

Three huge 'golden projects' have been initiated in **China**. The three projects – Golden Card Project, Golden Bridge Project and Golden Customs Project – will form the basis of China's information infrastructure that will advance the national economy well into the next century. These projects will be interlinked by an integration of a satellite network and the terrestrial network into a national public economic information network. The project will be a 'broadband network' at its completion in 2010.

The National Computer Board of **Singapore** is working to implement its 'Vision of an Intelligent Island' (1992). This vision is of a highly 'informatised' society in which information technology and broadband networks are used extensively in all sectors of society. The vision focuses on developing Singapore as a global hub for services, transportation and business.

c) *Defence*

Defence has traditionally been seen as the responsibility of national governments and has been used to stimulate national R&D. Changing international relations will require new ways of thinking about issues such as defence, particularly in smaller countries such as Australia.

While some predict that the new 'post Cold War' world order signals a lesser role for national defence there is a rise in the potential for local conflicts. This might change the type of S&T required by countries whilst concerns about environmental issues are limiting options for chemical and nuclear weapons.

The UK Technology Foresight study identified many changes in the global security situation, including the collapse of the Warsaw pact, growth in regional powers and conflicts, unstable regimes and a reduction in defence budgets in many countries. The nature of warfare is also changing and conflicts are increasingly won by rapid advances in cutting edge technology. The UK foresight panel recommended that seven key technology areas be given high priority by industry and the science base when deciding research funding allocations:

- systems integration eg for prime contractors;
- process technologies eg reduce time and cost to market by design, lean manufacturing, concurrent engineering;
- materials and structures eg in areas where access to overseas technology is denied;
- simulation, modelling and synthetic environments;
- aerodynamics eg computational techniques, emissions and noise;
- sensor systems, data fusion and data processing, eg surveillance, command and control; and
- high-integrity real-time software eg development and demonstration of tools, methods and processes.

The Australian Defence White Paper 'Defending Australia' identified two key elements in Australia's defence posture: geography and technology. Concerning the latter, the specific key technology areas in which Australia should achieve excellence were suggested as:

- intelligence collection, evaluation and distribution;
- surveillance and reconnaissance;
- command and control;
- key weapons and sensors; and
- electronic warfare.

Many of the key technology areas are strongly influenced by I&CT developments. Our increasing dependency on ICT infrastructure makes us vulnerable to new threats such as 'information systems warfare'. Developments in genetics and biotechnology add to the risk of new threats from biological and chemical weapons. The Australian emphasis on geography also indicates a need for detailed environmental information and research, eg hydrographic and oceanographic information areas are identified as priorities.

Other developments over the next 15 years, such as the establishment of a standing army under UN auspices could also catalyse changes in defence procurement with new opportunities for Australian defence ideas and industries.

Historically, the US Government has encouraged technology development through its investments in defence and space, which were expected to trickle down to civilian industry.

This is in sharp contrast to Japan and other developed nations where support for commercial technology has been greater. The United States has sought to meet the changing global defence, and economic, situations by improving the links between defence related R&D and industry. President Clinton's 1993 Technology Plan sets the target for increasing the ratio of civilian and dual use R&D to purely military R&D in the Federal R&D budget to 50% by 1998 (from 41% in 1993). This represents an increase of about $10 billion in civilian R&D.

d) Aging – Neurodegenerative Disorders

As part of this study ASTEC joined with the National Health and Medical Research Council (NHMRC) and the Council of the Aging, to study the contribution of S&T to managing neurodegenerative disorders (NDDs) of older people to 2010. These disorders are considered likely to become a priority health issue as Australia's population ages in the first half of the 21st Century. Four neurodegenerative syndrome areas were targeted by the study: motor instability and balance failure, cognitive impairment, motor slowing and sensory impairment.

More older people, in their 80s, are probably experiencing less morbidity from systemic degenerative diseases particularly stroke, cardiovascular disease and chronic lung disease. They are physically fitter and healthier as well as living longer. But as we approach the 21st Century, the NDDs – the disorders of brain aging – which certainly disable and greatly reduce quality of life for older people and their carers, are an emerging and increasing cause of morbidity and disability in older people.

> *'The fundamental mechanisms underlying neuronal aging are of particular significance in Gerontology because the brain cells do not divide following maturity and clearly have additional and specialised cell maintenance and repair mechanisms to survive the human life span intact. The best way to dignify aging is to keep the brain intact at least as long as the body that carries it around. The best way to achieve that aim is to understand the biological mechanisms underlying the NDDs.'*
>
> (Professor Tony Broe, Health Partnership workshop, 1995)

This presents us with a complex new set of social issues and consequent needs for S&T. It raises the prospect of a growing number of older people who find it difficult to achieve a high quality of life in their later years, with consequent impacts on their friends and relatives. Medical developments in reducing heart attacks, etc., have brought us face to face with these new challenges and it is critical that we consider these broader social implications as part of our medical research. In particular the debate on euthanasia, currently limited to discussing terminal illnesses in the context of major pain, will need to expand to consider quality of life issues in the context of NDDs. Governments need to ensure an effective framework for the discussion of contentious social issues is linked in a timely manner to potential S&T developments.

The partnership deliberately chose to focus on the common disabling multifactorial syndromes of brain aging rather than on the specific NDDs because of the links created between the three categories of gerontology, namely the:

- biology of senescence or the study of fundamental processes that underlie brain aging;
- links between these processes and the disabling syndromes and diseases of old age; and
- socio-economic outcomes for older people, their carers and the health service systems.

The study identified four major S&T developments over the next 15 years which will impact significantly on the delivery of services to older people with NDDs. They are:

- improved biomedical knowledge-base, achieved through the Human Genome Project, resulting in improved diagnostics and possible gene-based treatment of NDDs;

- improved understanding of the effects of environment on human health, including its influence on the occurrence and effects of NDDs;
- increased application of information technology developments on health diagnosis, prevention and treatment, resulting in increased availability of information at every level of management; and
- increase in applications of bio materials and bio sensors, creating new opportunities for novel treatments and prevention strategies. This will apply to a 'suite of technologies', emanating from diverse scientific fields, including polymer chemistry and micro-electronics.

Social inequities among older people with NDDs and their carers, are likely to be significant in limiting access to innovations. There is grossly inadequate education and training in the areas of gerontology and aging in university medical schools which has resulted in medical practitioners having poor skills for the management of NDDs in older people.

Considerable concern was expressed at the lack of a comprehensive directory of research activities in Australia in relation to NDDs. Significant progress has been made through the publication of the Aging Research Directory by the Office for the Aged but often funding and other details are not available. A comprehensive database of such activity is required for effective analysis of outcomes and evaluation of proposals for research. The study also recommended, among other things, the improvement of networking between research funders and service providers, giving a priority to inter-disciplinary research, and promoting more effective coordination between the various disciplines. This will help to ensure that the most effective outcomes can be achieved.

NDDs will be among the high profile research areas throughout the early part of the 21st Century. Health service delivery in this area covers a vast spectrum of disciplinary activities involving the basic and applied neurosciences, fundamental molecular and cell biology, epidemiology, the pharmaceutical industry, preventative medicine, high technology manufacturing industry, information technology and the social sciences of healthcare delivery.

The study found a requirement for more active participation/engagement of older people in future policy development and service delivery, particularly in relation to S&T developments. It was also seen as important for older people to have ready access to information about NDDs and education programs for older people should be developed.

e) Improving S&T in Government Businesses

As outlined above S&T can have a significant role in assisting governments to respond to the changes ahead. Many S&T based needs over the next 15 years will be in areas managed by government today – health, education, environment, infrastructure. A high proportion of the infrastructure and services which provide the basis for future growth are provided in Australia by public sector businesses, and some of our best aggregations of commercial and technological expertise are to be found in such businesses.

The role of the public sector has often been underestimated in S&T policy. A way of thinking about innovation systems, which incorporates the public sector, is the theory of 'Complexes' (Marceau, 1993). This integrate the strong welfare element in small economic systems such as Denmark and Australia. This recognises the very considerable importance of public, rather than private, sector R&D in these countries, which have few major industrial companies and home-based multinationals and low absolute level of funding for R&D.

The complex is analysed as a network of co-operation between producers (industrial firms and public sector research organisations), users (usually other firms) and regulators (at different levels of government). For example, innovation in the construction industry complex (Gann,

1994) is affected by the regulations concerning environmental impact and health and safety, and apart from the influences of companies – materials suppliers, architects, builders etc. – agencies such as planning authorities are also deeply involved. In the healthcare complex, government purchasing decisions, hospital funding arrangements and the statutory obligations of health authorities all profoundly affect the level of innovation in pharmaceuticals and medical equipment.

Marceau points to four benefits of using the 'complex' lens when considering innovation systems, as it:

- contains a specific role for government authorities which may act directly to assist the complex rather than being reduced to providing general infrastructure or targeting particular companies;
- indicates the central importance of public R&D facilities;
- allows the analyst to pinpoint weaknesses much more clearly and to devise policies for plugging gaps – weaknesses which may not lie in the 'obvious' industrial participants, but in public institutions and policies not usually considered in the overall framework of innovation support; and
- identifies lead organisations – such as hospitals – which once encouraged towards innovation can have the knock-on effect of further developing the complex.

In Australia each of the sources of demand for sophisticated manufactures and sophisticated services – military spending, telecommunications development and infrastructure provision – which had been so important to the development of European, American and Japanese industry was subordinated to other requirements and priorities (Saunders, 1995). This makes the role of other public sector R&D even more vital.

It has been argued that cost pressures placed on government enterprises over the last decade will of necessity produce innovative responses. However, Saunders (1995) argues that the corporatisation and privatisation of government business enterprises, which began to gather momentum in the early 1990s, is unlikely to increase the demand stimulus for sophisticated manufactures and services, despite the emphasis given to government-industry links in research.

Evidence on this issue is unclear. It has been reported $100 million R&D syndicate has been set up to fund a joint project on new power generation technology by a company formed from the privatisation of the former Coal Corporation of Victoria and the State Electricity Commission of Victoria. However, the in-house research capacity of electricity authorities has been seen to have contracted considerably during the process of industry reform (Scitech, April 1995).

Another area of concern is that R&D is only included in Government programs for micro-economic reform if individual companies pursue it. ASTEC believes R&D should be explicitly included in all major government programs of micro-economic reform eg ports and transportation.

Saunders (1995) also argues that the corporatisation of government business enterprises and the outsourcing of major government functions, such as IT services, provide a once only opportunity to enhance the structure of firms within the Australian economy, while improving the balance between major Australian owned firms and foreign firms.

> *'... there appears to be unrealised potential for innovating public sector enterprises to sell technology based innovations they have developed into Asia and elsewhere. Highly rewarding collaborative relationships can develop with private partners as a result of this commercialisation of their products, services and processes. Such*

> *collaboration should become an expected and accepted modus operandi for public enterprises. Leading edge new customers often take risks in purchasing or helping to develop new and improved products, services and processes.'*

If public sector businesses increased their innovative activities, for example, by improved spending on R&D, there is a strong likelihood of substantial social benefits. These can arise both from improved quality of life and increased exports. However ASTEC is unaware of any explicit incentives for them to undertake R&D. Because such bodies are not taxed, focused tax-based R&D incentives – such as those used by the private sector – cannot be used.

Increased R&D capability in these public enterprises will help raise the technological proficiency of the networks or complexes of which they are part, and will improve their ability to be innovative suppliers and innovation-demanding users with major benefits for private sector firms.

ASTEC previously suggested a review of the potential role of government enterprises in fostering innovation, including through R&D, into the 21st Century. ASTEC proposed an option for discussion for a public sector business R&D incentive scheme with features such as:

- a cash rebate of say $1 for every $4 spent on bona fide R&D undertaken in pursuit of the business objectives of each enterprise (eg not paid for 'public good' research);
- applying the scheme to both public trading enterprises and to organisations in the general government sector (excluding any tax paying publicly owned bodies); and
- an annual amount equal to cost of the scheme is deducted each year from the total funding of public enterprises, according to a formula to be developed.

10.4. Conclusion

Governments at all levels in Australia will be impacted on by the four Key Forces for Change identified by ASTEC.

Globalisation causes us to consider the structural impact on government and how the roles of nation states may change. Traditional regulatory instruments employed by national governments may not be adequate to the task of policing this new world. If national borders are to become less important then our relationships with other countries in bilateral and multilateral associations will become more important.

The environment does not stop at national borders. Concerns about environmental issues are driving bilateral, regional and international agreements on air pollution, land-based marine pollution, climate change, ozone depletion, fishing practices, preservation of the antarctic, desertification, biodiversity and forest management.

I&CT are bringing many changes. They are allowing governments to provide services more efficiently and providing a potentially greater level and range of information. However, the technology raises important longer term issues of equity and access and impacts on national culture and identity.

Genetics and biological technology have the potential to provide many benefits to Australia and they suggest many ethical and legal issues. Governments need to continue to develop safe and balanced 'best practice' approaches to innovations using these technologies.

S&T has a pervasive but often subtle effect on our society and governments need to consider how S&T can be used in preparing appropriate strategic responses to change. It will be important for governments to have ready access to S&T information and to incorporate a knowledge of the impacts and potential contributions of S&T into policy development and service delivery.

Area for Action: Improving the Input of S&T to Government Programs

ASTEC considers it necessary to develop a more effective input from S&T to decisions by Governments. The greatest challenge however is not simply injecting an S&T knowledge base, but also to effectively integrate a greater consideration of potential contributions from, and impacts of S&T on, government decision-making processes and programs in a wide range of areas. This involves not just traditional 'S&T' issues but all those related to a productive economy, eg micro-economic reform, and programs for a stable supportive social fabric.

This will require governments and agencies to enhance their ability to recognise and utilise the potential contribution of S&T (including engineering and R&D) to programs and other decisions and to communicate this information effectively to stakeholders.

There is a need to develop effective mechanisms to ensure science, engineering and technology information relevant to Government objectives is disseminated more effectively to stakeholders (eg S&T, economic, social and resource management information on sustainable development should be made available to farmers).

Priority Action for the Commonwealth Government – 4

ASTEC recommends that as a priority the Minister for Science and Technology in conjunction with other Ministers, take action to:

- examine the scope and adequacy of sources of information on relevant science, engineering and technology in Commonwealth Departments and Agencies, and to consider the identification or appointment of S&T advisers, with line management responsibilities at executive level, to contribute to strategic planning and policy development.

Chapter 11. Impacts for the Community

11.1. Introduction

This chapter explores how the Key Forces for Change identified by ASTEC, and related new technologies and scientific understandings, could alter the daily lives of Australians by 2010. It also explores how this might impact on the gaps between different groups in Australian society.

Globalisation is expected to bring significant change in terms of how closely international issues will be integrated in our daily lives. We may regularly travel overseas, spend time working in another country, maintain close friendships with people who live overseas, or even communicate with others through the Internet.

The implementation of ecologically sustainable development, with consequent changes to attitudes, education regulations and further introduction of environmental costing would also lead to changes. For example, it could encourage further recycling and the replacement of rubbish tips with long-term material storage. Full costing of water could lead to dual water systems in most homes, the rise of xeriscape gardening and the introduction of water tanks attached to private houses. Increased energy prices could lead to the wider use of solar power, collected and used on a household basis, and increases in the cost of private cars. In turn this could lead to the need for dwellings to be closer to transport nodes and moves away from suburbia.

The revolution in information and communications technology will not only impact in industry and government but also in the home. At some point in the next twenty-five years any home or small business will be able to afford enough computing power to be able to compete against a multinational corporation. Communications will have experienced a similar revolution. The mobile personal telephone will have replaced the fixed-station telephone and home and office phones will be used more for data transmission and video links. Meanwhile compression of data is at last making the video phone a practical proposition on existing phone lines. The expansion of TV channels will continue, so that the structure of the broadcast media becomes much more akin to the structure of the print media: a few national and international products, but a multiplicity of special interest channels, the equivalent of specialist magazines.

We will also be experiencing the first stage of the biotechnology revolution. Mapping of the human genome is likely to have reached the point where information can be had about our pre-dispositions to certain diseases whether or not this information will be freely available. We may also be able to purchase genetically modified food that has nutrients added to prevent the onset of certain diseases.

Not only will developments in S&T change the way we live, but society will also be able to influence what technologies are adopted and diffused. For example a number of developments in the Japanese Delphi were seen to be constrained by consumer demand, particularly social/cultural issues. (Box 11.1)

Box 11.1. 1992 NISTEP Delphi Topics for which 'Cultural' Constraints are Significant – Topics with Average Realisation Times up to 2010.

Life Sciences

- Fully fledged medical manipulation of genetic disorders.
- New plants produced through gene manipulation widely used as food.

Energy

- Practical recycling of low level radioactive wastes.
- Practical safe disposal of highly radioactive solid waste.

Production

- Widespread home office work based on advances in video telephones, on line computer system and facsimile.

Transportation

- Practical use of nuclear powered merchant ships.

Health and Medical

- Routine performance of organ transplantation.
- Perfection of systems to lengthen organ preservation, enabling world wide supply of some kinds of organs for transplantation.

Lifestyles and Culture

- Development of technologies that enable control of traditional tastes, flavouring and seasoning to one's taste.
- Widespread use of diverse artificial products that provide a touch similar to that of natural substance such as mink to enhance the conservation of nature.
- Spread of different kinds of information needed by consumers on a daily basis (information searches, guiding, reservations, orders, etc.) through home terminal systems providing information (still and animated graphics, hard copies, video/sound, etc.) at any time of day or night in response to natural language questions posed by the consumer.
- Systematic organisation of programs incorporating resources with traditional craft, and arts and culture to enrich lifelong education.
- Widespread use of an independent sociability training system designed for groups of children of different ages enabling them to be trained in social interactions.

Source: NISTEP 1992

11.2. Changes to Aspects of Society and Individual Lives

This study reviewed preferred, expected and possible futures, from varying perspectives. This section looks at 2010 from the perspective of the individual, and briefly explores some of the changes for different aspects of our lives in the areas of security, crime and violence; sport; education; health; shopping and retail; transport; housing and employment. The discussion covers only a small number of aspects and is not intended to be comprehensive. It includes information on some specific technological developments suggested in Japanese and UK Delphi surveys. However, such surveys do not provide advice on how communities and individuals might experience new technology because of their focus on research and industry perspectives.

a) Security

Personal security and crime are central to many people's fears about the future. ASTEC's survey of young Australians, undertaken as part of the Youth Partnership, found almost 70% believe that crime and violence will be worse in 2010. Gangs of 'Uzi machine-gun-toting youths' on inner city streets was forecast by Shell in 1992. The ability to 'predict' this was seen by Shell as one of the ways in which its scenario-building technique enables it to 'think the unthinkable'.

I&CT is likely to find many applications in combating crime and improving personal security such as: video camera surveillance of streets; electronic immobilisers for cars; photographic imprints on credit cards; and mobile telephones. The 1992 Japanese Delphi suggested security communications systems offering reinforced confidentiality through use of identity verification technology based on fingerprints, penmanship, voice and facial expression would be available by 2006; and there would be widespread use of new ID systems, eg for identifying genes, fingerprints and voiceprints, to replace card-based systems by 2005. It will become possible to 'electronically tag' convicted criminals, perhaps even as an alternative to prison sentences.

Other changes include the growth in private sector security companies and guards, both official and unofficial. In the US the job of security guard is one of the fastest growing, and some project up to 40 per cent growth rate between 1990 and 2005.

A growing issue is organised crime syndicates, equipped with private 'armies' and highly sophisticated equipment. Many such groups have grown up to protect drug empires, and the volume of arms available on the world market, is likely to increase their size and firepower over the next 15 years. The prospect of such groups turning to organised 'electronic crime' is a growing risk in an I&CT-based financial system.

b) Sport

Sports participation is a major element in the quality of life of many millions of people, providing both fun and fitness. It is also an important component of social life.

The UK Technology Foresight study considered that 'winning in the sports sector is now a technology issue'. This requires consistent funding, expert management and the application of leading edge life-science developments like bio-mechanics. Representatives from the sports industry identified technological inputs to sport as lowering entry barriers, eg by better application of technology to sports equipment, or using interactive I&CT networks to allow people to find sports partners and team members and book venues. They also suggested developing 'expert systems' to support self-learning and practice.

The UK Delphi survey suggested new targets for development such as: 50 per cent of homes with computer-assisted fitness equipment; feasible interactive technology to teach sports and other leisure skills; and virtual reality to simulate competitive sports activity. The last two items were seen as twice as likely as the first, but all of these have quality of life and wealth-creation potential.

c) Education

In education, which has been a public responsibility for more than a hundred years, there has already been a marked shift towards private provision as well as private funding in most industrial countries. While the state retains responsibility for basic schooling everywhere, spending on such schooling has fallen as a proportion of total educational spending with the growth of higher education and adult education. This is likely to continue. Also, higher and adult education is less likely to be the sole province of the state with the company sector increasingly funding, and often providing, adult education.

New digital I&CT technologies will spread over the next decade to impact strongly on education. The UK Foresight study considered that new education technologies offer the potential to make learning richer and more rewarding, more consumer-led, more efficient and provide a significant source of exports.

People will engage in more independent learning, using CD-ROM, video conferencing or equivalent technologies. Schools and universities have the potential to widen their reach to different groups, including remote locations or overseas, and to lengthen their associations with people. Also, group learning situations will be different. A number of Australian institutions such as the University of Technology, Sydney, are investigating potential 'classrooms of the future' that combine the benefits of new I&CT technology for interactive networking and accessing large amount of information, with traditional social and face-to-face teaching situations.

Lifetime education is likely to become more a reality as people pursue a number of careers across their lifetime. New I&CT can assist by delivering electronic learning materials at a distance, eg in the home or workplace. It is uncertain how such prospects will impact on the need for, and levels of, face-to-face teaching, and on the financial resources of educational institutions.

d) Health

A structural shift is expected in demand for health care in 2010. One effect of an aging population is to increase the need for nursing care in the community and in older people's homes rather than hospitals. Much investment directed towards residential care of the very old, be provided by the private sector. Improved medical procedures will continue to cut the average hospital stay and enable many conditions to be treated in out-patient clinics. While the commitment of the state to universal health care is unlikely to be weakened, in practice, part of the rising bill for health care is expected to be carried directly by individuals.

Delphi survey health and medical topics show new methods of diagnosis and treatment being used as well as applications in health care delivery, including greater automation. There is also a trend toward greater understanding and application of preventative and dietary methods in health care. The Japanese Delphi suggested that by 2008 people may be able to use cultured organs grown from their own tissues, extracted and cultivated in advance.

Preventative medicine through lifestyle changes is expected to be more important in the 21st Century. The 1992 Japanese Delphi survey suggested that an improved understanding of the links between nutrition and health will bring about widespread use of guidelines for lifestyle (eg nutrition, rest, exercise) to help prevent adult diseases by 2002.

Concerns have been recently expressed about the emergence of new viruses, that might mutate into deadly and easily transmitted diseases. A continuing concern will come from viruses such as HIV although Japanese experts suggested a cure for AIDS by around 2007. Even without a cure, a combination of education and changes in personal behaviour is expected to contain its effects in the industrial world by 2010, although not in some of poorer countries in Africa, parts of Asia and South America.

Box 11.2 Perfect Health in 2010?

Ten things we'll see:	Ten things we won't see:
Transplanted bowels, bladders, bones, teeth and tendons will be commonplace. Experimental dogs have them – humans can be only a decade or two away.	Medicare. National health insurance schemes, the British example excluded, have a limited lifespan. The bare bones of this one were published in 1968, so it's getting on now. Medicare is unlikely to survive another 25 years in it current form.
Vaccine-preventable diseases like measles and whooping cough will continue to infect children because governments and general practitioners will never co-ordinate their activities well enough to eradicate them.	Big public hospitals. They'll be lean and mean. All but the deathly ill will be in and out in a couple of days. Mobile teams of nurses, doctors and physiotherapists will carry out as much treatment as possible in the home or in outpatient clinics.
The rise of another disease transmitted through blood transfusions. In the 1970s it was hepatitis B, HIV dominated the '80s and hepatitis C will do the same this decade. What is out there now that we don't know about?	Health departments. The push towards intersectoral collaboration, to use the government jargon, will continue until health becomes part of the Ministry for Personal Environment involving air and water quality, housing, lifestyle choices and medicine.
Private health insurance. The squeeze on the public system will continue to the point where, for the first time in decades, there will be a difference in the quality of care between public and private sectors. Eventually, private health insurance will buy better care, not just cleaner sheets.	Drugs available as freely as they are now. The Pharmaceutical Benefits Scheme is costing 12% more each year and new drugs are ever-more expensive. No government will continue to subsidise drugs to the same extent.
Doctors unemployed: hospitals are getting smaller, general practice will restrict entry and specialists will never relax their cartels.	Smokers getting bypasses and drinkers getting liver transplants! The coincidence of interests between health evangelists and economic rationalists will see to that.
Nurses running GP-style clinics and performing minor surgery.	The family doctor who cuts and stitches in the morning, talks in the afternoon, visits at night and stays sane.
Governments still rationing health care, while pretending not to.	The use of doctors as expert witnesses in court. Judges will work out that an adversarial approach using expert witnesses with different opinions relies on judging the credibility of the witness, not the evidence.
The discovery of a virus-like particle as the cause of chronic illnesses like rheumatoid arthritis, diabetes and asthma.	Psychiatrists deregistered for having sexual relationships with their emotionally fragile patients setting up as 'counsellors' offering sex therapy. Someone, somewhere, will work out how to stop it.
Germ cell therapy in which genetic diseases like haemophilia can be eradicated.	So much energy poured into prolonging the pain of the dying. Those who might live will be given every chance, while those who won't will be allowed to die.
The use of germ cell therapy to improve height, intelligence or profile.	Smoking in public. Good health and fear of litigation will prevail.

Source: The Bulletin, 24 January 1995.

e) Shopping and Retail

There are many new prospects in shopping and retailing, as stores use more sophisticated I&CT technology in their operations and adopt new practices to meet consumer demand.

Delphi surveys indicate an increased diversity of foods and greater commercial use of genetically modified foods. It is suggested that this will be accompanied by more sophisticated labelling and packaging to provide information for a more educated consumer.

Over the next 15 years progress in bio-medical science is expected to lead to the increased use of genetically modified foods, as part of preventative health care. The Japanese Delphi suggested two major changes: new plants, produced through gene manipulation, as food (2003); and, personal nutritional indices that take individual differences into account through scientific elucidation of the interrelationships between nutrition and metabolism, exercise, physical strength, etc. (2002).

Head, (CSIRO, 1995) suggested the use of electronic menus and labelling in retail stores to provide consumer information about the health potential of foods, including non-traditional nutrient content such as protective anti-oxidants. He suggested a greater use of 'functional' or therapeutic foods, enriched in beneficial substances either by genetic manipulation eg of plants, fish or micro-algae, or by adding extracts. As knowledge of individual genetic risk factors for disease grows people may choose, or be required, to adopt specific lifelong eating habits.

Retail and leisure sectors are likely to continue to converge, with leisure, shopping, entertainment, dining, etc., on a single site. The UK Technology foresight study's vision of the future in retailing, has many UK retailers expanding their product lines, improving their retail and distribution systems and, in some cases moving into new markets. Likely trends include retailers moving into financial and other services, home shopping, do-it-yourself, in-house franchising; and a growth in specialist retailers and fast food services.

I&CT will bring major changes in the chain from manufacture to supply. Traditional roles of manufacturer, distributor and retailer may merge and change significantly, eg manufacturers selling directly to the public via interactive I&CT networks. New partnerships and relationships will develop between disparate organisations to market and deliver products and services through I&CT networks.

The application of I&CT in retail and distribution have substantially improved efficiency and reduced costs. The continued application of such technology is foreseen in the introduction of home shopping, CD catalogues, self-scanning checkouts or virtual reality to market expensive items. The UK Foresight study suggested that the extent of such changes will depend on the level of 'dehumanisation' in the sales process that is acceptable to the public.

In the future businesses will be able to build up knowledge about their customers. It will soon be technically possible to hold on computer a more or less accurate profile of every family in the industrial world. This has enormous implications not just for commerce but also for public administration and (as the enactment of data protection legislation around the world recognises) for civil liberties.

f) Transport

The need for environmental sustainability suggests limits to the growth of the vehicle population and reducing emissions. In California, an increasing percentage of new vehicles must have zero emissions from 1999. In Singapore, there is a tax of $100 000 for permission to own a car. However, experts expect the number of cars on the world's roads will continue to grow. In Australia, which already has one of the highest rates of car ownership in the world, the car population is expected to rise from eight to fourteen million in the next 20 years. However, the main growth will occur in the developing nations – China, India, South-East Asia and Eastern Europe. In China, car production is forecast to increase from 300 000 to 1.5 million a year by 2000. Worldwide, the 470 million vehicles in use today are expected to grow to 2000 million by 2044.

In the early part of the 21st Century, cars will probably not be all that different to today. They will be lighter, more fuel–efficient and smaller externally, but just as big inside. They will also be safer. But they will not necessarily be dearer to buy because car makers must find the technology to build them more cheaply to maintain sales volumes.

I&CT will play an even greater role in vehicles in engine management and traction control. Prospects include satellite navigation systems combined with maps, infra–red headlamps, devices to wake up drowsy drivers, or in–car radar to keep vehicles in their lanes and apart at safe distances. However, cost may restrict many of these to luxury cars.

Box 11.3. UK Foresight – A Vision of 'Clear Zones'

The UK Foresight study Transport Panel recommended three 'Transport Foresight Projects' as initiatives arising from their study: 'The Informed Traveller', 'The Foresight Vehicle' and 'Clear Zones'. The clear zones initiative focuses on improving the liveability of urban centres, with improved access and pollution control, and reduced congestion. The following is the Vision as expressed in the UK study to help define the set of innovations encompassed by the preferred future of Clear Zones.

It is Saturday morning and the family decides to go shopping in central Bigtown, a few miles' journey by car. Traffic is heavy as we approach the town centre. Our route guidance computer advises that today's weather conditions and the build up of traffic threaten to cause air pollution at levels which exceed mandated limits and zoning has temporarily been extended across eastern approaches to the centre. Access controls apply and we are advised to use Park & Ride Area 3.

I drive into the car park. Payment for parking and travel within the zone is transacted via my contact-less smart-card. I feel happier leaving my car in the knowledge that my smart-card ID number has been temporarily recorded with the vehicle's registration (no personal details are stored) and the barriers wouldn't open on exit unless the system once again matches both card and car. We wait in the spacious, comfortable terminal building. The electronic signs indicate the next bus will arrive within a couple of minutes. The bus scheduling system has anticipated the demand created by the broadcast traffic advice and has raised the service frequency. We board the bus – our 'tickets' stored on the smart-card are checked automatically – and the short trip to the town centre begins.

The journey is rapid and uninterrupted. There is little other traffic within the zone. In any case, the traffic control system gives the bus priority. The bus drops us off in the central shopping district. The environment is particularly pleasant; largely traffic-free, quiet, relaxed. It is good to see some of the street life that used to be associated mostly with mainland European cities happening here. Although we haven't come shopping for anything in particular, most of the stores now offer a deliver-to-car- service within the hour for bulky or heavier items. They would be held for us at the manned collection point in Park and Ride Area 3.

Moving around the town centre is easy. It is pleasurable to walk. For longer distances, I could use the frequent trams that ply the streets, or I could book an electric taxi using my mobile phone which is guaranteed to arrive in under two minutes thanks to sophisticated tracking and scheduling technology. That is in the unlikely event that there isn't one available to flag down.

Source: UK OST 1995g

Engine technology under the bonnet is expected to change significantly, but the internal combustion engine is expected to remain. Expected changes include increasing use of fuels such as diesel and liquefied natural gas, and later vegetable oils and hydrogen fuels. Electric–powered vehicles are expected to be confined largely to city use because of their short driving range.

Other expected developments include 'smarter' roads, using intelligent traffic control systems for optimal control of traffic flow in cities based on determinations of types of vehicles on road, speed and level of congestion (by 2003). A preferred future scenario for urban centres arising from the UK foresight study are shown in Box 11.3.

g) Housing

In Australia by 2010, 60 per cent of housing will be residences built prior to 1995, with up to 40 per cent constructed over the next 15 years.

Experts have suggested that we will see many changes in the construction and facilities in our homes. By 2010 we will be able to live in smart houses with management systems for temperature, power use, entertainment and security. The top six topics identified in the UK Construction sector Delphi considered most important for quality of life were:

- halving travel to work distances through local development strategies and I&CT;
- transport efficiency increases by 100% through totally integrated transport systems.
- minimised impact of construction on the local community (cleaner, quieter, quicker);
- criminal acts are reduced by 40 percent through designing buildings and public spaces for enhanced security, and without compromising civil liberties;
- needs of the elderly and disabled redefine the standards and practices for building design, layout and fit out; and
- interactive TV as a normal feature of everyday life.

The use of I&CT to bring interactive broadband television is potentially seen as having a major impact on our lives. There is probably a very substantial market in interactive information services to the home. The UK Delphi responses suggest that by 2004 there will be fully interactive electronic means of obtaining train times or further information about current news events, tapping into databases and obtaining education. The Japanese 1992 Delphi suggested next generation cable TVs would be available to more than 50% of households by 2007. They would be capable of transmitting programs on 300 channels or more by means of data compression.

The Japanese Delphi suggested the use of artificial intelligence-based home devices that check the state of health of elderly and mentally or physically handicapped persons and give advice in daily-life matters (by 2003); household solar cells (by 2007) and automatic sorting garbage boxes (by 2005).

Experiments in future housing are underway in Australia, such as at the Multi Function Polis or the Oakden project home in South Australia. This trials features such as: a central computer system, hot water using rainwater, recycling waste waters and solar powered lighting. New standards of 'environmentally friendly' housing and urban planning are being trialed as part of the 'Green Olympics' for Sydney in 2000.

h) *Employment*

Changes in the 21st Century imply a need to rethink traditional concepts of work, job and career. Prospects include a reduced number of people in conventional full-time jobs, accompanied by an increase in self-employment; a trend towards 'portfolio' working with self-employed people working for two or more businesses on a contract basis (Box 11.4).

Developments in I&CT suggest a reduction in the importance of location. This may increase the possibilities for working from home providing for example, a greater freedom to choose where to live, not only within countries, but also between them. Some suggest that global integration will bring large scale job migration and countries might use regulation, or lack of it, as a way of attracting investment and people. Clerical jobs may migrate to countries where there is a ready supply of cheap well-educated labour, giving developing countries a new area where they can compete. This is expected to become a much more contentious issue over the next 25 years.

Box 11.4. 'Thinking Upside Down' – the Changing Nature of Work and Career to 2010

One characteristic of living in the changing world of the future will be 'thinking upside down'. This form of 'discontinuous upside-down thinking' challenges the existing order, and will be needed to cope with the new situations in which we find ourselves – to produce new and different ways of looking at old and familiar problems.

By the 21st Century less than 50 per cent of the workforce will be in conventional, full-time jobs and there will be a massive growth in self employment. This necessitates a fundamental rethink of the traditional concepts of work, job and career, and will impact on issues like family support and the organisation of firms. An increasing proportion of the available jobs in our community require high-order intellectual rather than manual skills. This has major implications for the education system as well as for the credentials that young people are expected to acquire prior to seeking employment. The tendency for women to re-enter the work force will intensify which has implications both for the way in which organisations are run and for the structure and support of the family

Older people will constitute a growing proportion of the population. This raises fundamental issues such as what they will live on, what they will do and, in many cases, who will take care of them. Upside-down thinking is needed to produce opportunities rather than problems for the 'third age' – the age of living that follows the ages of learning and of work.

Demographic changes are being bolstered by a fundamental change in the nature of work and, more particularly, careers. People are working more intensively but over fewer years; they are leaving and re-entering the workforce with, greater regularity; and they are retiring earlier to pursue other interests or career options.

These changes in the nature, of work and career are a consequence of the trend away from labour-intensive manufacturing towards knowledge-based organisations and the provision of services.

We will experience new forms of organisation as well as new ways of working and living in 2010. The challenge is to be prepared to engage in a process of continual learning to see the opportunities of an ever-changing world.

Source: Handy, 1989

The trend which has seen increasing numbers of women enter the workforce is likely to continue. By 2005 85% of women between 20 and 44 years are expected to be participating in the labour force (up from 44.4% in 1966). The trend to women's ownership of small business is also set to continue (currently 30% of all small businesses in Australia). However, women's participation in senior private sector executive management has actually declined in recent years. Women's participation in business decision-making has recently been highlighted by the Karpin Task Force on Leadership and Management Skills and is likely to remain a prominent issue.

Ruthven considers that Australia is already a 'post-industrial; economy entering a new 'Infotronics Age', where wealth is created by intellectual property and I&CT. He suggests a strong future for employment in knowledge and service industries. For example, more diversified personal services, including the provision of household services by small enterprises organised using franchising and outsourcing, suggesting growth in cleaning, hot food preparation, maintenance, gardening, home tutoring, laundry, security and child minding etc.

Large firms will increasingly move to flatter structures and outsource activities on a contract basis as part of their management of complex processes. Export wealth will increasingly come from knowledge-based services such as educational, financial, legal, marketing, real estate and management consultancy. Box 11.5 shows another view of future employment opportunities.

We have illustrated some of the variety of impacts the Key Forces for Change might have on aspects of life. However, this picture, drawn largely from international work, must be viewed within the context provided by Australia's unique circumstances and society.

Box 11.5. Changes in Occupations – Shrinking and Growing Areas?

Shrinking or disappearing trades:	**Growth areas:**	**Change from physical to electronic:**
Air couriers (replaced by high-speed data networks); Answering machines (computers); Insurance claims assessors (neural networks); Bailiffs (electronic credit freezes); Checkout staff (image recognition software); Cash register suppliers (computers); Coal & solid fuel merchants (electricity); Company registration agents (networks); Dictation & secretariat services (voice recognition software); Layout artists (computer templates); Duplicating equipment (computers); Factory cleaning (intelligent robots); Film processors (digital, chemical-free film); Hotel booking agents (software); Industrial relations arbitrators (employment deregulation); Notaries & commissioners of oaths (video recordings); Draughting equipment makers (computer-aided design); Typewriter manufacturers (computers); Window cleaners (intelligent robots); Airlines (rising fuel prices); Middle managers (networks)	Advertising (fuelled by opportunities in new media); Alarms & security equipment (rising crime due to unemployment); Corporate entertainment (to keep staff and customers happy); Sports equipment (more leisure time); Hi-fi & computer dealers (convergence of technology); Cellular radio dealers (more networks); Environmental systems (tighter laws); Recycling (tighter laws, higher material costs); Computer programmers (need for better interfaces); Designers (producing and choosing computer templates); Telemarketing (chance for wider access to public); Career consultants (increased redundancies); Trauma consultants (rise in random criminal acts); Personal matchmakers (less time for workers to socialise); Escort services (importance of appearing sociable in public); Cruise companies (for leisurely business trips)	• Market research • Novelty goods • Lawyers • Doctors • Surveyors • Cinema • Detective agencies • Estate agents • Journalists • Writers **New trades:** Internet plumbers (PC won't talk to your fridge? Call one out – they'll solve it); Workgroup synthesisers (bringing together ideas from staff on different projects in remote locations); System hosts (the DJs and talk-show hosts of the Internet, who will be famous for the discussions they provoke each day. The true megastars of the future.)

Source: New Scientist 1994

11.3. The Role of S&T in Responding to the Key Forces for Change in the Australian Community

There is little doubt that S&T promises much for the future – greater convenience, longer life, improved access to services and products. It will be an essential part of developments which could improve our lives. However, the future presented in the first part of this chapter may not be achieved. The community itself might prevent some aspects of the future that are inconsistent with our goals for Australia in the 21st Century as a creative productive, inclusive and ecologically sustainable society.

One important issue is whether the benefits of developments in S&T will be shared equally across the Australian community. This chapter looks at the future needs of our community, focusing on the gaps between different groups, and whether S&T developments will help to achieve an inclusive Australian society by 2010.

Australian society comprises many different groups. Our large land area, scattered population, multi cultural society and large regional centres raise particular issues. By 2010 the Australian population is expected to have grown to approx 21 million (ABS). As this is determined to a large extent by immigration, it could change dramatically according to government decisions on migration levels.

Significant changes are expected in the make-up of the Australian population. While Australia's population will be aging, this will not have as dramatic an impact on Australia as other developed countries such as Japan. There is expected to be an increasing number of Australians of Asian descent and greater diversity in the source of countries for immigration. The number of Aboriginal and Torres Strait Islanders is expected to increase slightly, although there is still likely to be a gap between their situation and that of non-indigenous Australians.

It has been suggested that the aging population will lead to conservatism in politics and pressure to cut public spending. An influential 'older Australia' is expected to seek low inflation, low unemployment, low crime, and have a much lower tolerance of disorder and anti-social conduct, with a greater acceptance of authority in controlling behaviour. A slow, if uneven, decline in gender inequality particularly in developed countries is also likely.

A majority of young Australians believe the gap between rich and poor will worsen by 2010 (Youth Partnership, 1996). S&T could further entrench inequities between 'haves' and 'have nots' over the next 15 years. Groups such as older women are likely to be disadvantaged by pervasive and sophisticated I&CT developments. And people could be refused employment or access to life insurance due to developments in genetic screening.

Many new technologies are being developed to address concerns in the industrialised world, such as proposed work on genetics to reduce fat levels and cure aging; or developments to increase the effectiveness of organ transplants on an international basis. Some of these appear to fly in the face of the needs of the majority of the global population living in developing countries. Overall, there has been a tendency to transfer technologies of developed countries into the third world context and a failure to recognise the different priorities of these communities.

The ASTEC study explored the relationship between the Australian community in 2010 and S&T in a number of ways. Three examples of particular importance to the views of the community in 2010 are young people, residents of rural and remote areas and Aboriginals and Torres Strait Islanders.

a) *Young Australians: The Voice of the Future*

ASTEC's Youth Partnership explored the views of young Australians on probable and preferred futures for Australia in the 21st Century and the role of S&T in shaping these futures. It found young people want Australia to be a society motivated more by generosity and less by greed: one that places less emphasis on individuals, material wealth and competition – 'Growth Australia' – and more on community and family, the environment and cooperation – 'Green Australia'. They wish for a future in which they can contribute to the decisions which affect them.

Many young people saw the future in terms of a worsening of today's global and national problems, although they also expect some improvements. Young people care about the future of the global environment, perhaps more than any other single issue. Other concerns include: the impact of growing populations; the gulf between rich and poor; high unemployment including the effect of automation and immigration; conflict, crime and violence; family breakdown; discrimination and prejudice; and economic difficulties including the level of foreign debt. A national opinion poll of 800 young Australians showed that:

- a slight majority (55%) believe the world's future is one of '..crisis and trouble', compared with just below half (41%) who believe the world will enter a 'new age of peace and prosperity';
- about one-third (35%) believe that the quality of life in Australia will improve, while almost the same number (34%) believe it will worsen, and another third (29%) believe it will remain the same; and
- pessimism about the future is more prevalent among females and in most cases increases with age in both females and males.

Young people see S&T as important in the future. They recognise its value in solving problems which confront society but do not see it as a universal panacea (Box 11.6). It is a tool which could be used to achieve the future they want and they would like to see more emphasis given to placing it in a social context.

Most young Australians see themselves embracing technological change more readily than older generations, but some question the benefits and feel that the rate of advancement is getting out of hand: for example, technological advances should not be used to replace jobs, but as a tool for facilitating more productive work.

Young people are particularly concerned with the social context of S&T- how it might improve or reduce our capacity to realise our goals as a nation; who will make decisions on priorities for S&T; how governments allocate funds to S&T; and related ethical issues. They argue for more consideration of human needs – funds would be better spent on solving problems such as poverty first – and are concerned at the use of S&T to further entrench wealth and power.

Young people consider tools are available through S&T to improve the global environment, and Australia is well placed to contribute to developments in this area. They consider the urgency of the environmental crisis must lead to the evolution of alternative and renewable energy resources, such as nuclear fusion, solar, wind or tidal power. Other areas needing attention include: biodegradable and recyclable materials; more nutritious food (from 'superplants'); less harmful agricultural practices; improvements in public transport; environmentally friendly computer driven cars; more economical/ecological housing design; sustainable agriculture (genetically engineered sheep, fast germinating crops); and environmental damage repair. They consider environment related S&T should be given a higher priority by government and industry but it will need to be complemented with changes in lifestyle.

Genetic engineering is seen as an inevitable technological progression which poses serious ethical considerations and evokes strong feelings. On a positive note, it is seen as having applications such as fertility control and food production. The downside is that applications like gender choice for babies, cloning and genetic manipulation are viewed as 'takeover technology'. Young people argue for a major focus on ethical considerations.

The Internet, and other advances in I&CT, are seen to be having a large impact on society. Young people look forward to improved access to information from global sources and the social and cultural benefits that it allows. However, they are concerned at the way computers will be used to watch and regulate people, taking away control from individuals and increasing unemployment.

Box 11.6. Opinions of Young Australians on Specific Future Effects of S&T

Specific effect of S&T in the future (n = 802)	**Agree (%)**	**Disagree (%)**	**Don't know (%)**
S&T offer the best hope for meeting the challenges ahead	69	28	3
Science will find ways to conquer new diseases	87	11	2
S&T will find ways of solving environmental problems without the need to change our lifestyle	45	52	3
Science will find ways to produce enough food to feed the growing world population	39	58	4
Computers and robots are taking over jobs, increasing unemployment	58	40	3
Computers and machines will eventually take over the world	35	62	3
Governments will use computers and technology to watch and regulate people more	78	20	3
Advances in computers and other technologies will make democracy stronger, giving more people more control over their own lives and governments	43	51	6
S&T are alienating and isolating people from each other and from nature	53	43	4

Source: ASTEC 1996a

Overall, two out of three respondents (69%) believe S&T offers the best hope for meeting the challenges ahead. But this does not mean that they believe it will be used to address those challenges or has been used to do this in the past. About half the respondents (51%) believe S&T has had equal benefits and disadvantages to date.

Young Australians who are optimistic about the quality of life in the year 2010 view S&T more favourably than others. Half (51%) of those who believe that the quality of life will be better in the year 2010 also believe S&T has had more benefits than disadvantages. In contrast, just over one quarter (27%) of those who believe quality of life will be worse in 2010 believe S&T has more benefits than disadvantages.

Young people also perceive a relationship between S&T and the widening gap between rich and poor. They are concerned about technological advances increasing unemployment and alienating and isolating people from each other. They see advances such as the Internet as potentially breaking down barriers between different groups but are not sure it will be used this way. They consider governments should give priority to S&T to resolve problems such as poverty rather than further entrench wealth and power. They consider researchers and government should consult people more and ensure public understanding of progress.

b) Rural Communities

Some changes in the distribution of people across Australia are predicted by 2010. Queensland is likely to continue to attract high net migration from other states so that by 2025, it is expected to pass Victoria as Australia's second largest state by population. By 2011 the population of the Brisbane and Moreton regions is expected to reach about 2.8 million — approximately the current population of Melbourne. South Australia and Tasmania are expected to have the lowest rates of growth, with Tasmania's population possibly even falling. Within the states it is forecast that most immigrants will settle in the capital cities and there will be continued drift away from inland centres.

ASTEC's program of national consultations identified significant differences across Australia in perceived needs for 2010. These national consultations, conducted away from the big cities of the east-coast graphically illustrate that local differences could be more important than national averages in regional S&T priorities.

Discussions in Townsville reflected concerns about dynamic development and urban growth in sensitive natural environments of 'rainforests and reefs'. Industry and employment growth in tourism etc., must both exploit and protect the unique environment. Rapid population growth presents new challenges in physical and social infrastructure development. A major international focus was on regional neighbours in tropical Asia.

In Hobart maritime issues dominated discussions. Tasmania's unique island situation focused attention on aquaculture and coastal policy, and its position in the Southern Ocean identified it as the gateway to the Antarctic with strong links to New Zealand.

In Adelaide discussions focused on industry and community development in an arid climate where water and energy resources were limited. South Australia's future was perceived as a regional node looking north to links with Asia (such as the Alice Springs to Darwin railway) and products for global export.

In Alice Springs the needs of rural and remote communities were emphasised. The need for simple technologies to meet basic needs, and the cultural values of Aboriginal and Torres Strait Islander communities were discussed.

In Perth, discussions highlighted isolation from the east coast with a focus on economic and community development and the needs of isolated communities. Their international focus was on Asia and opportunities in the Indian Ocean.

Many of these meetings argued that one group that has gained least from S&T are isolated communities. Many saw great opportunities for communities in isolated regions, if the potential of I&CT developments – telemedicine, distance education, employment at home – are realised. Commitment to resource these developments was questioned.

Notwithstanding the opportunities which information technology could bring, the application of this to populations will be intimately linked with government policies eg funding of health and communication systems. People living in these areas are even more disadvantaged in all aspects of independent living so that for many pensioners, even the telephone currently represents a prohibitive cost.

Services have certain pre-requisites for effective operation and often these are based on urban requirements and standards. An analysis of locational disadvantage of remote communities indicates the benefits of the city are often only sustainable through the adoption of urban lifestyles. To re-create these conditions for small communities can undermine the rights and abilities of these residents to establish their own priorities and standards.

Instead S&T needs to be designed to meet the needs of the community which may require specialist expertise. S&T experts should consider redefining their role to become specialist advisers to the community rather than technological decision makers.

c) Aboriginal and Torres Strait Islanders

Aboriginal health has been highlighted as an issue of concern in the 1990s. Indicators such as infant mortality and overall life expectancy reveal that indigenous communities have not shared equally in the health benefits of modern S&T.

Aborigines are expected to be one of the fastest growing groups in the Australian population into the 21st Century. Their population is expected to rise from 265,000 in 1991 to 340,000 by 2001. Some expect that the next 15 years will see a relative improvement in the position of Aborigines in Australian society due to government policies, developments in I&CT and increased economic opportunities, although progress is unlikely to be sufficient to ensure equality in realising benefits from new S&T developments.

Western civilisation is inordinately proud of its technology which is assumed to be precise, comprehensive and value free. Whereas, it is often presumed that the S&T of the Aboriginal and Torres Strait Islander communities is outdated. Yet there are aspects of social organisation and living skills – included under a broader definition of S&T – that are fundamental to survival even today in some of the harsh parts of Australia. Apart from 'bush tucker' and 'bush medicine' indigenous S&T is almost unknown.

As science is a method of observing the external world, and forms a basis for people's problem solving response, taking this away devalues their culture. A recent report of the Federal Race Discrimination Commissioner (FRDC, 1994) contends that western attitudes towards Aboriginal and Torres Strait Islander people have been shaped by indigenous responses to introduced technologies.

> *'Poor understanding by non-indigenous people of the process of technology transfer, together with misinterpretation of the symptoms of problems, forms the basis for intolerance and sows the seeds for racism. Racism in this context arises from frustration, fear and persistent misunderstanding created by differing expectations and values attributed to material goods and services when introduced to Aboriginal and Torres Strait Islander communities'*
>
> (FRDC, 1994).

Technology is supported by values and skills which have a social origin. Lack of awareness of the links between values and technology leads to the use of inappropriate sophisticated technological solutions. Technological choices available to Aboriginal and Torres Strait Islander people are generally limited to existing off-the-shelf items because very few centres are funded to research and develop technologies that integrate with Aboriginal and Torres Strait Islander values and aspirations.

A significant concern expressed to ASTEC was the relatively low level of Aboriginal and Torres Strait Islander involvement in making decisions about technology implementation. Often decisions are taken by professional technologists, who have their own perceptions of a particular solution's merits. In some cases this may lead to the use of technologies which have high recurrent and replacement costs and require a greater portion of community budgets for their operation and maintenance.

Aboriginal and Torres Strait Islander communities have been used as test-beds for untried technologies and funds from Aboriginal and Torres Strait Islander programs have been allocated to research products for remote situations. For example, solar technology or new waste disposal methods and modified sewerage treatment systems. The latter have been built in communities without the community being aware they were experimental (FRDC, 1994).

Technologies suitable for urban structures, where economies of scale increase feasibility and the use of specialist skills is optimised, may not be suitable for remote communities. Rather, decisions need to take account of local involvement, control and maintenance. Further, proposed technologies are often assessed on the performance of newly installed equipment, and may not adequately consider on-going maintenance, eg health benefits of a poorly functioning water-flush toilet compared to a ventilated pit latrine.

Within an Aboriginal and Torres Strait Islander community the decisions to use technologies are taken by a community council. However through its lack of control over technology, the 'how and why' of the response is left to someone outside the community. There are no Aboriginal and Torres Strait Islander engineering students in Australia at present; nor indeed any technical expertise or involvement beyond trades proficiency. There is an urgent need for policy makers to address the significant relationship between technology and development within Australia. The issues of values and culture, and the provisions of international covenants must have a central position in assessing the provision of technologies. Many fundamental assumptions that have previously directed the level and type of infrastructure and technologies used in Aboriginal communities must be questioned.

11.4. Conclusions

Aboriginal and Torres Strait Islander communities in isolated areas highlight and demonstrate the need for rural and remote area communities to implement appropriate technological solutions. Such solutions will not necessarily be simple technologies. Complex and innovative technologies may be suitable, as long as their cost and life-time maintenance and replacement needs are taken into account. It can be argued that if we can respond to the needs of Aboriginal and Torres Strait Islander communities, then we will be able to develop the skills and infrastructure to equitably respond to the S&T needs of other rural and remote communities.

One system that has been tried overseas is the use of a mediator to overcome the difficulties of the donor-recipient relationship. Internationally, non-government organisations such as the Red Cross have filled a role of negotiation and mediation between community groups and governments. The third-party is not necessarily aligned with the stance of either group and has the opportunity to think laterally, explore within the community a diversity of views and opinions and to relieve governments of direct involvement in the process of negotiating appropriate outcomes.

The fostering of independent technical advice through non-government organisations to provide grass-roots input to technical decision-making is one of ensuring greater control of service provision by communities, while at the same time resourcing communities with expertise responsive to community aspirations.

The Federal Race Discrimination Commissioner (1994) suggested establishing a network of independent technical resource centres which concentrate their attention on the specific problems faced by Aboriginal and Torres Strait Islander communities. Such centres could foster of independent technical advice and provide grass-roots input to technical decision-making. A longer term alternative is to provide this infrastructure within Aboriginal and Torres Strait Islander communities.

Area for Action:
Developing Technological Literacy in Aboriginal and Torres Strait Islander Communities

ASTEC considers that S&T offers much promise in promoting wealth generation and improving community well-being. It is important to ensure that the benefits of developments in S&T will be shared across Australia's many metropolitan and regional centres and rural and remote communities.

To develop the critical role of S&T in the Australian community will require attention to all areas. An immediate area of action is the capacity of Aboriginal and Torres Strait Islander communities to access infrastructure to develop, undertake and evaluate appropriate S&T.

Priority Action for the Commonwealth Government – 5

ASTEC recommends that the Minister for Science and Technology and the Minister for Aboriginal and Torres Strait Islander Affairs:

- consult with Aboriginal and Torres Strait Islander communities, particularly in isolated regions, about their capacity to access infrastructure to develop, undertake and evaluate appropriate S&T; and
- explore options for developing infrastructure programs similar to those for health and education, where there is a local indigenous technology innovator, reviewer and adviser to communities, or adviser-consultants attached to specified tertiary education institutions.

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Part D: Implications for the Science and Technology System

Australia's science and technology (S&T) system is complex and pluralist. How well is it attuned to Australia's emerging needs? How responsive will it be to changes that arise? Is it sufficiently flexible to assist us achieve national goals of a productive, inclusive, creative and ecologically sustainable Australia in the 21st Century?

ASTEC identified a number of important changes required in the Australian S&T system to meet the challenges of the 21st Century. There is a need for Australia to integrate further into the global S&T system. There is a demand for more effective linkages within the S&T system and with other systems. And there is a well articulated need for the S&T system to better reflect changing community values.

The identification of 'critical' technologies is often associated with technology foresight exercises, yet it is harder to identify 'critical' science. From a 'critical' technology perspective Australia's underlying science base is relatively well placed to help respond to the Key Forces for Change and the prospect of a globally integrated S&T system. However, there are areas of weakness.

Managing uncertainty requires skills to respond to the challenges ahead. The skills of people in the S&T system will determine to a large extent our success in meeting Australia's needs in the 21st Century.

Part D discusses the S&T system in terms of strategic orientation and emphasis, whereas debate in the 1990s has often focused on appropriate institutional structures, particularly for public sector research. The outcomes of this study should contribute to a renewed and ongoing debate.

- Chapter 12 explores the changes required to develop a forward looking S&T system and a new conceptual framework for S&T which can better take account of broader socio-economic and environmental needs;
- Chapter 13 identifies technologies critical for the 21st Century and considers how Australia is placed with regard to them;
- Chapter 14 looks at the Australian S&T system in the context of a global S&T system; and
- Chapter 15 explores the skills required to manage the challenges ahead.

Chapter 12.
A Science and Technology Culture

12.1. Introduction

In the 21st Century wealth creation, social well-being and the health of our natural environment will increasingly depend on the S&T system – including engineering – as a vital part of the 'knowledge economy'. What changes are needed to improve our S&T system for the world of the 21st Century? What are the critical priorities for technology and skill development? How can we build effective linkages to the community?

This century has seen an explosive growth of knowledge and information generated by modern scientific research and its technological application. S&T have increased our material well-being to an extent that is unequalled in any other period in history. The insights gained through science and our improved understanding of nature have contributed fundamentally to the shape of our culture and society.

S&T has a complex role in our society and economy – we both influence it, and are influenced by it in many ways. Recent sophisticated interactive models of innovation illustrate the complex interplay between customer needs and wants, technical possibility and the many sources of knowledge and new technology (eg DIST 1996). There are many drivers and constraints to S&T. Innovation, industrial research and the systematic use of knowledge and technology to create competitive advantage and generate wealth are now essential ingredients of our economic fabric. As a society we increasingly draw upon S&T to improve community well-being and to help solve local and global problems.

The Australian S&T system includes R&D funders and performers in both the public and private sectors, R&D advisers, professional organisations and other non-government groups. It includes private and state research agencies, and the organisations responsible for R&D in primary industry. There are a host of influential forces in the S&T system and many cross-links and productive interactions between them. The system is pluralist and decentralised.

S&T has become an important part of the Australia economy. Total R&D expenditure was 1.56 per cent of gross domestic product (GDP) in 1992-93 and the research sector employed almost 1 per cent of the Australian workforce. The majority of Australian S&T is funded by, and performed in, the public sector, dominated by our universities, CSIRO and key funding bodies such as the NH&MRC and rural R&D Corporations. Major policy actions of the last decade have helped to increase our relatively low levels of Business Expenditure on R&D, and improve links between public and private sectors (eg IC, 1995a).

The flexibility of Australia's S&T system has improved over the past decade. CSIRO, our national flagship for publicly funded R&D now derives over one third of its income from external sources. The deployment of its researchers now reflects the need for multi-disciplinary studies; its management practices have been streamlined for more rapid response to industry and government priorities. Encouraged by funding pressures, basic research conducted in within universities often has a defined socio-economic purpose and researchers are more willing to seek the application of their discoveries in industry. Our rural R&D Corporations, part funded by industry contributions, have programs targeted to their clients needs – and clients are increasingly articulate. The impetus of such changes needs to be maintained.

The potential effects of the Key Forces for Change will provide a test of the flexibility and responsiveness of the Australian S&T system. It will be critical to develop an S&T system that can take into account potential opportunities and threats from these forces.

Box 12.1 Some Facts about Australian R&D

- Annual R&D expenditure in Australia is running at over $6 billion, of which government support comprises about 60 per cent.
- About 28 per cent of R&D spending is on 'basic' research.
- Research within the public sector accounts for 0.9 per cent of GDP, fourth largest in percentage terms among OECD countries.
- Of all public sector research, higher education accounts for about 50 per cent, and CSIRO performs about one fifth.
- Business R&D represents about 0.7 percent of GDP. While this ratio is still significantly below the OECD average, BERD grew during the 1980s at an average rate of 13 per cent annually, well above the OECD average.
- Australians produce over 2 per cent of the scientific research papers world wide.

Source: IC 1995a

ASTEC explored *the need for a forward looking S&T system to 2010* using a scenario for 2010 of a world dominated by a 'market economy' model, combined with strong pressure for smaller government (Box 12.2). It suggested:

- the absence of effective national borders on science, technology and industry;
- greater recognition of the critical value of S&T to industry;
- widespread use of new I&CT for rapid access to vast intelligent databases that allow immediate interactions with collaborators around the globe; and
- diminishing boundaries between disciplines and types of research.

Box 12.2. A Scenario for 2010 – the Starting Point for an ASTEC Roundtable

ASTEC's Roundtable on *the need for a forward looking S&T system to 2010* brought together some 60 people to consider a scenario for 2010 – one of a market-driven, global S&T system where Australia struggles to maintain its identity. Participants were encouraged to consider the implications of this scenario and what it might be like to live in such a world. This scenario does not reflect either ASTEC's view or preferences for what the future will be. Rather, it was used as a device to encourage an exploration of long-term issues for the S&T system.

- In 2010 Australia is a small player in a highly competitive global S&T system. Globalisation, encouraged by governments and industry, and facilitated by technology, has proven to be a powerful influence on a world dominated by a belief in the virtues of a free market.
- The world economy is structured around several large trading blocs, within which very few restrictions on trade are tolerated. In APEC, tariff barriers have been removed in all developed countries and government assistance to industry for research and development (R&D) is soon to be outlawed under World Trade Organisation rules.
- S&T is now an international enterprise. Its services and 'products' are traded in the same way as commodities in the global marketplace. There are no effective national borders on S&T and the influence of the Australian Government on the S&T system has decreased over the last fifteen years.

(cont'd)

Box 12.2. A Scenario for 2010 – the starting point for an ASTEC Roundtable (cont'd)

- S&T in 2010 are integrated into economic activity and are broadly embraced as central pillars of industrial competitiveness, with most R&D undertaken by industry. A strong S&T base is perceived as key to attracting internationally footloose industries and facilitating effective government decisions on complex social, political and environmental issues.
- The global companies of 2010 conduct and use more R&D than in the late 20th Century. These enterprises retain as their core asset a highly skilled staff. Companies enforce long-term career contracts and talented students who gain industry-funded university scholarships find themselves wedded to firms as a result.
- Belief in the virtues of 'the market' has led to a strong preference for smaller governments. Funding for S&T is no higher in real terms than it was in the late 20th Century. And government funding for trade related S&T is currently being reviewed to enable compliance with WTO rules.
- The limited amount of Government funded research is competitive, directed to support specific government decisions (national and international) and costed against particular government programs. The CSIRO has been privatised and has become an international 'brand leader' for Australian S&T. Most of the organisation's time is now taken by international clients – most of whom do not even have bases in Australia.
- Information technology has helped globalise S&T. Clusters of researchers, using broad band communications are now spread around the globe. These include pre-competitive cooperative research centres. Most of these centres are located in Europe, US and Japan with new centres being set up in South and East Asia. Australia is the location of the hub of a handful of these new centres, but this is a highly fluid situation.
- Many types of international and inter-regional linkages have been consolidated by the widespread use of 'virtual' person-to-person contact via computers. Broadband communications have integrated global education. Prestigious global universities have emerged with 'virtual campuses' in many locations, offering access to courses in multiple languages, using quality assured franchisees. Vast databases of factual technical information are available on-line from intelligent databases around the globe.
- In 2010 people no longer find it valid or useful to distinguish between different 'types' of research; 'basic', 'strategic' and 'applied'. Rather, all these types of research can be combined in achieving the 'discovery' tasks of 2010. Successful innovation requires inputs from multiple 'disciplines' and many different kinds of knowledge. Personal networks and negotiation of complex interactions are crucial to success and R&D experts are rewarded for these skills.
- While there is some criticism of the limitations of market economies, such as a lack of will to deal with global-scale environmental problems, such issues remain unresolved. Many concerns are also being expressed about the loss of national sovereignty and the power of global companies.
- While Australia is but a minor player in a very competitive system of global S&T, Australian researchers are often part of breakthrough events. We are recognised as having strengths and advantages in many S&T areas. In particular Australian researchers gain great respect for their contributions to biomedicine, agricultural transgenics, environmental management and signal processing for space applications.

Source: ASTEC 1995 /

This plausible yet challenging scenario provoked broad discussion of the impacts of a global, market-based future for S&T. It raised questions of whether the society represented in the scenario was desirable. Was it consistent with Australia's goals for an inclusive, productive, creative and ecologically sustainable society in the 21st Century? Could it address the human and ethical dimensions of S&T developments? Would it provide an intellectual climate that discouraged discovery?

The debate encouraged by the scenario revealed many tensions and fears within our S&T system. The threat of a global system where Australian priorities were overwhelmed by world commercial interests was deemed abhorrent, and revealed a need to target our 'in the public good' expenditure. The speculation that all research might in the future be required to have a utilitarian purpose was viewed as unacceptable. It is clear that our S&T system would not welcome radical changes influenced by world forces. New strategies are needed to enable our S&T system to conceptualise and cope with the prospect of rapid and radical change. The generalised discussion of the hypothetical scenario events revealed that some of the projected influences are with us now, albeit in a milder form.

12.2. A Global S&T System

To survive in a more internationally integrated and competitive world, the many different parts of Australia's S&T system will need to effectively identify and service their niche markets in competition with larger institutions and companies based elsewhere. To attract scientists and centres of R&D to Australia it will be critical to promote Australia as an attractive place to live with a relatively clean environment, stable financial and government systems, and a good place for business.

Potential tensions between countries and transnational companies were identified as important influences in a global S&T system. Australia will need to manage new linkages in our region, whilst continuing relationships with historical partners in Europe and the US. We must also integrate into the diverse range of systems constituting global S&T including global companies, networks with small and medium enterprises, international research programs, regional organisations, academia and national research institutions.

To be well-placed in this new global system Australia will need to articulate the role of a national S&T system and debate 'national benefit' criteria.

12.3. An Integrated S&T System

More effective communication across discipline boundaries with better linkages across the S&T system will be required. Advances in I&CT over the next 15 years will allow more geographic diversity in work groups, underlining the importance of networking and the need for common goals within teams. Better linkages between the S&T, financial and legal systems are required, for example, to ensure adequate access to capital for research and business growth.

While technological developments are often difficult to anticipate, social, legal and regulatory issues might be readily identifiable as potential impediments to beneficial applications of S&T. For example, the management of intellectual property in a global, information technology-rich environment is a key issue. A prospect of a freer globalised system with research facilitated by the Internet and shared computer systems suggests widespread benefits. However, an alternative possibility is increased 'intellectual protectionism' where researchers become more secretive in response to rapid 'losses' of knowledge advantages. This could lead to a fragmentation of knowledge and greater restrictions to access. A novel suggestion emerging from the Roundtable to was to develop a new framework for intellectual property allowing ready access to information and knowledge, whilst ensuring compensation to the originator – perhaps through a sophisticated version of today's citation indices. Speakers called for a greater dialogue between the legal and S&T systems to achieve a leading edge intellectual property system.

12.4. Reflecting Community Priorities

A strong feature of the preferred future was a more open and inclusive S&T system, more involved with the wider community and recognising and incorporating community values and changing needs and priorities. A system that understands the social context and impacts of technology and considers cultural issues might better manage the important decisions required over the next 15 years and beyond.

An example is the development and application of appropriate technological solutions to match social and environmental contexts. While Australia has a sophisticated infrastructure in 1996, half the world's population has never made a phone call. Towards 2010 these people will need special solutions from S&T to meet the challenges ahead. Australia's S&T strengths, multicultural diversity and global links suggest that our S&T system might be well placed to address such needs using appropriate solutions.

Social impacts of technology are of high importance. Equity and access emerged as substantial issues, and care will be needed so that sectors of the population are not cut off from the benefits of S&T developments. The S&T community may also need to interact with powerful global 'S&T-aware' consumer organisations.

12.5. Priorities and 'Critical Technologies'

The S&T system to 2010 offers the diverse prospects of being able to provide highly sophisticated, leading-edge technologies, being able to combine these in new ways, and to integrate them with less sophisticated technologies to develop appropriate and culturally targeted S&T. 'small' countries like Australia will not be able to cover all areas of S&T to 2010, nor indeed will the world's largest economies be able to seek leadership in all areas.

Therefore countries around the world are looking to set priorities for S&T development. Foresight is looked upon by some as a potential tool for this, eg in the UK and the Netherlands. However, it is difficult to choose priorities and there are many uncertainties. How much 'pure basic' science will we be able to afford? While priorities may be appropriate for technologies, can they be applied to science? How would a market-driven system support 'public interest' research? How can niches of strength be used to maximum effect?

ASTEC found strong support for a balanced approach to managing change for S&T to 2010. A strongly market-oriented system might support less 'public interest' research, and government funding would need to maintain this type of science and engineering. There is a need for a strategic approach to priorities at a firm, sector or national level; with governments required to give more attention to longer term policy and practices, and strategies to manage a more networked, integrated and multi-disciplinary S&T system.

12.6. Skills to Manage Change

A broad range of skills will be required of people in the S&T system – many initiated by the move to a 'knowledge economy'. Generic skills to improve our capacity to manage the challenge of change in management, I&CT, international skills and risk assessment were raised throughout this study.

A range of new occupations and new skills will be needed for data management: the ability to translate vast amounts of information into market relevant and useful knowledge. Digital technology will lead to new ways of communicating going beyond the linear writing skills taught at school, eg 'hyper-text' and 'multimedia' allow new ways of structuring information.

There is a need to provide students with skills in innovation and creativity, and to instil enthusiasm for lifelong learning in a changing society. Teachers will require skills in teamwork, mentoring and managing multi-cultural and multi-disciplinary work teams as facilitators.

12.7. A New Conceptual Framework for S&T

This study seeks to assess how well S&T is matched to future needs, thus giving a high emphasis to 'demand' perspectives for S&T.

During the past decade Australian governments have sought to improve the interface between industry and the research system and to ensure the S&T system is responsive to industry demands. Industry has been encouraged to conduct more R&D through incentives such as the 150 per cent tax concession, and to improve its links with public sector S&T through Cooperative Research Centres, among others. Some are, however, concerned that this may reduce scientific freedom and the probability of important basic science discoveries.

In previous times a distinction was made between 'science for policy' and 'policy for science': should scientific efforts be led by policy or should policy accommodate a relatively autonomous science system. Such a debate no longer seems relevant. Rather, in the long-term it is perhaps how to ensure that 'science for society' and 'society for science' are indeed compatible and mutually reinforcing concepts. This might provide a more appropriate attitude for coping with the challenges ahead, as it seeks to integrate S&T into all of society's various activities and to recognise society's many diverse needs.

ASTEC identified the need to consider a wide social context for S&T. The priorities for research should not be independent from broader society. The importance of fostering two-way dialogue between S&T experts and the broader community cannot be overestimated.

For instance, ASTEC's Youth Partnership suggests that many young Australians feel inadequate in their ability to influence the challenges of the future, but nevertheless recognise that S&T will make an important contribution to developing effective solutions (ASTEC, 1996a). While recognising that S&T offers the best hope of meeting the challenges ahead, young Australians do not see it as a universal panacea. Young people consider that S&T would be able to solve some problems such as health, but that it might not necessarily solve others, such as producing enough food to feed a growing world population.

Over the past decades a greater proportion of the community has come to identify S&T as having brought both significant advantages and disadvantages. Certainly there was considerable concern expressed throughout the Future Needs study about potential negative impacts of S&T.

The community's perceived problem with S&T may not be intrinsic to the nature of scientific research and knowledge. It has been argued that it could rest more with our immaturity in using a cultural tool as powerful as science. Perhaps with growing experience and wisdom, we can better use S&T to serve our best interests and deepest needs.

To better integrate these broader societal needs, the S&T system for the 21st Century should:

- enhance the contribution of S&T to effective decision-making processes;
- focus new scientific and technology developments to meet socio-economic and environmental needs;
- maximise the benefits of S&T for industry and economic growth;
- appreciate science as part of our culture – combined with a respect for other cultural perspectives; and

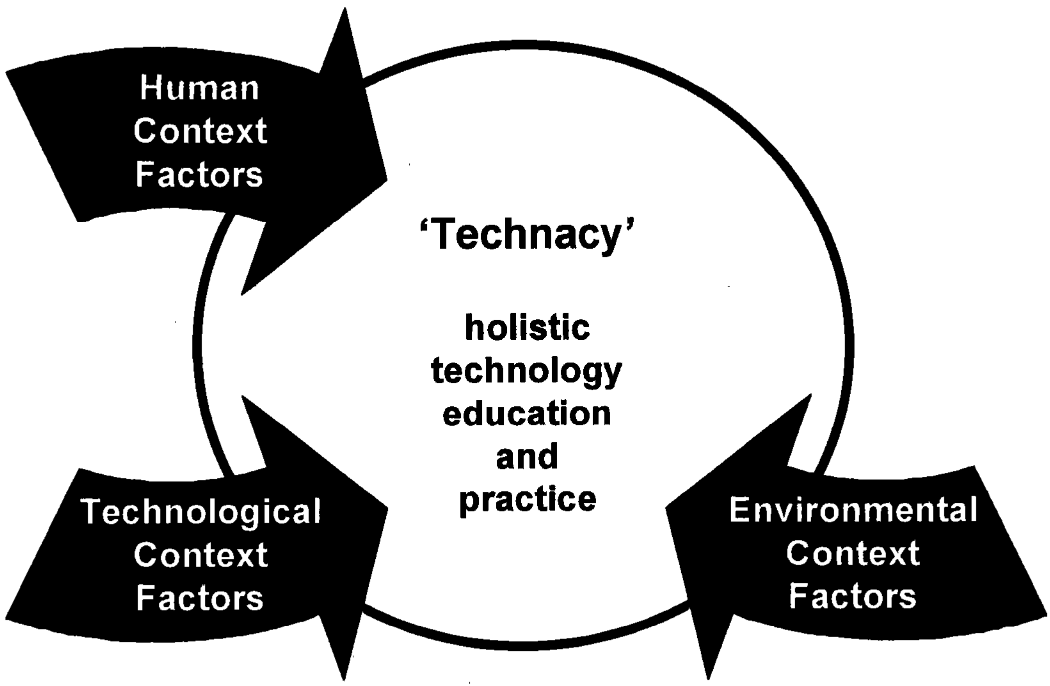
- build strong science, and its essential drive for the discovery of new knowledge, and strong technology systems and expertise, including an educated workforce.

During this study, ASTEC was introduced to the concept of 'technacy' which provides a framework for considering S&T within a socio-environmental context. Technacy is a way of defining the meaning of 'technological literacy' that goes beyond competency in using technology. Technacy is the technological equivalent of literacy and numeracy, and refers to a holistic view of technology problem solving, communication and practice that includes consideration of social, technical and environmental resources and constraints (Seemann and Talbot, 1995). It is a view the recognises the values underlying the design and application of technology. The concept of technacy is particularly applicable to cross-cultural technology delivery situations, but it has broad applicability in technology education and practice. Some have argued that it might be regarded as a third basic competence along with literacy and numeracy.

It is based on a three way interaction of interdependent parts: the human, technological and environmental ingredients of any technical undertaking. Each of the three parts both define and require the other two, and no pair can be adequately defined without inclusion of the third. For example, the possibilities of society are to a large extent dependent on technological knowledge and practice, and both human culture and technology are set in the context of the natural environment. The three factors of the technacy model are represented diagrammatically in Box 12.3.

S&T, human (socio-cultural and economic) and environmental issues need to be integrated with our national goals for Australia to be creative, productive, inclusive and ecologically sustainable in the 21st Century.

Box 12.3. 'Technacy' – Holistic Technology Education and Practice



Source: Based on Seemann and Talbot, 1995

Consultations in this study have consistently pointed to concerns about the 'purpose' of S&T – and whether it will have a positive or a negative influence on future society. Young Australians' preferences for S&T are firmly embedded in the type of society they would like to see in 2010 and the economic, social and environmental priorities this implies.

The technacy model requires us to consider issues such as access and equity and provides the community with a valid role in decision-making processes. It rejects the view of 'value free' technology, and provides a perspective relevant to decisions in industry, research institutions, funding agencies and Government policy areas. This would ensure that social and environmental inputs are considered as equally valid parts of S&T decision making processes.

There is a need to give emphasis to the social context and implications of R&D. For developments in genetics, our consultations stressed that issues of access and privacy must be addressed in parallel with the research, not after it has been undertaken. This requires new decision-making processes that involve legal and other systems at a much earlier stage.

The research community will need to respond to this framework by taking more responsibility for the context of their publicly funded research and its likely benefit to Australia. Australia has a strong base in research, but too often this valuable resource has not translated into economic or social benefit for Australians. Better mechanisms are needed to ensure that, where appropriate, this research is transferred to those in the private sector who can commercialise or apply it. Mechanisms to integrate socio-environmental concerns need to be developed so that researchers can become more adept at considering the social and economic value of their research at an early stage, and communicating this to the public.

Wide application of this model would impact on the structure of the S&T system. New sub-systems would be required at the interface between the S&T system and the community to develop a capacity to use and foster ownership of scientific results. These could for example include new forms of employment or volunteer participation.

12.8. Conclusions

For Australia to benefit from opportunities in the 21st Century, S&T will need to be deeply embedded in our culture.

Challenges such as genetically modified organisms, global information flows and medical breakthroughs will need to be matched by national S&T literacy, a commitment to underpin national investment in research and technology, and a sophisticated national debate which values social, economic, environmental and ethical concerns.

This requires an S&T community that is more aware of, and responsive to, community concerns. It must meet the community half-way in considering their concerns. It is likely that increased understanding would be matched by increased respect for S&T.

Area for Action: Building a Context-aware S&T System

ASTEC considers that, as a vital part of developing a 'knowledge economy', it is necessary to promote an S&T system that is highly integrated into its social and industrial context, and, while committed to excellence, is open and responsive to priorities arising from strategic industrial, social and ethical issues.

To help meet Australia's future needs in the 21st Century, we need an effective S&T system which both reflects and contributes to shaping, community values and economic progress.

ASTEC suggests that industry, funding agencies, professional bodies and others need to consider the preferred directions for publicly funded research in Australia and ensure that mechanisms to establish priorities in strategic research reflect the frontiers of knowledge, industry needs and community concerns.

It will be necessary to implement effective mechanisms to ensure on-going and effective two-way communication between S&T experts and the community and in particular to address the low participation of young people, especially women, for example, through volunteer participation in S&T activities (eg Waterwatch).

Chapter 13.
The Information Base for Research Decisions

13.1. Introduction

Technology 'forecasting', used as a key component in international foresight studies, provides valuable information on the internal dynamics of scientific and technological processes – technological trajectories. Such studies have identified many technological possibilities experts perceive as realisable over the next 10 to 30 years. ASTEC used the results of such forecast studies to provide the technological context for this study – glimpses of globally available technology to 2010.

Varying criteria have been applied to such forecasts to identify particular technologies that are considered 'very important', for example, for wealth creation or for community well-being. The results of such exercises in the United States in particular, have provided lists of important future technologies referred to as 'critical technologies'.

Given that this approach implies that priority should be given to strategic research directed towards the technologies identified, this chapter assesses Australia's science and technology (S&T) base in relation to critical technologies and to ASTEC's four Key Forces for Change. This analysis identifies areas of comparative strengths and weaknesses in internationally important longer term research areas.

It is important to note the key differences between critical technologies and foresight as developed by ASTEC. The identification of critical technologies is based on the expectations of groups of experts on future developments based on current research. It is a form of trend analysis. The criteria applied by the groups to rank the importance of prospective developments vary in their detail and reflect the purpose of the exercise and the performing organisation, eg for civil versus military end-use.

In the US, critical technology information is used as a benchmark to assess its leadership in S&T relative to other countries, particularly Japan and Europe. The commitment of the US is to remain at the forefront of 'all fields' of S&T. This national perspective of critical technologies is not appropriate for small countries such as Australia. We do not have sufficient resources to address all the rapidly increasing fields of knowledge within S&T. Explicitly, or otherwise, we must make choices.

From an Australian perspective the concept of critical technologies suggests research priorities. However, as noted in ASTEC's *International Perspectives* report, 'criticality' is not a property of the technology itself, but is partly a function of both the role of technology in economic processes and the objectives of policy-makers (ASTEC, 1994c). To this we can now add its role in helping Australia respond to long-term Key Forces for Change.

Foresight, through both its processes and the ideas it generates, can make a contribution to decisions on Australian S&T priorities. While ASTEC has not used this foresight exercise to recommend priorities for funding particular fields of research, we must recognise that foresight is being used to do this in both the UK and the Netherlands.

We must view priorities in the context of Australia's future needs, our science, technology and industry profile, and our strengths and weaknesses. For example, as a 'small' nation our international links will be crucial in maintaining a capacity to participate in leading-edge developments in specific fields, and to facilitate the transfer and adaptation of technology from overseas in a broad range of areas. Critical technology fields in this context become areas that we need to monitor carefully and, as suggested by Chapter 7, maintain a presence in intellectual property development to, at least, establish a bargaining position.

A concern has been expressed by some that foresight is designed, or could be used, to attempt to direct 'basic research'. However, ASTEC considers that viewing critical technologies in isolation does not provide the basis for imposing priorities for basic research. The identification of important future technologies can give broad indications of scientific capabilities required to develop them. However, the underlying dynamics and unpredictability of basic research, and the uncertainty about which piece or body of knowledge will be crucial in underpinning a new technological development, and the convergence of disciplines, suggest a need for great caution (eg Royal Society, 1995).

However, ASTEC considers that information about critical technologies is useful for a range of organisations involved in research, and that it should be taken into account in their decision making and long-term plans.

This chapter looks mainly at longer term strengths and weaknesses in our science base in relation to responding to the key forces of change. It recognises the 'bottom-up' effect of individual achievements and expertise of specific Australian scientists and engineers. Such people provide the core of our S&T effort, along with the infrastructure and equipment that supports them. Though such people we can generate and use intellectual property within Australia, which can form the basis for achieving further social and economic benefits.

The S&T system is, of course, only one instrument for achieving national goals. The S&T system's activities must be set in a broad socio-economic context, to take account of the needs of society as a whole and the capabilities of those, particularly in industry, who apply the outputs. Society has many goals and expectations for science.

13.2. Australia's S&T Base and the Key Forces for Change

An important measure of our ability to respond to the Key Forces for Change is the strengths and weaknesses of our longer term research efforts, as well as the position of more applied and industrial R&D. Indicators of the former are provided by publication and citation indices which reveal strengths and weaknesses in certain areas. While such indicators are used extensively in the following discussion it is important to recognise their limitations.

Recent work by Bourke and Butler (1994) identified strengths for Australian science in Earth Sciences, Biological Sciences and Agricultural Sciences (Box 13.1). It also raised concerns about relatively large declines in share of world publications in fields such as Applied Sciences and Technologies (which has declined 20 per cent between 1982-91), Mathematical Sciences (declined 16 per cent) and Physical Sciences (declined 13 per cent).

The level of aggregation is important, and within each field there will be areas of particular strength or weakness. Sub-areas which have declined strongly include Pure Mathematics, Astronomical Sciences, Analytical Chemistry, Other Chemical Sciences, and Materials Sciences and Technology.

Box 13.1. Australia's Percentage Share of World Publications by Field

Field	Share 1982-86	Share 1987-91	Change 82/6 to 87/91
Mathematical Sciences	1.82	1.53	-16.01
Physical Sciences	1.37	1.19	-13.17
Chemical Sciences	1.36	1.24	-9.01
Earth Sciences	3.48	3.58	2.94
Information, Computing & Communication Technologies	1.16	1.12	-3.15
Applied Sciences & Technologies	1.69	1.34	-20.76
General Engineering	1.39	1.33	-4.20
Biological Sciences	2.72	2.71	-0.18
Agricultural Sciences	4.28	4.33	1.16
Medical & Health Sciences	1.92	1.96	2.03
Not Field Specific	1.56	1.58	1.30
Total Sciences	**1.98**	**1.92**	**-2.78**

Source: Bourke and Butler 1994

In contrast an area of growing strength is the Earth Sciences. The Australian Research Council Earth Sciences review identified strengths in: petrology (igneous/metamorphic); structural geology / tectonics; isotope geochemistry and geochronology; metalliferous ore deposit geology; vertebrate palaeontology; and remote sensing. Areas of weakness included: geophysics; geochemistry; marine geoscience; environmental / engineering geology; hydrogeology; and computer applications in earth sciences. (NBEET 1992b).

Bourke and Butler reviewed the outcomes of international foresight in areas of critical or 'generic' technologies for ASTEC, and assessed Australian S&T strengths in relation to them (Bourke and Butler, 1995a). The results confirm that the Australian research presence is at its strongest in areas such as environmental and earth sciences, biomedical sciences, water resources and energy, which may be directly relevant to the Key Forces of *Advances in Biological Technologies and Environmental Sustainability*. However in areas related to the other Key Forces Australia's position is generally weaker and focused on niches eg optics and robotics for *Applying I&CT* and *Global Integration*.

a) Global Integration

S&T related to transport and I&CT are two of the likely contributors to addressing issues arising from *Global Integration*.

Business expenditure on R&D in transport in Australia is concentrated in motor vehicles and parts ($166 m in 1992-93) and ships and boats ($116 m 1992-93).

The UK Office of Science and Technology identified a number of priority technologies for transport: high strength lightweight materials; safety critical software; fuel efficient, low-emission power plants and energy recovery systems; quieter vehicles; accurate location systems; and pattern processing and recognition technologies (OST, 1995g). The breadth of this short list serves to emphasise that no simple connection can be made between scientific disciplines and critical technologies, or key forces of change.

Globally, in the transport sector, aircraft manufacturing is a very large and intensive R&D performer and Australia will remain dependent on importing such technology. Similarly in the motor vehicles sector, the world is dominated by a few very large companies. However, new companies are emerging in East Asia. On the other hand Australia potentially has a strong role in specialised smaller ships and boats eg luxury yachts and fast ferries, which is not already dominated by large shipbuilders. The recent Bureau of Industry Economics benchmarking study identified high growth rates in some areas of small ships (BIE, 1996b).

b) Applying I&CT

Bourke and Butler have shown that Australia's share of publications in I&CT journals is modest and well below the overall national average for science.

This indicates an overall weakness in the science base underlying the force of *Applying I&CT.* However, a more in-depth review reveals niches of strength (Box 13.2). Australian presence in fields of 'Optics' and the 'Inter-disciplinary applications of I&CT' are comparatively high. In the latter the journal set focuses on communicating with machines and applying I&CT to a variety of disciplines.

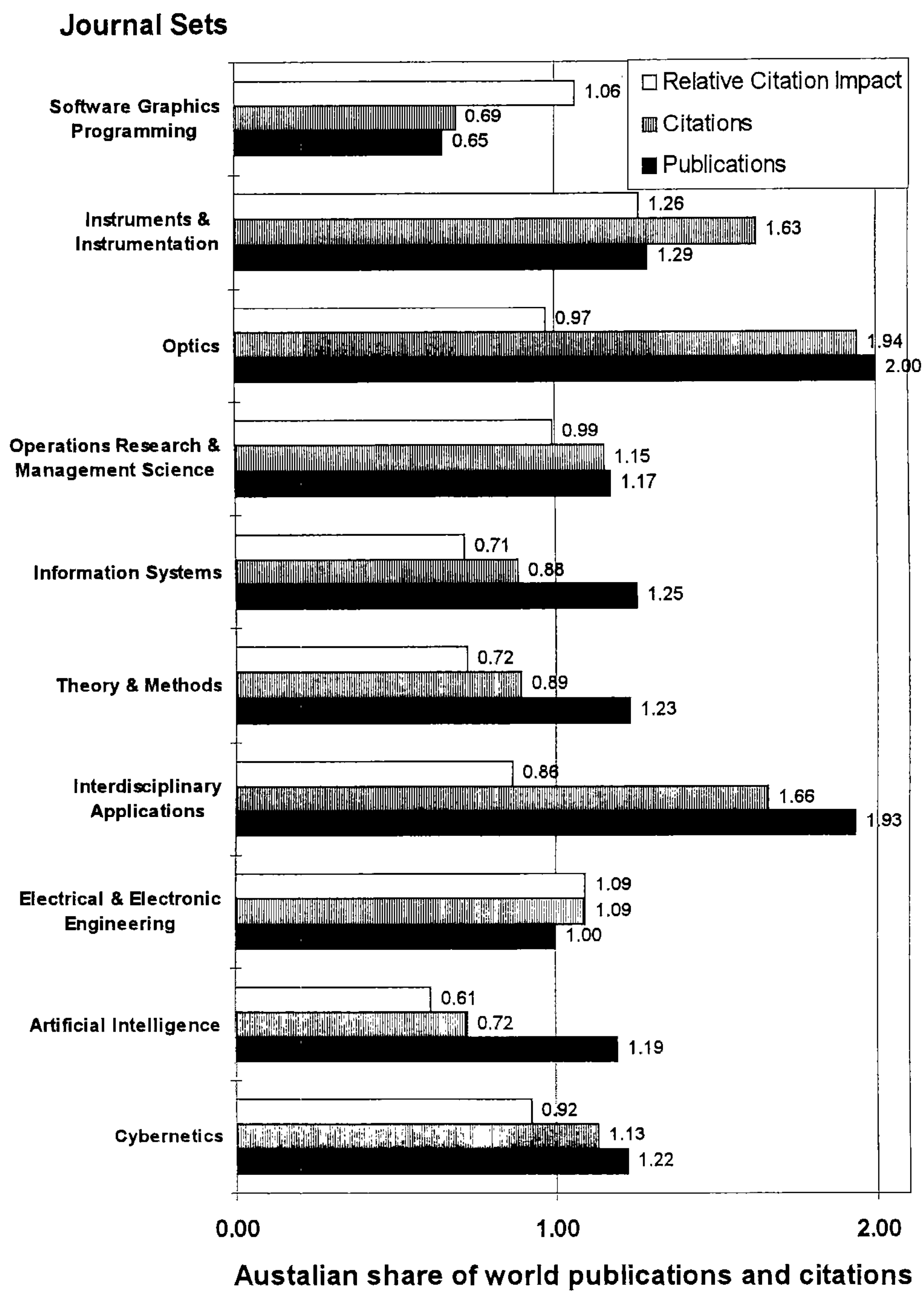
Australian publications also generally had a high 'impact' as measured by a relative citation index (RCI). Interestingly, international research collaboration in I&CT was higher (27 per cent) than the national average and growing (increasing by 77 per cent over the period).

This is complemented by industrial research. The two largest areas of Australian BERD, accounting for 31 per cent of all BERD in 1992-93, were in computer software (23 per cent) and electronic equipment (8.6 per cent). This represented a total investment of $875 million.

A recent ASTEC report identified Australian strengths and weaknesses in I&CT, and outlined specific actions necessary for Australia to perform adequately in this industry (ASTEC, 1995f). It recommended that Australia focus on the quality of its skilled graduates over the next 5 years. This will require directing funds to developing outstanding centres of research and training, building on centres of strength. In addition, school students need to be alerted to the significant career opportunities in the areas of I&CT and to the importance of I&CT literacy in almost all occupations.

Australia's I&CT science base has a focus on the application of I&CT in other sciences and industry, and not on the development of new hardware. This may appropriately reflect the position of Australia as primarily a user, and innovative applier, of technologies and services developed elsewhere. Skills will be an important part of adapting to the future.

Box 13.2. Australian Share of World Publications: UK Generic Priority of 'Harnessing Future Communication and Computing' – Annual averages for period 1981 - 1992

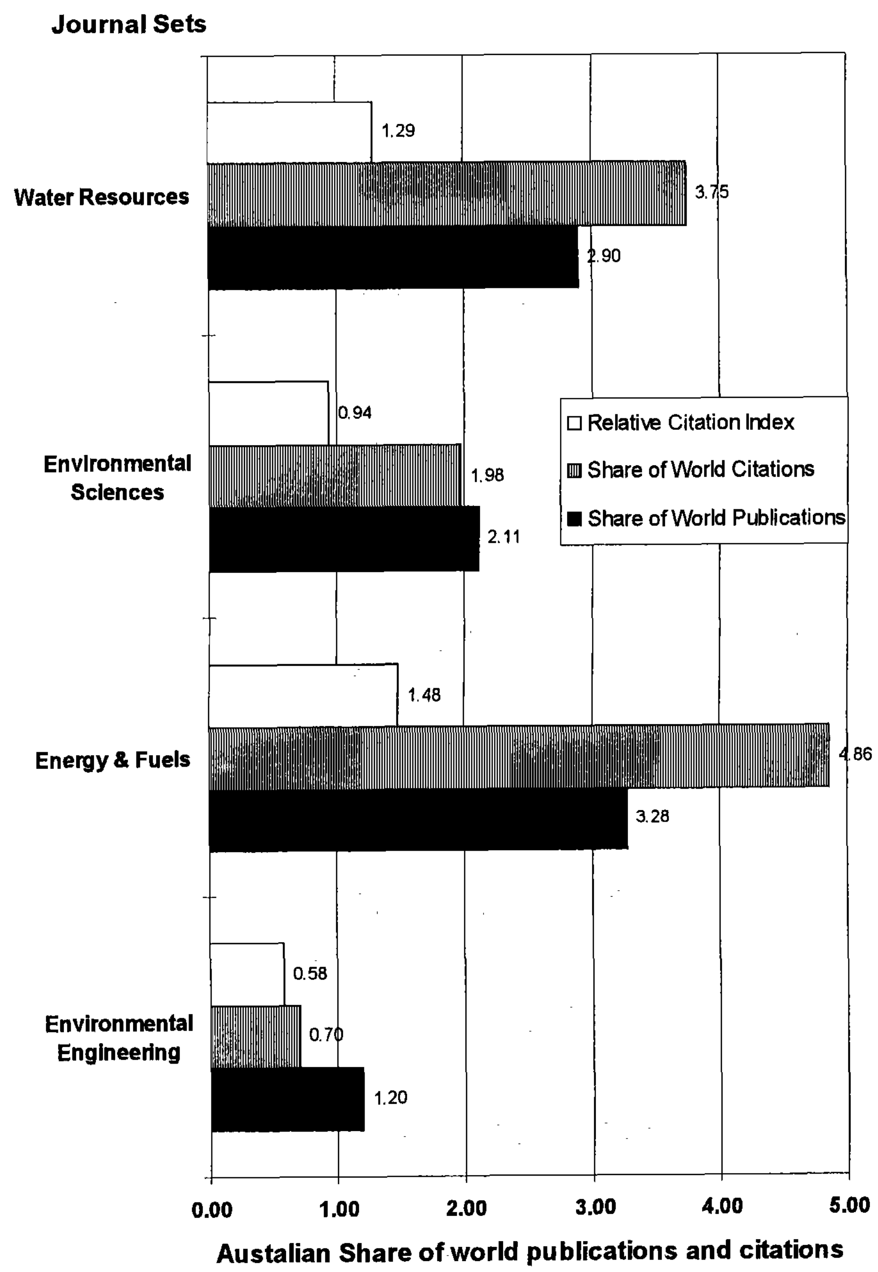


Source: Bourke and Butler 1995a

c) *Environmental Sustainability*

Bourke and Butler indicate that Australia's share of publications in environment-related journals is particularly strong, although Environmental Engineering is well below the overall national average for science (Box 13.3). This indicates strength in the science base underlying the force of *Environmental Sustainability*.

Box 13.3. Australian Share of World Publications: UK Generic Priority of 'A Cleaner World' – Annual averages for period 1981-1992



Source: Bourke and Butler 1995a

The non-business sector expended about 4500 person-years of effort and about $320 million on environmental R&D (including energy) in 1990-91. The performance of this effort in 1990-91 was 35 per cent by CSIRO, 28 per cent by universities, 22 per cent by states and territories, 14 per cent by Other Commonwealth and 1 per cent by private non-profit. To this must be added the considerable research spending of the private sector and the significant efforts of voluntary groups.

The areas of public sector R&D in environment related socio-economic objectives is shown in Box 13.4. Two areas are prominent: natural ecosystems, where R&D is mainly in the universities, and the environmental aspects of primary industry, conducted mainly by State governments and CSIRO. Australia is a world leader in ecosystem monitoring by satellite imaging of changes such as land clearing, siltation of rivers and decline of coral reefs.

Box 13.4. Non-business R&D, 1990-91 – Environment Related Socio-economic Objectives

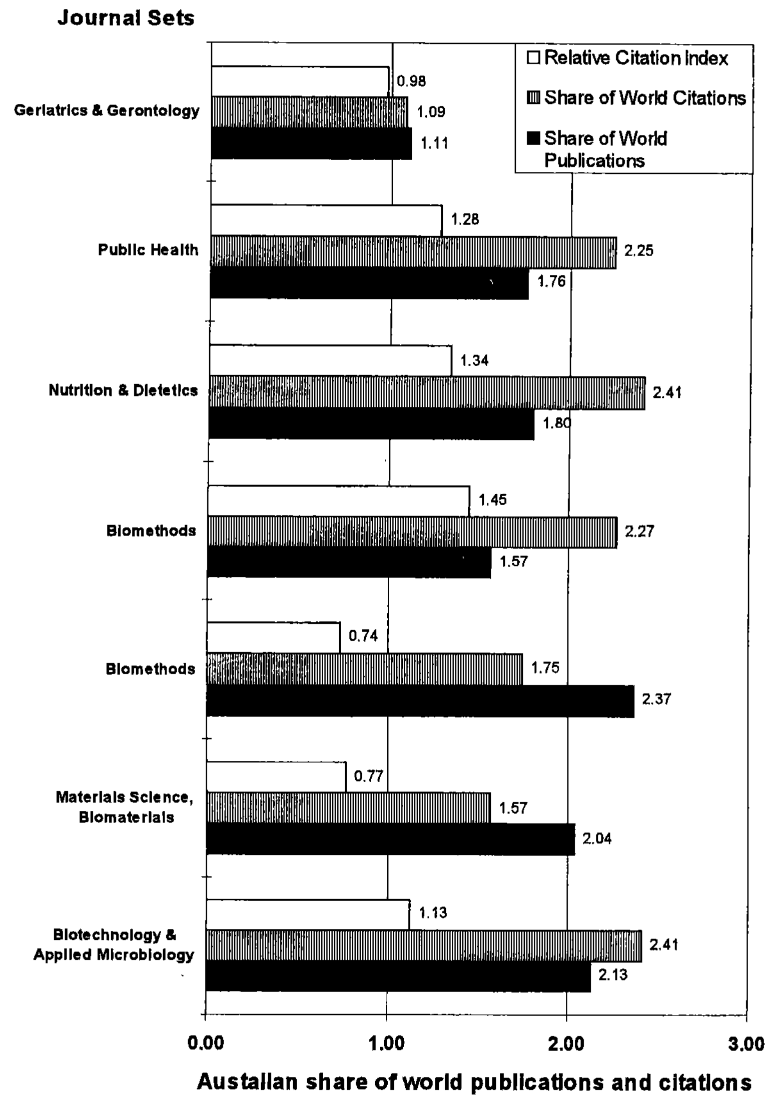
Socio-economic objective	$m	Human resources (persons)
Environment		
Natural ecosystems	76.1	1181
Climate	19.5	213
Water Resources	19.4	298
Impacts, protection	18.6	274
Oceans	12.4	130
Atmosphere	10.7	129
Land, land use	9.5	137
Other	9.3	133
Sub total	175.7	2495
Economic development – environmental aspects		
Agriculture, forestry and fishing	87.5	1231
Manufacturing	17.9	256
Mineral development	10.8	125
Energy	5.8	71
Construction	5.6	76
Commercial services	1.4	20
Transport	0.7	11
Other	8.2	105
Sub total	**138.1**	**1896**
Health – Environmental health	**7.1**	**90**
Total	**320.9**	**4481**

Source: Department of Industry, Technology and Commerce (1994) Australian Science and Innovation Resources Brief 1994, Table A1.6 DIST, Canberra.

The Australian Research Council (1995) released an analysis of the degree of emphasis on ecologically sustainable development (ESD) objectives in the projects it had funded during 1993 and 1994. This study found that 2.2 per cent of ARC-funded research ($7.3 million) was strongly ESD-focused, while another 14.1 per cent had a strong relationship to ESD and 13.7 per cent a weak relationship. A total of $100 million was spent in the two-year period studied by the ARC on research projects that are related in some way to the objective of ESD.

d) Advances in Biological Technologies

Box 13.5. Australian Share of World Publications: UK Generic Priority of 'From Genes to New Organisms, Processes and Products' – Annual averages for period 1981 - 1992



Source: Bourke and Butler 1995a

Bibliometric information on publications in genetics and biotechnology areas show Australia's share is consistently above our average share of world publications of 2 per cent. One area of comparative weakness is in 'Geriatrics and Gerontology' (Box 13.5), which was also identified in the ASTEC Partnership on neurodegenerative disorders.

These strengths in basic research contrast with the limited scale of Australian business in biotechnology. There has been significant growth in both small specialist firms and in multinational companies locating operations in Australia, but the level is well behind international performance.

However, an analysis by the BIE suggests that the Australian Pharmaceuticals sector is one of our best performing high technology sectors, using revealed comparative advantage as a measure, both in human and veterinary medicines. Pharmaceutical and veterinary products is the fifth largest area of Australian business R&D, with expenditure at $136 million in 1992-93.

This brief review illustrates that Australia has a strong science base for responding to the Key Forces of *Advances in Biological Technologies* and *Environmental Sustainability*. There are niches of strength relating to responding to the Key Forces of *Applying I&CT* and *Global Integration*.

13.3. Comparison of International 'Critical Technologies'

What technologies do other nations consider as 'critical'?

As noted above 'critical' depends to a large extent on context. Long-term scientific developments arise from the interplay between what is technically feasible and what is required from a political, economic or environmental point of view. Clearly, the individual circumstances of a firm, nation or region, and the time frame of analysis, will influence planning and policy decisions.

Critical technologies are generally considered to be those which underlie major areas of industrial growth. Such technologies can also underpin several different areas of industrial development and can thus be termed 'generic'. Lists of critical technologies have similar overall groupings of technology fields, yet vary considerably in their detail as a result of the specific criteria used. A more extensive review of international critical technology lists is given in *An International Perspective* (ASTEC 1994c).

There is a strong view that the dominant technologies of the 21st Century will be those that combine knowledge from different fields – an integration of what used to be separate branches of science. This synergy will allow new products and processes to be developed. Exciting new areas are already emerging in photonics and nanotechnology with potential applications such as molecular-scale electronics and bio-sensors.

A German study focusing on emerging new technologies considered that the technology of the early 21st Century 'will defy any attempt at demarcation in the traditional sense' (Grupp, 1994b). Indeed, they identified 100 inter-connected areas of technology, grouped loosely under nine headings (see Box 13.6):

- advanced materials;
- nanotechnology;
- microelectronics;
- photonics;
- microsystems engineering;
- software and simulation;
- molecular electronics;

- cell biotechnology; and
- information, production and management engineering.

The lack of clear boundaries between many of these areas became particularly clear with regard to areas of eventual application. For example, systems applications of new telecommunications technologies arise from progress in the fields of both microelectronics and photonics, but would be inconceivable without significant contributions from software development.

Developing, managing and exploiting such multi-disciplinary technologies will present new challenges for research, industry and policy.

The US experience provides an example of a range of criteria for critical technologies. While underlying criteria are used to identify technologies essential either for national security or to maintain the competitiveness of industry, the detailed outcomes of this general approach vary. For example, the US Department of Commerce criteria stress the potential economic benefits of 'emerging' technologies ie those which over a 10 year period had the potential to create new products and industries with markets of substantial size, or provide large advances in productivity or in the quality of products produced by existing industries which supply large, important markets, or drive the next generation of R&D and produce spin-off applications.

Box 13.6 German List of Critical Technologies at the Beginning of the 21st Century

1. Advanced materials	• High-performance ceramics • High-performance polymers • High-performance metals • Gradient materials • Materials for energy conversion • Organic magnetic materials • Organic electric materials • Surface and film technology • Surface materials • Diamond layers and films • Molecular surfaces • Non-classical chemistry • Meso-scale polymers	• Organised supra-molecular systems • Clusters • Adaptronics • Multi-functional materials • Lightweight construction • Composite materials • Aerogels (solid foam) • Fullerenes • Material synthesis in standard shape • Implantation materials • Manufacturing of materials
2. Nanotechnology	• Nano electronics • Single electron tunnelling	• Nano-scale materials • Manufacturing in micro and nano-scale
3. Microelectronics	• Information storage • Signal processing • Microelectronic materials • High-speed electronics	• Plasma technology • Superconductivity • High-temperature electronics
4. Photonics	• Opto-electronics • Photonic materials • Laser technology • Flat display technology • Luminous silicon • Telecommunications	• Broad-bank communications • Photonic digital technology • Advanced broadcasting (HDTV, DAB) • Optical computing

Box 13.6 German List of Critical Technologies at the Beginning of the 21st Century (cont'd)

5. Micro systems technology	• Micro-actuator technology • Signal processing in micro systems	• Micro-sensor technology • Mounting and connecting techniques
6. Software and simulation	• Software • Modelling and simulation • Molecular modelling • Bio-informatics • Simulation of materials	• Non-linear dynamics • Simulation in manufacturing • Cognitive systems (AI) • Fuzzy logics • Data network safety
7. Molecular electronics	• Bio-electronics • Bio-sensor technology	• Neuro-biology • Neuro-informatics
8. Cellular biotechnology	• Molecular biotechnology • Science-based medicine • Catalysis and bio-catalysis • Biological production systems • Bionics • Biomimetic materials	• Biological hydrogen production BWS • Renewable resources (biomass and agents) • Environmental biotechnology • Plant breeding
9. Production and management technology	• Management techniques • Modelling in manufacturing • Control station technology • Production logistics	• Lean-resource production • Behavioural biology • Ethics in science and technology

Source: Grupp 1993

The US National Critical Technologies Panel also developed criteria under three headings:

- National Needs, including: Industrial Competitiveness; National Defence; Energy Security; Quality of Life;
- Importance – Criticality, including: Opportunity to Lead market; Performance / Quality / Productivity Improvement; Leverage; and
- Market size – Diversity, including: Vulnerability; Enabling/Pervasive; Size of Ultimate Market.

Work by the Rand Corporation for the US Critical Technologies Institute considered four alternative definitions of 'critical' technology:

- state-of-the-art;
- a component of national self-sufficiency;
- a the 'rate determining factor' for specific applications; and
- generic and pre-competitive.

The latter two definitions were considered most appropriate because they demonstrate that 'criticality' is not a property of the technology itself, but is partly a function of both the role of technology in economic processes and the objectives of policy-makers. Tentative conclusions from the study indicated that the value of the concept of 'critical' technologies 'derives not from the reduction of many technologies to a ... list, but from its power ... to distinguish among technologies based on their relevance to policy goals and to indicate links between innovation, economic prosperity and public policy.' (Bimber and Popper, 1994).

The most recent US study (1995) was undertaken by the US Critical Technologies Panel. It identified seven 'National Critical Technology Areas':

- Energy: Principal goal to increase economic efficiency at the level of output per unit of energy input. Particular emphasis on the sub-fields of energy storage, conditioning, distribution and transmission.
- Environmental Quality: Monitoring and assessment, remediation and restoration and pollution avoidance the central issues. Principal technology demands in the field of the remote assessment of biosystems and pollution control.
- Information and Communication: Essential to the definition of modernity. Critical technologies are those contributing to components, communications, computer systems, information management, intelligent complex adaptive systems, sensors, software and tool kits.
- Living Systems: Four chief areas: biotechnology, medical technology, agriculture and food technology, and human systems all converge on similar technological demands for intelligent systems to overcome human data management limitations, integrated information systems, functional diagnostics, biocompatible materials and the rapid identification of bacterial and viral infectious agents.
- Manufacturing: Discrete product manufacturing, continuous materials processing and micro/nanofabrication are vital technological areas to support much modern industry. Two main areas: an enhanced capacity to make a familiar substance; and opening the use of a new material by producing it economically eg some new alloys.
- Materials: Advanced alloys, ceramics, composites and polymers are enabling technologies especially for the key areas of high performance aerospace and surface transportation.
- Transportation: The field of intelligent transportation systems is vital. Special concerns to develop in aerodynamics, avionics and controls, propulsion and power, systems integration and human interface.

An important related project was a comparison between the results of the Japanese 1992 Delphi survey and an equivalent survey conducted in Germany (NISTEP FhG ISI, 1994). This comparison showed that particular industrial and institutional settings of these countries explain important differences of emphasis in forecasting. Nonetheless, overwhelming levels of agreement were found arising largely from the increasing globalisation of research and technology in all modern and modernising economies.

In their study for ASTEC Bourke and Butler identified a strong convergence in the sectors and technologies identified in international foresight exercises. They considered the principal convergences are in specifying demand for technologies in areas which enable:

- computer systems capable of massive data control, intelligent complex adaptive systems, sensors, software and toolkits;
- human interface with massive information systems;
- development of intelligent, remotely controlled management and transport systems;
- biotechnology industries in human health and agriculture;
- the generation of new materials; and
- environmental management.

Further, Bourke and Butler suggested that the convergence of international foresight activities was adequately reflected in the six 'generic priorities' of the recent UK Technology Foresight program:

- Social Shaping and Impact of New Technology
- Harnessing Future Communications and Computing;
- From Genes to New Organisms, Processes and Products;
- New Materials, Synthesis and Processing;
- Getting it Right: Precision and Control in Management; and
- A Cleaner World (including energy).

They suggested that these six areas provided a suitable 'shopping list' of technologies for the beginning of the 21st Century, at least to allow an initial examination of the relative position of Australian S&T. However ASTEC considers further refinement of the UK list is required. Specifically, the need to include transportation, identified as one of the seven US critical technology categories, and prominent in Japanese-German Delphi. Furthermore the UK priority 'social Shaping and Impact of New Technology', which included demographic change, risk assessment and management and workplace and home seeks to address the limits to technological developments from changes in demand. This is not well reflected in the outcomes of other international studies.

Thus in summary a 'generic' list would include:

- Environment, including energy;
- Transportation;
- Information and Communications Technology and Electronics;
- Genetics / biotechnology;
- Manufacturing / precision and control in management; and
- New materials.

Although the various international foresight studies start from different points and present an array of potential technological developments, there is common ground. While it may be possible to identify a 'global list' of categories for critical technologies, of greater interest would be a comparison and definition at the level of 'sub-areas'. The ASTEC study did not attempt to develop such a list for Australia because it was outside the scope of the current exercise. It is of value however, and strongly recommended for future work.

13.4. Australian S&T Strengths and Weaknesses in 'Critical Technologies'

How well placed is Australia in these technological areas?

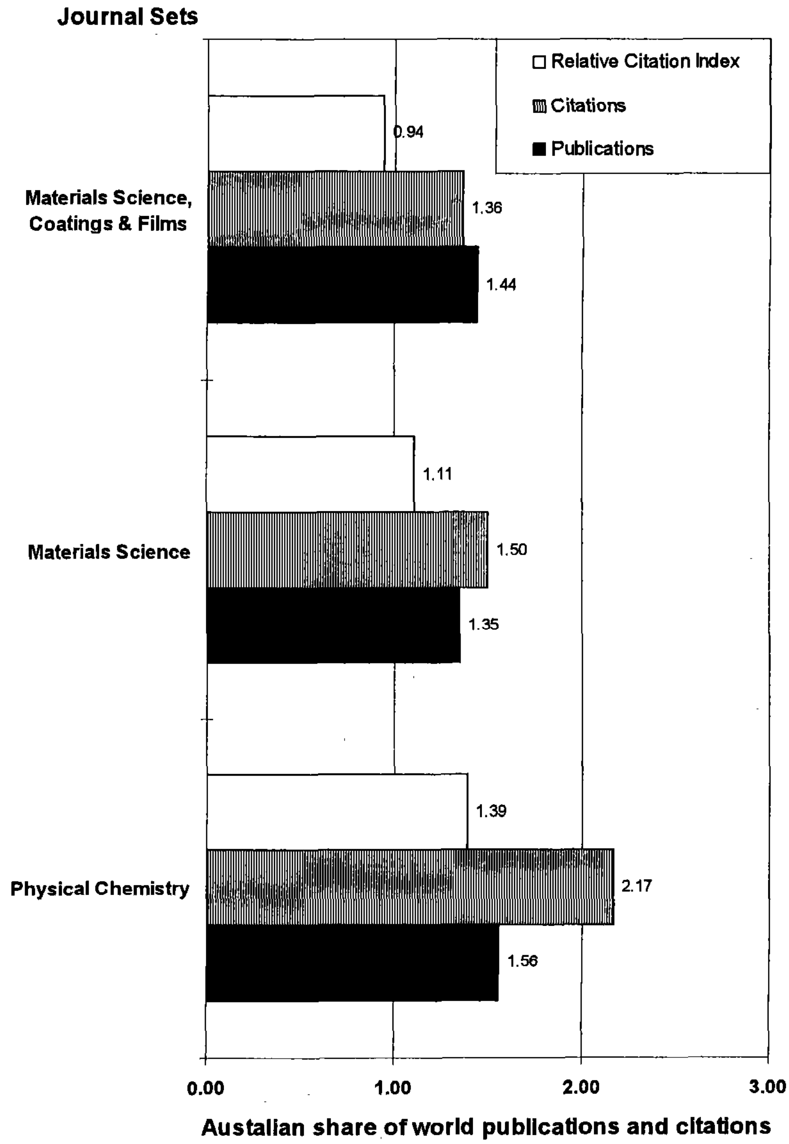
The first have been examined in section 13.2 above. Two critical technologies remain to be considered:

- *Manufacturing / precision and control in management*, which based on the UK and US studies, includes: management and business process engineering, automation including robotics, process engineering and control, sensors and sensory information processing, security and privacy technology, discrete product manufacturing, continuous materials processing and micro/nano-fabrication and machining.

- *New materials* which, based on the UK and US studies, includes catalysis, chemical and biological synthesis, materials and materials processing technology, and structures.

As expected from previous parts of this report initial analysis suggests Australian research and industrial capability is generally relatively weak in these two areas. Bourke and Butler found a small Australian presence in the fields of science related to new materials (Box 13.7). The most significant presence was in 'Physical Chemistry' – including organic chemistry journals, which however may be too broad to adequately reflect a capability in new materials. Journals in 'Materials Science' areas show Australia's performance is relatively weak (around 1 per cent of publications) and uneven.

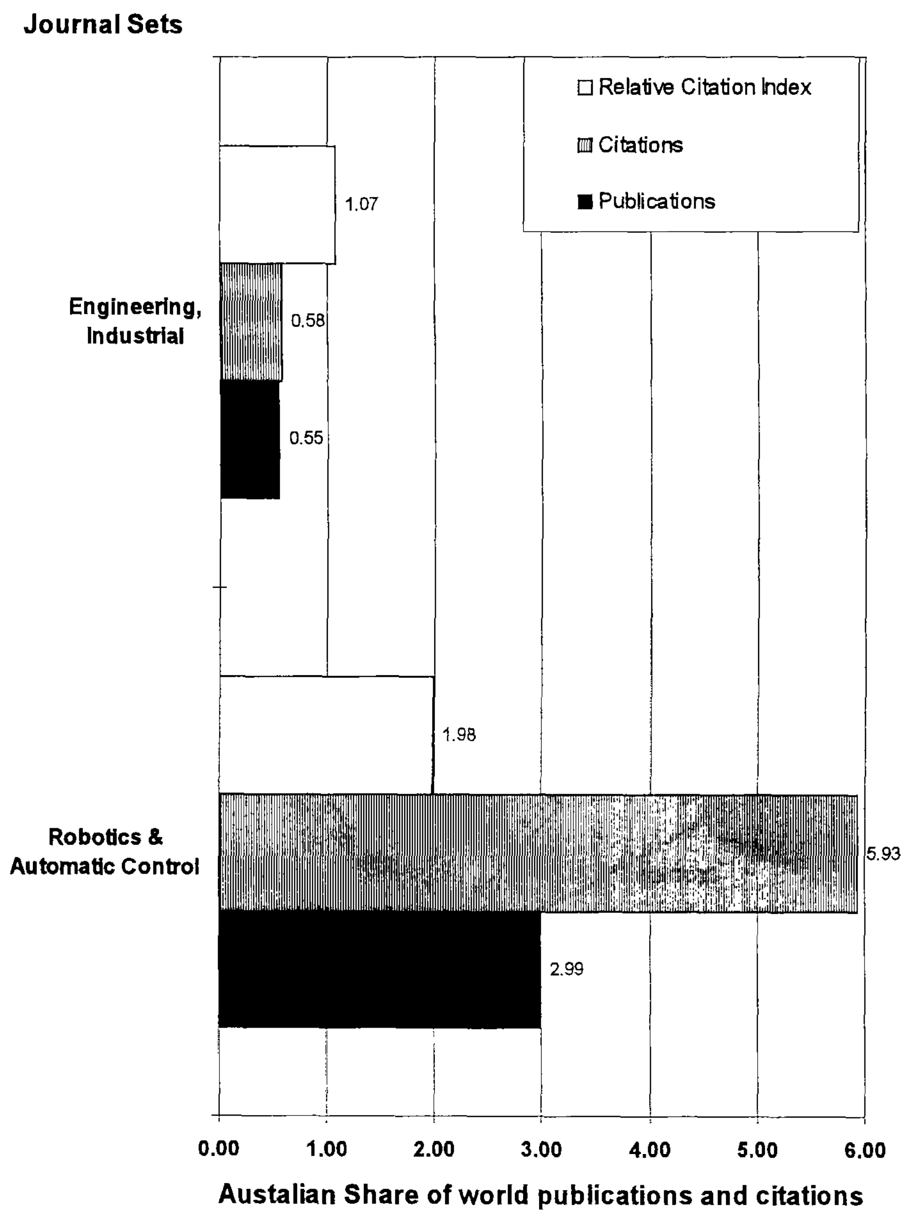
Box 13.7. Australian Share of World Publications: UK Generic Priority of 'New Materials, Synthesis and Processing – Annual averages for period 1981 - 1992



Source: Bourke and Butler 1995a

The limited journal sets did not allow them to obtain an overall impression of 'precision and control in management' (Box 13.8). However, they found Australia had shown a strong performance in 'Robotics and Automatic Control', an important sub-set of this critical technology area. However, this strong performance may be a result of a small number of particularly well cited Australian papers from the 1980s.

Box 13.8. Australian Share of World Publications: UK Generic Priority of 'Getting it Right: Precision and Control in Management' – Annual averages for period 1981 - 1992



Source: Bourke and Butler 1995a

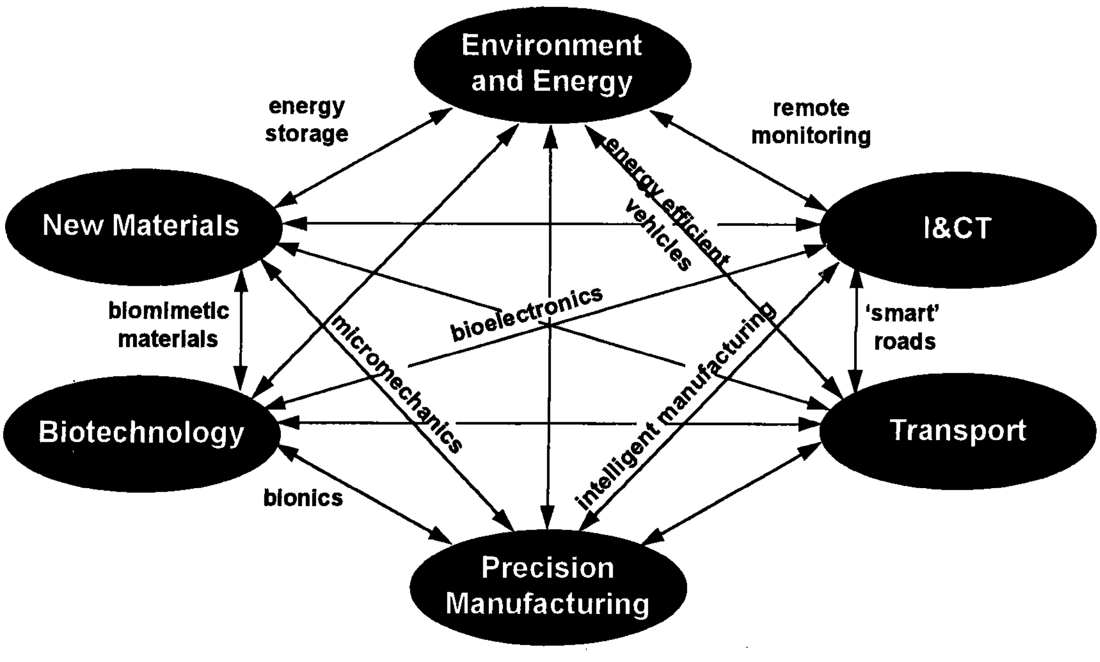
The picture emerging from bibliometric indicators is consistent with the outcomes of studies of other, more applied, aspects of the S&T system. An example is provided by an analysis of patent indicators, which reflect the emphasis of close-to-market technological developments. The results suggest that Australian patterns of technological specialisation are statistically similar to those found in Canada, Norway and Finland where national technological advantage is also based on raw materials technologies and related machinery. Experience in these countries indicates that moves away from commodity or resource based technology towards higher levels of technological sophistication are possible (Bourke and Butler 1995a).

To shape the future we must design a strategy to:

- build on relative strengths in environment and biotechnology, noting the need to improve commercialisation aspects;
- nurture and explore further niches of strengths in I&CT and transport; and
- consider how best to develop niches of strength in precision manufacturing and materials.

ASTEC considers, particularly in the light of the German experience, that it would be useful to explore cross linkages between technology areas – such as between precision management and I&CT. It may be possible to use strengths in one area to assist developments in another. This could include strategies that, for example, seek to link new growth in precision manufacturing with its application in environmental management, or build links between I&CT and energy efficiency, or strengthen new materials capacity by supporting their application in biotechnology or small ships. (Box 13.9)

Box 13.9. Some Examples of Links Between Broad Critical Technology Areas



Source: ASTEC

This suggests an approach based on building on the distinctive strengths of the country in basic science and projecting forward from particular activities, in which we have an identifiable comparative advantage, to consider possibilities, not necessarily clearly evident at this time, for developing into the fields deemed to be 'critical' elsewhere.

This implies the need to look at the spectrum of research from basic research, mainly conducted in higher education establishments, through to applied research in industry. While the scale of Australia's effort is relatively small on a global scale, the relative intensity of much of our effort may provide a 'critical mass'.

This approach suggests the need to maintain a strong basic science base across the spectrum of disciplinary and multi-disciplinary activity, and to carefully review and explore 'niche' opportunities. It also suggests the need to further explore our strengths, weaknesses, opportunities and threats in relation to cross-disciplinary and multi disciplinary work, in both S&T, which links the six critical technology areas.

13.5. Conclusion

Australia has strengths and weaknesses related to those technologies which others have called 'critical'. In general, Australian science is well positioned in areas of health and medicine, for biological sciences, earth sciences and agriculture. It is not as well positioned for other areas although there are pockets of high performance. Should we give priority to building on strengths or to overcoming our weaknesses? Should we seek to build our science in areas where we have strong technological capacities or develop new areas?

Establishing priorities, including building on strengths, are issues being debated, in many countries around the world, not just Australia. The UK chose to identify 'generic' priorities at a high level to guide their S&T decisions whereas the Japanese disseminate information about developments for others to act upon. A broad knowledge of critical technologies and Australia's strengths in relation to them can help decision-makers in industry and government.

This information can be used for competitive advantage and it will be important for Australian organisations to have access to it. The Commonwealth Government can provide information to assist the range of decision-makers to consider the outcomes and implications of critical technology exercises conducted overseas. It can also facilitate Australia's involvement in a range of international critical technology exercises

Australia appears to have a limited capacity to gain an overview of emerging technologies and to put in place longer term technology programs to ensure that Australian firms are well prepared to take advantage of technological developments over the next 10-20 years. A long-term view will influence both our ability to take up technology developed overseas and to progress emerging technologies in Australia.

This perceived 'market failure' is seen to be partly caused by Australia's lack of:

- firms that are able to think and act with a long-term perspective on technology, in contrast to many Japanese, US, European or Korean firms;
- information available about promising and new areas; and
- organisations and infrastructure able to help develop and disseminate such information.

Australia must position itself to capture the potential opportunities provided by critical technologies and combinations of emerging technologies. It is imperative to continually consider, assess, evaluate and speculate about future technological developments. Whether Australia is the major developer, we need to have a 'place at the table' when these important emerging technologies are being commercialised. Many of the technologies of tomorrow will not be developed in one country, but across national borders, thus emphasising the importance of global links.

There is an emerging perspective that the major new technologies will emerge at the boundaries of existing technologies and disciplines through a process the Japanese have called 'fusion'. New areas already growing rapidly include: photonics and nanotechnology with potential applications such as molecular-scale electronics and bio-sensors. Managing and exploiting such multi-disciplinary technologies will present new challenges for research and industry. Multi-disciplinary and interdisciplinary work must be encouraged and monitored.

Area for Action: Enhancing the Information Base for Research Decisions

ASTEC considers it necessary to develop mechanisms to review emerging research and technology areas and assess Australia's strengths and weaknesses in critical technology areas, including evaluating potential barriers to multi-disciplinary research and new collaborations.

There is a great deal of information about emerging technologies, and the strength of the research fields that underpin them, that now may be brought to bear in a more systematic fashion to shape, in the broadest sense, decisions of focus and research allocation amongst the scientific community and research funders. Moreover, the purposeful exploitation of knowledge boundaries has been shown to be highly effective.

ASTEC considers a priority is to introduce, without threatening either the strength of the basic research system or the integrity of peer review processes, more purposeful and better informed mechanisms for shaping the context within which research decisions are made.

Priority Action for the Commonwealth Government – 6

ASTEC recommends that as a priority the Minister for Science and Technology take action to:

- commission a review of Australia's relative strengths and weaknesses in emerging 'hot spots' in research and technology, and commercial prospects into the 21st Century, involving representatives of the Academies, leading researchers and industrial research organisations; and
- review barriers to the development of inter- and multi-disciplinary research, including funding processes and investigate mechanisms to encourage inter- and multi-disciplinary S&T, including through innovative course design (eg Science-Arts) or funding.

Chapter 14. Integrating into a Global Science and Technology System

Governments and businesses are seeking to use their S&T base to increase competitiveness and assist decision making in a wide range of areas. However, the scale and diversity of potential areas of S&T needs and applications are beyond any one country's capacity to provide. In many sectors international linkages and collaborations have become more common, especially amongst multinational firms.

The previous chapter outlined Australia's S&T base in relation to a list of critical technology categories. This analysis suggested Australia is relatively well placed in relation to *Environmental Sustainability* (including energy) and *Advances in Biological Technologies*, and has niches of strength in *Applying I&CT* and *Global Integration*. However, there are overall weaknesses in new materials, and precision and control in management.

We now extend this discussion by assessing Australia's position in relation to these critical technologies in the context of a globally integrated S&T system. This Chapter begins by looking at the nature of Australia's current international links and the potential opportunity for Australia in the Asia-Pacific. We then consider how the Key Forces for Change and other insights from this study provide a fresh perspective on managing this unique opportunity and the need to redefine the concept of 'national benefit'.

14.1. Australia's International Links

S&T in the future will be traded even more on a regional and global basis. It is likely that many important links in our region will be based on S&T. Such links can allow further relationships to grow, including in applications and industrial cooperation. It is equally important to be aware of the possibilities of developing S&T linkages as a result of industrial links. This may change our view of what is in the national interest.

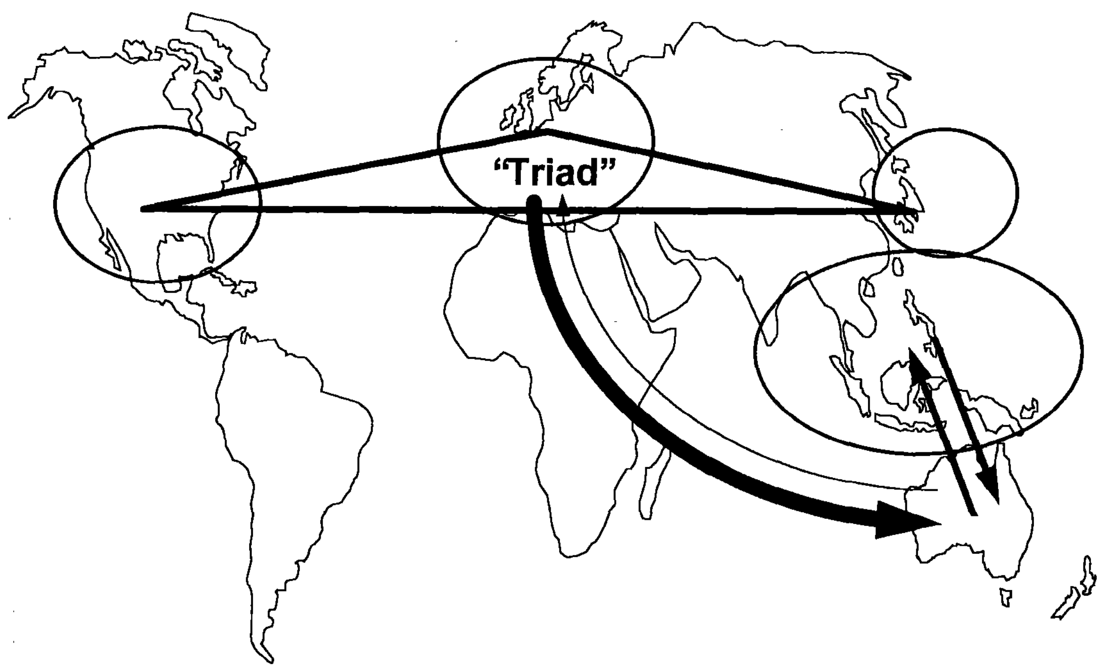
ASTEC recognises the many government policy initiatives in international S&T and supports the continuation of these efforts. Australia has an internationally recognised university and public sector research effort with well developed links across the world. The CSIRO is an important example of a world-scale R&D establishment. There are also many significant players in private sector R&D, and they too need to be encouraged and facilitated in building S&T links.

The traditional power centres of S&T are in the 'triad' of Europe, US and Japan (Box 14.1). They currently comprise most of the world's economic activity and they make up our traditional links for S&T. Like all countries, except the US, we 'import' most of our S&T, either in the form of basic research results or embodied in goods and services.

The three corners of the triangle, US, Europe and Japan, are distinct in their S&T and each is changing in different ways. The US has a very large and diverse S&T system with a commitment to excelling in all aspects of S&T. In the past, the US system emphasised defence and aerospace related R&D and government contracts; however, this is changing more towards civil expenditure in response to Japan's economic success.

By contrast Japan focuses on applied industrial research, particularly in consumer electronics. Recently they have become increasingly involved in basic research, particularly large collaborative projects such as the Human Genome project. They are also becoming more involved with aerospace, eg through collaboration with Boeing to develop the 777.

Box 14.1. Australian Science and Technology – Links to the World



Source: ASTEC 1995h

Each nation of Europe has particular S&T strengths, eg German chemicals and pharmaceuticals, or Italian glass and ceramics. The changes being brought by the European Union include development of new joint research and industrial programs, from EU Framework programs on 'critical' technologies, to aerospace eg Airbus.

As Bourke and Butler (1995a) found, our inherited international relationships in science are almost without exception pointed towards the United Kingdom and the US. These inherited relationships developed from the bottom up in the sense of evolving with the lives, careers and networks of Australian pioneer scientists and scholars which were allowed to assume a strong independent cast through the particular institutional arrangements in Australia.

While the content of many current links with Asian countries varies widely, in most cases aid and commercial objectives are inter-linked. Our regional neighbours clearly have a view of S&T that recognises its practical potential through applications to wealth creation. This is evidenced by a number of 21st Century 'Plans' (eg Singapore Forum, 1994) and the strong emphasis on research and development (R&D) in the private sector.

A number of reports (eg PMSEC, 1992; NBEET, 1995) have pointed to the growing importance of international collaboration across the world and using the outcomes of S&T. ASTEC considers the next 15 years will present both qualitative and quantitative changes to this international perspective.

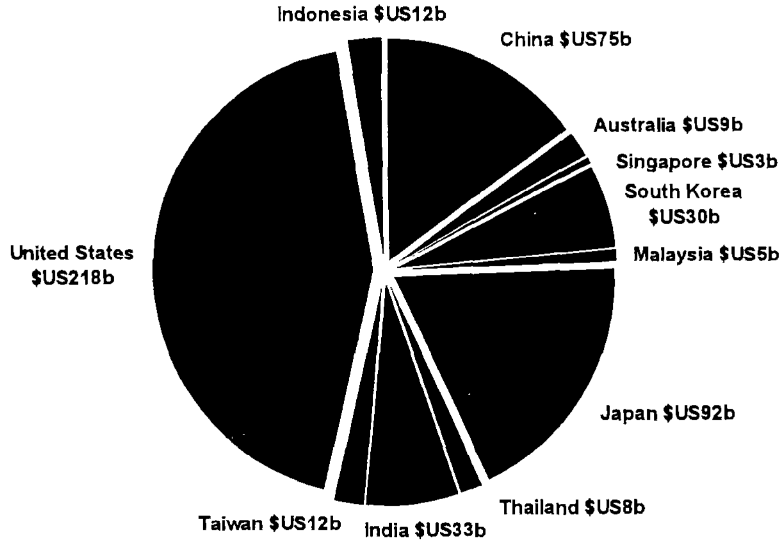
14.2. Asia: The S&T Powerhouse of the 21st Century

The Asian economies, as we all know, are set for continuing substantial growth.

Whereas the total GDP of the nine economically powerful East Asian and ASEAN countries amounted to only 32 per cent of that of the US in 1970, in purchasing power parity terms by 1995 total GDP of these countries exceeded the US figure. By 2005 it is expected to be 50 per cent larger again than that of the United States. If India is included then by 2005 the ten countries' GDP will be double that of the United States.

The total R&D spending of these nations is likely to be of order $US270 billion per year by 2005, 25 per cent higher than total R&D expenditure in the US (Box 14.2). This will be about thirty times the level of Australian spending. The significance of this growth is illustrated, for example, by South Korea which is targeting a level for R&D of 3.5 per cent of GDP. This would be significantly higher than the current level of any country – the highest being Sweden and Japan at about 2.9 per cent of GDP.

Box 14.2. Projected Levels of R&D Activity in 2005: United States and Selected Asian Countries (inc. Australia)



Source: Sheehan et al. 1995

The Asian region's growing technological strengths are also indicated by patent statistics. The major trends are the continued rise of Japan, the emergence of Taiwan and South Korea as countries of technological strength, and the relative decline of the major North American and European technology nations (BIE, 1995). Germany, the UK and France (the largest patenting countries in Europe) and Switzerland, Italy, Sweden and the Netherlands (the medium patenting countries) have all seen their proportions of US non-resident patents fall considerably.

An important feature of the growing levels of R&D in the Asian region is that it is focused on technology transfer and the application of existing technologies, with an emphasis on rapid commercialisation of S&T developments. This difference in orientation between Asian nations and Australia is illustrated by the relative numbers of scientific and technical workforce in industry vis-a-vis government, and education. (see Box 14.3).

Box 14.3. Distribution of S&T Workforce by Sector (per cent)

Country	Government	Education	Industry
Japan (1991)	12	25	63
South Korea (1992)	17	28	57
Taiwan (1992)	22	24	54
Thailand (1987)	2	45	52
Singapore (1987)	9	50	40
Australia (1990)	**23**	**49**	**28**
China (1992)	30	42	28
India (1990)	58	17	24

Source: BIE 1995

Many Asian countries are taking active policy decisions to develop regional clusters or networks of companies, supported by local and regional skills and infrastructure. This is consistent with the developing trend of 'techno-globalism' as a strategy to build critical mass. In addition to investment attracting policies in taxation, measures to promote the creation of special technology precincts associated with universities, advanced technical institutes, or national research facilities are being increasingly used, as are cooperative centres linking industry, government and academic R&D activities in a particular area of S&T.

14.3. Australia's Position in Asia-Pacific S&T – A Window of Opportunity

Australia is currently one of the leaders in S&T in the Asia-Pacific region. We have a well established and respected S&T system with internationally recognised strengths in many areas. If we are not to be marginalised in the rapid development of our neighbours we need to turn the rhetoric of the 'opportunity of Asia' into the reality of partnership.

Developing a greater Asia-orientation in Australian S&T will require a changing mindset in both Government agencies and in academia. While Australia can contribute to the region through its more established R&D base, collaboration offers mutual benefits.

A driving force in capturing regional opportunities will be the perceived strength of Australian S&T. In absolute terms Japan, China, India and South Korea have considerably more scientists and engineers than Australia. However, as Box 14.4 shows, Australia's concentration of researchers in the workforce was second only to Japan in the region. This situation is changing rapidly with the high growth rates of Taiwan and South Korea.

Box 14.4. Numbers of Researchers, Scientists and Engineers Engaged in R&D and per 10000 Labour Force, by Country

Country	Researchers	Per 10000
USA (1989)	949 300	76
Japan (1991)	491 102	75
Sweden (1991)	26 515	59
France (1991)	129 780	52
Australia (1990)	**42 760**	**50**
Canada (1989)	65 209	47
UK (1988)	126 000	45
Taiwan (1990)	32 100	38
South Korea (1990)	68 800	37
Singapore (1990)	4 300	30
New Zealand (1994)	4 825	29
Spain (1990)	40 642	26
China (1990)	391 100	6
Indonesia (1988)	32 000	6
Thailand (1991)	5 500	5
India (1990)	106 000	3

Source: BIE 1996b, persons as full-time equivalents.

The Commonwealth Government has a range of international S&T linkages with countries in Asia. These links have largely developed independently between government agencies. A report for the Coordination Committee on Science and Technology (Hill, 1995) noted that:

- Japan, China and Republic of Korea are the main focus of Australian Government funded science collaboration in the region;

- the ASEAN countries are the main beneficiaries of Australian aid funded S&T technical assistance in the region;
- Indonesia and Malaysia are the main sources of students in technical courses sponsored under the aid program; and
- China, Indonesia and Thailand received a large proportion of Development Import Finance Facility funds last year under the aid program.

In addition State and Territory Governments' industry development programs (most of which are focused strongly on Asia) have a regional S&T cooperation element to them. Many are establishing links with the region. State business enterprises, such as electricity authorities and water boards, are also involved in commercial enterprises in the region.

Internationalising Australian S&T is on the agenda of some Commonwealth Government agencies like the Department of Industry, Science and Tourism (DIST) and the Department of Employment, Education, Training and Youth Affairs (DEETYA). However, the absolute level of Australia's commitment to international scientific relations – particularly with Asian nations – remains small. For example, activities related to S&T linkages with Asia (apart from aid funding) account for 0.4 of one per cent of Australia's overall Commonwealth R&D budget and 0.2 per cent of Australia's federally funded national research and innovation budget. (PMSEC, 1992)

Many consider that the next decade presents a 'window of opportunity' for Australia to capitalise on its S&T strengths in the Asia-Pacific region. There is a need to act quickly before the pace of Asian economic and S&T development passes us by. Major countries in the region are developing their national S&T strategies and competitors like Canada are also seeking to take advantage of the opportunities in the region (See Box 14.5).

Box 14.5. Global Links with the Asia-Pacific Region

A number of countries from around the world have been placing increased emphasis on developing S&T links with the rapidly growing economies in the Asia-Pacific region.

- Since 1989, the United States has intensified effort to renegotiate bilateral S&T agreements with a wide range of Asia-Pacific countries, but principally to protect and allocate rights to intellectual property furnished or produced in the course of S&T cooperation. Resistance to these provisions by some countries, for example, Republic of Korea and China, has reduced cooperation under these agreements.
- Japan has broadened its S&T goals. Its initial emphasis was on the acquisition of scientific technology from advanced countries of Europe and the United States. It now seeks international collaboration in pre-competitive research, for example, under the Human Frontiers Science Program, and the enhancement of regional capacities to meet the environment, lifestyle and technological challenges of the 21st Century under the Multifunction Polis concept (with Australia). It has also engaged in bilateral cooperation with other countries in East Asia and South-East Asia.
- Canada and European countries are increasing their bilateral S&T cooperation links with Asian and Pacific countries. The European Community, for example, is conducting systematic joint studies of possible areas and modalities for cooperation with Republic of Korean and Thai organisations in order to establish a 'decision support resource' to guide the development of formal programs and informal interactions. The Canadians are placing emphasis on the formation of cooperative links with small firms.
- The United States and Canada are seeking to develop their role in environmental industries.

Source: PMSEC 1992.

A recent review of S&T in Asia identified a number of barriers to effective linkages, including the low priority accorded to internationalisation and S&T policy support generally within government (Hill, 1995). Hill questions how long Australia's unique window of opportunity will remain open and argues that there is an urgent need for Australia to emphasise:

- the importance of personal global networks such as those formed by overseas students at Australian universities;
- Asia-orientation of S&T agencies, such as the CSIRO and CRC's, should adopt international strategies early;
- monitoring and shaping APEC S&T policy;
- maintaining the traditional links with Europe and the USA whilst building the links with countries of this region; and
- while some programs currently focus on Japan, these should be broadened to include other countries.

14.4. Managing Global Relationships in a Changing World

Australia needs to adopt a dynamic perspective which takes account of complex changing relationships with countries around the globe. Key challenges over the next 15 years will be to develop a balance between national, regional and global orientations in Australian S&T through strengthening links with our region, manage traditional links, and building new links around the globe, eg the Indian Ocean rim.

This will require us to address, in many different fora, a complex range of issues from intellectual property to education and training. If we want to capture potential opportunities and aspire to regional leadership in S&T we must be prepared to further develop government support, industry links and cooperative policy development. This requires a coherent and flexible management strategy, developed jointly with industry.

Almost paradoxically, a 'global world' is not necessarily an homogenised world. Regional and local strengths can create nodes of excellence that transcend national boundaries, such as is currently evident inside national borders. Markets will be shaped by highly sophisticated understandings of comparative and competitive advantage. We need to consider Australia's place in this world.

Global Integration must be seen as a long-term process. ASTEC's Roundtable on this issue suggested it is a 'two-way street' that requires mutual learning. Globalisation should not be viewed simply as the opening of new export markets. Rather, it provides the potential for developing deep and lasting relationships and a greater degree of economic integration. S&T as one of Australia's key assets, can provide an important basis for such relationships. Australia's S&T strengths include higher education and training capabilities, a strong basic research capability and a culture which places emphasis on flexibility and practical problem solving.

In an era of free trade and 'open regionalism' between countries there should be the confidence to specialise and focus on those areas of comparative advantage. A fundamental characteristic of techno-globalism is building alliances as part of a networking strategy. This aims to facilitate access to knowledge and markets around the world. Effective linkages are central to the emerging 'fifth generation innovation system' and the increasing importance of multi-disciplinary research (Rothwell, 1994). It is based on complementarity – on building 'win-win' relationships.

The 1992 Japanese Delphi survey provides some insights into the opportunities for Australia to collaborate with Japan. Japanese experts consider that collaboration is necessary where other countries are more advanced in the particular area of S&T, such as the environment and life sciences, and in topics requiring more basic research (Box 14.6). Therefore their collaboration efforts are focused on projects with a long expected realisation time and, where funding is likely to be the most important constraint on realisation. The Japanese Delphi report notes that the Japanese government plays an important role in R&D investment and international joint development and is likely to play a major role in Japanese initiated international collaborations. For Australia therefore, the Japanese are most likely to seek longer term government sponsored collaborations in basic research and the environment and life sciences.

Box 14.6. Japanese Views on Necessity for International Joint Technical Development

Topic	Forecast realisation time	Constraints on realisation	Necessity of international joint development
Japan is more advanced	Relatively early	Cost	Low
Other countries are more advanced	Relatively late	Funding	High

Source: NISTEP 1992

This example illustrates the need to understand the motivations of other countries when considering potential collaborations.

Collaboration is promoted by personal networks, often established during education. Pavitt suggests that for many large UK companies' the primary asset of a graduate employee was their personal networks, which included international links developed during education.

Australia's higher education and training capabilities are recognised in the region. Indeed Australia is highly ranked in terms of the proportion of foreign students from the total population of students (BIE, 1996b). It is vital to explicitly recognise and develop Australia as a regional network node in S&T activity.

Personal global networks, such as those formed by overseas students at Australian universities must be appropriately valued. In the past the benefits of foreign students attending Australian universities may have been perceived as flowing mostly to their country of origin. This may no longer be true in a globally integrated world, and provides a good example of the importance of re-considering national benefit criteria for Australian S&T.

It was also suggested to ASTEC that Australian organisations should seek as far as possible not to engage in destructive competition with each other in developing new links and relationships. Australian international actions and programs should be consistent, mutually reinforce each other to the extent that this is feasible, and avoid competition that could be damaging to Australia and its image in the region. This may require new mechanisms to share knowledge of various activities and to promote collaboration.

Effective networks can assist in overcoming mutual weaknesses. The performance of some areas of Australian manufacturing may be improved by forming networks to address specific problems eg commercialising research. Other countries, weak in some areas of basic science may benefit from closer links with Australia.

Sheehan points to the potential complementarity of Australian S&T vis-a-vis East and South-East Asian nations:

'Australia's strengths in Biology, Earth and Environmental sciences are those areas in which Asia is weakest, while those in which Australia is less specialised, Physics, Mathematics, Chemistry and Engineering, are the central focus of the emerging system in these countries. This in turn suggests that there is room for extensive mutually beneficial cooperation between Australia and the countries of East Asia and ASEAN in the future development of basic science.'

Sheehan et al. 1995

This suggests Australians may be well positioned for a bright future in the Asia-Pacific in the 21st Century. Our current strengths in S&T, provide real leverage to establish mutually beneficial collaborative relationships.

This contrasts with our situation viewed from the perspective of the 1990s when many commentators suggested Australia's S&T and economic structures were not appropriate, as evidenced by large current account deficits in manufacturing in the late 20th Century. The growing importance of *Advances in Biological Technologies* and *Environmental Sustainability*, and our relative S&T strengths in these areas suggest we might be better placed for the 21st Century.

Australia has many unique features. We have historically had a resource-based economy and our S&T system, while evolved from a UK model, has developed strengths in earth science and agriculture. Attempting to make very substantial changes to fundamental aspects in the economy is risky and slow, requiring considerable investment and cultural and political support. The opportunity costs of doing this must be carefully considered.

Laver, a member of the ASTEC Reference Group, suggested that in a globally integrated world, there is a hierarchy of priorities for national research based on three levels of technologies. These are:

- core technologies which build on national advantages and either can be most effectively developed in Australia, or would not be developed elsewhere eg research on merino wool, and Australia's competitive advantage in medical research;
- enabling technologies where Australia would not lead the world but would need to have access, as they either support core technologies or enhance outcomes eg I&CT; and
- internationally available technologies which are not critical to competitive advantage and can be purchased on satisfactory terms from others eg motor vehicle technology.

This model seeks to combine different levels of criticality with national perspectives in a global framework. It is therefore worthy of further consideration. The list of critical technologies derived earlier from international foresight studies are probably best considered from the perspective of 'core' and 'enabling' technologies. However some sub-sets of them could on further scrutiny, be redefined as 'internationally available'.

'Maintaining a place at the table' has been a dominant motivation for engaging in certain areas of international research programs. In the area of biotechnology this requires us to generate and control significant core and related technologies, eg via patentable knowledge. Without this we will not be able to leverage opportunities. For smaller countries the scale and cost of maintaining a place in international activities is such that strategic choices are required. At a minimum we should remain involved in activities which are important in responding to the Key Forces for Change, and carefully review our position regarding new materials and precision in management.

14.5. Conclusion

Global integration offers many opportunities and challenges for Australia. Some of our areas of strength are related to potential growth areas of the future. At the very least ASTEC considers we need to monitor the commercialisation of S&T developments in environment management and biotechnology, monitor global developments and explore new niches in I&CT and transport, and seek to establish new networks in the areas of new materials and precision and control in manufacturing.

Global Integration provides a new perspective on S&T decision-making – one that requires us to reconsider the meaning of 'national benefit'. Many aspects of S&T policy internationally have been framed by concerns about what constitutes 'national sovereignty', eg the interpretation of critical technologies in the US to ensure national standing at the leading edge of developments. However, ASTEC believes this paradigm could change in response to the prospect of reduced global barriers. A strategic view of 'national benefit' criteria should take account of the changing nature of research, technology and innovation at the beginning of the 21st Century, and the impact of the Key Forces for Change.

Many aspects of managing global relationships, and developing mutually beneficial collaborations, relate to intangible factors. Too narrow a view of national benefit may discount such factors, resulting in less effective long-term relationships.

As confirmed by the recent Industry Commission review of R&D there are many spillovers benefits from research. Indeed, they found that the average social rate of return from R&D was high, with estimates up to about 100 per cent (IC 1995a). To the extent that increased carriage of Australian funded research in other countries gives rise to spillovers in those countries it is important to consider the nature and extent of other longer term (including indirect) national benefits accruing to Australia. Indirect benefits might come from additional downstream applications, industrial and other cultural or trade links that might consequently be developed.

It is difficult to establish the exact nature of these potential benefits in advance – thus the question of whether criteria can be used to preface involvement. These might include criteria related to issues such as intellectual property, commercial rights, education and training, equipment provision, etc. It important that Australian public sector research organisations who are tasked with generating benefit for Australia carefully consider their interpretations of 'national benefit' when engaging in international work.

Area for Action: Implications of Globalisation for the Science and Technology System

ASTEC considers it necessary for the S&T system to develop an effective response to global integration by adopting a dynamic perspective which takes account of complex and changing relationships with countries around the globe.

S&T can play an important role in developing bilateral and multilateral relationships and in fostering downstream commercial and industrial interaction. Yet there are risks in loss of intellectual property or from structural factors which limit the economic return to Australia.

An effective response to Australia's increasing integration into the global S&T system over the coming decades will require a more sophisticated understanding of national benefits and periodical review of what is 'in Australia's best interest'.

Priority Action for the Commonwealth Government – 7

ASTEC recommends that as a priority the Ministers for Science and Technology and Trade take action to:

- establish a review to assess existing 'national benefit' criteria for Australian involvement in international science, engineering and technology activities, and for foreign investments in S&T in Australia; and
- evaluate Australia's ability to provide relevant and timely scientific and technological information to support Australia's strategic needs in international negotiations, eg for agreements on trade, the environment and non-tariff issues.

Chapter 15. Science, Engineering and Technology Skills

15.1. Introduction

A country's competitiveness into the 21st Century will be tied increasingly to its labour force and the skills of its population. Effective use of these skills will be made more difficult by the operations of a global labour market for highly skilled people, such as S&T specialists. As the level of technological sophistication increases, many more jobs will have a partial emphasis on S&T.

ASTEC identified a number of specific S&T skills from the Partnership studies and the outcomes of international foresight studies. We also identified a number of generic skills, complementing those specific to S&T, which will enable Australians to cope better with the changes ahead.

Generic skills will be needed not only across the S&T system but also more broadly across the community. Currently many leading edge organisations are trying to promote a vision for the 21st Century. A critical part of this vision is the effective operation of a series of flexible, dynamic and inter-connected networks. In 2010 our skills will need to be displayed within the organisational structure of these networks. This creates new challenges for the skill base.

Since the end of the 1980s companies have been increasingly moving towards focusing on their core business; attempts to influence the environment in which organisations operate; a willingness to acknowledge the differences within the organisation and its sub-systems; and a growing interest in other aspects of an organisation eg its culture. Some suggest such factors have resulted in the emergence of a new blueprint for management (Limerick and Cunnington, 1993) based on:

- dealing with ongoing discontinuous change;
- organising around small, loosely coupled units;
- networking as required within and outside the organisation to achieve synergy;
- promoting collaborative individualism;
- uniting the organisation through its shared vision and mission; and
- exercising 'transformational leadership' to hold it all together.

The predominant factor which has led to the emergence of these new organisations is the phenomenon of discontinuous change when the past does not prepare us for the future. This aptly describes the world to 2010, where technology and communication create a global market place in which money and information know no borders. This makes it critical for organisations to make strategic alliances, whether on a regional, sectoral or global basis. Many of these alliances are temporary in nature, coming together to perform a particular task and then disbanding when the task is done. This requires a new set of skills.

15.2. S&T Skills to Manage the Challenges Ahead

Skills – both specific skills required for the S&T system and generic skills to improve our capacity to manage the challenge of change – were identified strongly throughout the study. In particular, generic skills in management, I&CT, international skills and risk assessment were raised consistently.

Box 15.1. Science, Engineering and Management Skills for the 21st Century

APESMA suggests that while many lists of particular skills can be generated, four broad groups of skills are required:

- *theory skills*: emphasises cross-disciplinary skills in I&CT, materials and environment;
- *practice skills*: concerns the way work is performed and knowledge is integrated into production, include manufacturing, resource management, environment and cultural issues;
- *management skills*: illustrated by engineering education developments, such as the Institution of Engineers, Australia, requiring 10% management content in undergraduate courses, and increases in double degrees in engineering and business. Skills required in management include people management, finance and economics, total quality management and society, ethics and law; and
- *personal and interpersonal skills*: needed to facilitate team-work and develop staff. Skills include leadership, communication, time management, creative and planning skills.

Source: APESMA 1994

A report on skills for the future prepared by the Association of Professional Engineers, Scientists and Managers of Australia (APESMA, 1994), suggested that Australia undervalues engineering and science skills. The report argued that our skills development should focus on the concurrent development of technology and non-technology skills and that non-technology skills in the broader business and management context are needed to ensure that the utilisation of technology and opportunities for further skills development are maximised. APESMA's classification of skills is in Box 15.1.

Engineers are today embracing management studies to a greater degree than ever before. The proportion studying a formal post graduate management program has increased from less than 2 per cent in the early 1950s to 15 per cent in 1995. Approximately half of this increase in enrolled in APESMA – Deakin University Master of Business Administration program (APESMA).

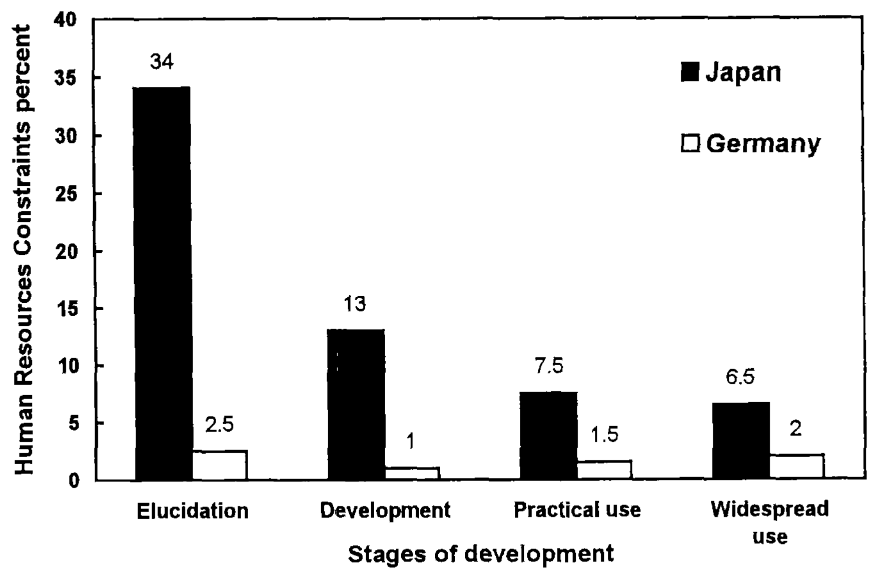
A number of Australian studies have considered skill needs into the 21st Century, including several by the Department of Employment, Education, Training and Youth Affairs (DEETYA). ASTEC also found the Australian Research Council Discipline Reviews, submissions from member organisations of the Federation of Australian Scientific and Technological Societies (FASTS) and the Institution of Engineers, Australia, very useful on this issue.

Sectoral studies are suited to the development of advice on specific skill needs and in some cases to targeted predictions. Most international technology foresight studies have identified discrete skills required in particular sectors into the 21st Century, although some processes such as the US review of critical technologies did not include skills.

The comparison of German and Japanese Delphi surveys revealed a general confidence that skills would be only a minor constraint to prospective technology developments (NISTEP FhGISI 1994). However, important differences between nations were identified. For the Japanese experts, fostering and securing human resources emerged most strongly as a constraint in the fields of Life Science and Environment. These are perceived by the Japanese as the technological areas where much is expected in the future and where a concerted international effort is essential. Human resources emerged as a constraint for the Japanese on specific topics rated as highly important, where other countries were considered to be more technologically advanced – in particular at the level of basic research.

In contrast, constraints in securing human resources were hardly mentioned by German experts in the survey. This might be due to the fact that in Germany enough well-educated personnel are available and the scientists of the former East Germany have additionally to be integrated into the unified R&D system. Therefore many scientists may be unemployed whereas in Japan at the time of the survey, there was a severe lack of personnel. The differences between German and Japanese responses is graphically illustrated in Box 15.2.

Box 15.2. Comparison of Japanese and German Constraints in Fostering or Securing Human Resources by Innovation Phases



Source: NISTEP FhGISI 1994.

The UK foresight study identified a small number of sectors where competence will be fostered as much by investment in human resources – developing new skills and deepening understanding of business processes and consumer preferences – as by investment in relevant areas of science, engineering and technology. Manufacturing, construction and leisure and learning sectors were identified here.

A consistent theme, across all sectors of the UK foresight study was the need for new I&CT skills. The Retail and Distribution panel suggested the need to determine the information technology (IT) literacy requirements of the emerging and existing workforce, and improve IT literacy skills of teachers and students. The Leisure and Learning Panel suggested a national college for high-level multimedia skills, supplemented by a special unit teaching skills in special effects, computer animation and related IT based creative skills. Overall, the UK study gave highest priority to 'training the trainers', particularly in the fundamentals of mathematics and physics, as a way of achieving change.

The ASTEC Partnership studies discussed skills, although S&T investment rather than skills was the major focus of these studies.

The Urban Water Partnership identified a wide range of skills needed for a 'whole system' approach to the urban water life-cycle. Box 15.3 shows inter- and multi-disciplinary S&T needs identified for a whole systems approach. They also identified a need for universities and CRCs to better integrate the skills needed in planning, engineering and ecology programs into their courses for professionals working in the urban area.

The I&CT Partnership identified the need for a broad base of skills related to digital technologies to provide the needed flexibility to meet changing directions in the industry. This includes the need for high-level specialised expertise in technical and creative areas of multi-media content delivery, eg human interface design. Also identified were skills in project and team management.

The Health Partnership on neurodegenerative disorders (NDDs) identified the need for a higher priority to be given to gerontology and aging skills development in medical schools. It sought a review to ensure that general practitioners will be skilled to manage NDDs in older people over the next 15 years and beyond.

Box 15.3. Expertise Required for Urban Water Issues

Examples of the inter- and multi-disciplinary S&T expertise required for water issues into the 21st Century identified in the ASTEC Urban Water Lifecycles Partnership include:

Meteorology/Climatology – Changing rainfall patterns, climate change, el nino effects, artificial rain making and better long-term forecasts.

Hydrologists/Land Managers – Predicting run-off from catchments, catchment management strategies, most probable flood estimation, ground water interactions, transport of contaminants in surface and ground waters.

Ecologists – How to maintain and restore functioning aquatic ecosystems, processes within rivers, wetlands and lakes by which nutrients and contaminants are processed, the assessment of river health management of reservoirs, impacts of waste discharges.

Chemists – Monitoring traditional water quality indicators as well as the new organic substances being introduced to the environment by industry.

Engineers – Construction and management of dams, treatment plants for drinking water and sewage treatment, construction of pipeline systems, replacement / maintenance strategies, design of drainage and flood plain structures. Risk identification and management.

Information Technologists – Capturing and processing data about performance of the all parts of the system. Ranging from remote collection of data on rainfall, run-off and water quality to in-home monitoring of water use and billing.

Planners – The form and density of new urban communities have important implications for the costs of water infrastructure, water usage and the volumes of stormwater that must be managed.

Materials Scientists – New materials for pipes and other processes.

Microbiologists – Monitoring microbial populations in water supplies, pipelines, waste treatment plants and discharge zones. Including new concerns about contamination with virus materials. Microbial ecologists have an important contribution to make in nutrient cycling in the environment and the processing of organic materials.

Epidemiologists/Medical Profession – What are the disease / health risks of operating to different water quality standards? What are the best indicators of water quality from a health perspective? What are the likely health effects of breakdowns in various parts of the system?

Soil Scientists – Ability to predict infiltration and the movement of water and contaminants through the soil column.

Source: ASTEC 1995c

The Youth Partnership identified the need for young people to develop skills in media analysis to make sound judgements based on information obtained from different parts of the media, including the Internet.

Some specific skill needs were also identified through the ASTEC Key Issues Roundtable discussions. For example, the need for:

- a core of people who have the skills to put genetic technology into practice, eg multi-disciplinary clinical genetics skills;
- skills in natural resource management, particularly in managing the localised and downstream impacts of a mosaic of intensive agricultural production within a framework of ecologically sustainable development; and
- skills to enable informed community discussion of highly contentious issues taking into account S&T, environmental and socio-economic perspectives.

The ARC investigated the needs for skilled professionals in various discipline areas in 2010 as part of their current study. For example, in commercial services research to 2010 must include overcoming skill deficits in the complexity of integrating high technology into systems and their linking with the human dimension. This requires the integration of psycho-social research with research in the physical sciences.

This need for multi- and inter-disciplinary skills for future S&T, linked with the growing importance of converging technologies which blurs the boundaries between disciplines, is one of the strongest themes to emerge from this study.

15.3. Generic Skills Requirements

This chapter is not a comprehensive analysis of the skills required by the S&T system over the next decade. Rather, it focuses on a small number of 'generic' skills in more detail. Four skills were identified from the ASTEC study as particularly important to the S&T system in its efforts to institutionalise a more effective response to the changes ahead. They were skills in business management, international issues particularly for Asia, using I&CT, and risk assessment and management.

These areas focus on prominent themes related to our ability to manage change and respond to the opportunities and threats presented by the Key Forces for Change. Two of the skills areas relate directly to responding to the challenges presented by *Global Integration* and *Applying I&CT*, and the other two relate to issues of management, particularly in the context of the changing nature of innovation and industry.

The possible changes discussed in this report indicate the need for broad skills amongst the S&T community. It was suggested that scientists and technologists need to consider S&T from a holistic perspective and build skills in communication, networking and team-building.

The UK foresight study concluded that the combination of technical and design skills essential to the upgrading of the UK's workforce will need new approaches to education. One aspect of this is better integration between the different stages of education, so that preparation bears a closer relationship to expectations. Concerns were expressed that schooling currently overspecialises. They reported that the practical development of the UK national curriculum must not encourage narrow or compartmentalised learning.

Increasing the capacity to incorporate a range of viewpoints and a variety of information in decision-making will assist more effective consideration of the wealth generating, socio-economic and environmental contexts of S&T.

Ways to broaden the educational focus suggested to ASTEC included the concepts of 'Year 13', or a return to the 'medieval university ideal' of relatively small integrated communities providing specialist tutorial and membership services, while also providing access to a much wider range of services from other universities.

a) *Improved Management*

> *'... it appears incontrovertible that Australian enterprises, training providers and educational institutions are not moving quickly enough to address the new paradigm of management. Many of their counterparts overseas, and especially the leaders in various fields of industry and education, are changing more rapidly and more extensively, and will be better prepared for the next century.'*
>
> (Karpin Task Force, 1995).

The Karpin Task Force believed that Australian enterprises can deliver world competitive products and services, but only through the enhanced productivity of their people and technology; and their ability to innovate quickly and creatively. Australian managers in large enterprises need to be more pro-active in creating opportunities and more outwardly focused in their thinking. This global orientation is not only necessary for those who wish to build an international business, but also in assisting all managers to recognise how world best practice can help their organisations defend local markets and increase productivity.

A survey of Australia's customers in the Asian region (Japan, Singapore, Taiwan, Malaysia and Indonesia) rated Australian managers a long way behind the other five 'competitor countries', on six key measures of entrepreneurial skill. It is particularly important to note the very poor impression people had of Australian managers on managing risk and uncertainty – both in financial terms and in exploring new business opportunities (Box 15.4).

Box 15.4. Survey of our Customers Views on Australian Managers, Mean Responses on a Six Point Scale from (1) Best to (6) Worst

Entrepreneurial expertise	Australia	Germany	Japan	Taiwan	UK	USA
Entrepreneurial skills	4.8	3.7	2.3	3.4	4.1	2.6
Taking advantage of new business	4.9	3.8	2.0	3.3	4.3	2.7
Willingness to take financial risks	4.6	3.8	2.7	3.6	3.9	2.5
Willingness to take initiatives in making friends with business people from another country	4.2	4.0	2.9	3.8	3.8	2.3
Creativity in generating new business ventures	4.9	3.7	2.0	3.6	4.2	2.5
Ability to explore business opportunities	4.8	3.8	2.1	3.4	4.2	2.5

Source: Karpin, 1995

The last twenty years have been dominated by a management focus on productivity improvement by reducing costs in staff or resources: so-called 'denominator management'. The focus of the next decade must be on 'numerator management', and how 'smarter' management and addition of resources can improve the 'top line' through the effective management of creativity, risk and growth.

The Australian culture and community has a generally ambivalent or negative attitude toward business enterprise. Australians need a better developed entrepreneurial spirit that nurtures a strong small business culture.

The Task Force decided that the primary focus of enterprise education should be on the young – potential employees and managers – rather than existing managers, as broadly based enterprise values are developed in early life rather than as one matures.

A vital part of Australia's innovation infrastructure is a technologically literate society. Firms are becoming increasingly integrated in their technology-creation activities, and collaborative R&D with other firms, universities and research organisations. Firms are also increasingly integrated in their manufacturing technology through linked computer-integrated manufacturing, local area networks and electronic data interchange.

Industrial competitiveness, in this 'world of technology' will depend on an educated and aware workforce. Yet it is estimated that in Australia only 30 per cent of Australia's 300,000 industry supervisors hold any formal qualifications. In Japan, USA and Europe, shift supervisors are often engineering graduates, whereas in Australia, 'graduate engineers do not aspire to such positions, nor would sufficient graduates be available' (PMSC, 1991).

The Karpin Report sets out a vision for Australian enterprises and their managers in 2010:

- knowledge, the ability to learn, to change and to innovate in this new marketplace, will be accepted as the more relevant criteria for selecting managers than gender, ethnicity or even prior experience;
- the 'learning organisation' will be the standard philosophy for many Australian enterprises and a major way they cope with change and turbulence;
- managers will create conditions conducive to learning for both individuals and the enterprise as a whole, within and between groups, across individual business units and between enterprises and their external environments. Employees will be more motivated and skilled;
- quality will act as a guiding light within all organisations with a customer first mentality being all pervasive. This focus will help improve productivity and profitability in enterprises through a concerted commitment to continual improvement;
- most Australian enterprises will earn higher rates of return on investment than in 1995 and successfully defend and expand their position in the global marketplace; and
- many Australian enterprises will be benchmarked as achieving world best practice in their operations, some will be acknowledged as setting world best practice standards.

The Karpin Task Force concluded that enterprise education is the main arena whereby entrepreneurship can be encouraged across an entire society and the range of business organisations. ASTEC supports the Karpin recommendations aimed at achieving cultural change across Australia but suggests this must be integrated with skills to meet the challenge of new technology, and notes the government's response in the 1995 Innovation Statement.

Several recent reports addressing innovation issues have stressed the importance of skilled and knowledgeable people, who understand and can communicate within the firm, and with its external technical and market environments. They also suggest an exploratory or searching approach to knowledge gathering and use.

The Industry Commission in its report on R&D (IC, 1995) noted that for firms to compete effectively through innovation they must:

- know about and be responsive to changing conditions in the markets;

- develop, where appropriate, the knowledge base, competencies and complementary assets required to undertake either research, development or commercialisation on its own account; and
- know about and have the ability to absorb from external sources, relevant new technology in all its forms – knowledge, human capital and equipment, and be able to manage collaborative effort and outsourcing arrangements.

The Australian Manufacturing Council suggested that, for innovation, firms needed to follow three broad practices (AMC, 1995. *The Innovation Cycle: Practical Tips from Innovative Firms*):

- create the need for new ideas by adopting practices to place them in the most competitive markets and in contact with the most demanding customers;
- trawl the market for solutions using internal capabilities to identify, gain access to and use the external environment for expertise and knowledge; and
- set up to maximise the contribution of their key resources, the skilled people employed (especially in their role as communicators to make technical skills productive).

Srinivas suggests the need to adopt a 'global mindset' as the foundation for business competencies such as managing competitiveness and uncertainty (Box 15.5).

Box 15.5. The 'Global Mindset' – a Model for 2010

'A global mindset is a way of approaching the world, a tendency to scan the world from a broad perspective. Globally thinking persons tend to be open to themselves and others by rethinking boundaries and changing their behaviour ... Global mindset is the foundation for business competencies such as managing competitiveness and managing uncertainty.'

K M Srinivas

The components of a global mindset are:

- *a curiosity and concern with context* – including placing current tasks against a backdrop of the past and probable future;
- *acceptance of complexity and its contradictions* – seeing opportunity in adversity and creativity from diversity;
- *diversity consciousness and sensitivity* – building teams and networks, and sensitive to assumptions and needs of others;
- *seeking opportunity in surprises and uncertainties* – knowledge from education and experience enabling self-confidence in taking risks under uncertain futures;
- *faith in organisational processes* – trust and delegation, with fast information flows rather than rules and regulations;
- *focus on continuous improvement* – self-improvement, rethink boundaries, adaptive changes;
- *extended time perspective* – A long-term view is taken – planning and visioning; and
- *systems thinking* – organisation thought of in terms of interdependent parts and cause-effect chains, to anticipate potential impacts and be prepared to deal those that cannot be anticipated.

ASTEC considers that foresight has a potential role to play in helping businesses develop this mindset.

Source: Srinivas, 1995

Foresight is a potentially powerful tool in developing knowledge about the external environment of the firm and in promoting internal communication, cohesion and shared vision. It is useful in obtaining and understanding strategically relevant information about external technical and broader developments. It has many features which can help the development of a 'global mindset'. ASTEC identifies foresight as a vital skill for managers of the future.

b) International and Regional Skills

> *'Asia is not one mountain, but many mountains. Each is tough to climb, with very steep sides. Australians have to learn what it means to deal across cultural boundaries that are often quite unfamiliar – with Asian institutions and worlds that, whilst appearing similar to outsiders, are very different indeed.'*
>
> Business Council of Australia, 1992

Cultural sensitivity is critical. Australian companies' successful entry into Asian markets requires a willingness to take a longer term view and work over many years to develop business in the language of the country to maintain relations with customers, government authorities and agencies. Companies have to be flexible and internally highly effective to provide a high quality approach to product, product development and service.

A common cultural expectation through most Asian countries is that trust, personal relations and time are essential ingredients in building relations – whether personal or business. This places a strong priority on *networking*, building relations at both official and professional levels, as mechanisms for establishing national interests. Both multilateral and bilateral relations play a role.

Becoming an 'insider' is arguably a precondition for forming successful S&T and business relationships in Asia. This requires sensitivity to each country's particular business practices and also to local exercises of power. In Thailand, economic activity tends to be controlled by the main private families, through their relationships to the royal family, the military and government. In Hong Kong, the Board of the Hong Kong Bank involves key economic players. In the Republic of Korea, responsibility for pursuing economic opportunities is commonly bestowed by government on ruling families of the major *chaebol* companies

Australia has a diverse and multi-cultural society providing a sound base on which to build links with many Asian countries. We need to ensure that our skills for working in and understanding Asian society and culture are developed as a fundamental part of Australia's higher education in S&T and built into our scientific and technological capabilities. We need to understand the varying institutional and organisational practices, goals and rewards, and meanings of scientific research, across different national, organisational and research cultures.

For example, Japanese organisational cultures are concerned with consensus building and discussions at middle-organisation levels. Republic of Korean organisational culture, whilst appearing similar from the outside, is far more hierarchical than Japanese. Republic of Korean culture meanwhile is strongly influenced by China and Japan, yielding a Confucian set of cultural values that emphasise education, literacy and bureaucracy, but still tend to view Western science as a 'tool' for development rather than a central component of contemporary Republic of Korean culture (PMSEC, 1992).

Cooperative regional relationships can serve an important role through networking, in increasing information and knowledge and reducing market uncertainty. Regional cooperation processes can communicate a less directly nationalistic interest whilst Australia increases its visibility as an S&T resource of use to the region. A beneficial product of regional economic relations is therefore credibility and networks of influence. Such relations will not lead directly to commercial pay-off, but regional links build an essential platform of mutual understanding, intelligence, and of relationships on which interests can subsequently be built.

At the same time Australia will need to respond through organisation such as Asia Pacific Economic Cooperation (APEC) group to the clear expressions of urgent concern by Asian countries at the role of S&T in their continued development. Australia is playing a leading role in APEC's development. This provides opportunities for Australia to help define regional approaches as well as providing opportunities for Australian businesses and research institutions to become involved in 'fabric building' and networking. In some work projects, Australia is already involved in activities with a S&T dimension. In others, there is potential for Australia to become involved and demonstrate the value of enhanced S&T capabilities.

Continuity of membership in networks is also very important. International experience demonstrates that the subsequent formation of strategic alliances across national boundaries follows from personal contacts and knowledge rather than from data bases. The training of people from the Asia-Pacific region in Australia has been an important way of developing long-term S&T relationships. Colombo Plan alumni with a knowledge of Australian S&T capabilities, who are now in senior positions in government and business in the region, have been useful for establishing personal contacts and Australian credibility.

Strengthening personal relationships between scientists and S&T personnel is an important means of developing S&T links with the region. This may require deliberate targeting of conferences, more use of post-doctoral fellowships in both directions and seeking out opportunities to host specialist research meetings in Australia.

Personal contacts established over time and sensitivity to the specific cultures of the individual countries in the region are critical to the successful realisation of commercial opportunities. This requires an understanding of Asian institutions and methods which, while appearing similar to outsiders, are quite different. It also requires sensitivity to each country's particular business practices and to local exercises of power.

Knowledge in this area is growing both through the experiences of business involved in the region and through increased study in research and industry organisations. This knowledge needs to be more easily available to those, particularly smaller businesses, becoming involved in the region.

c) Skills in I&CT

A range of skills will be required to manage the 'knowledge economy' of 2010. Growth is expected particularly in occupations which require synthesis skills, translating abundant information into market relevant and useful knowledge.

ASTEC recently completed a major investigation of Australia's skills base in relation to I&CT (ASTEC, 1995f). It found that a highly skilled workforce and excellent research infrastructure can contribute significantly to Australia's competitiveness but there is still a failure to recognise the importance of these technologies and services in employment. Although there is a demand within industry for increasingly highly skilled graduates in the I&CT area.

There is a relatively low demand amongst school leavers seeking to enter university programs related to the I&CT industries (computer science, information technology, software engineering, electronic engineering, etc.). Also, as only a small proportion of school leavers entering industry-related I&CT courses have high tertiary entrance scores, this raises questions about the overall quality of these graduates.

ASTEC supports the development of a small number of universities as 'centres of excellence' by developing leading edge programs and attracting high quality academic staff and researchers. It also recommends a significant (20 per cent) increase in the number of post graduate scholarships for I&CT courses. Indicators also suggest that Australia is likely to need to increase the supply of high-quality graduates with skills related to the I&CT industries to enhance Australia's skills base (ASTEC, 1995f).

Understanding the importance of I&CT should begin in school. Children of both primary and secondary years should be given increased opportunities to gain familiarity with the ever-increasing range of possibilities and applications of this technology. Programs are required to ensure that teachers are skilled users of I&CT services. Recent government initiatives to establish the Education Network Australia (EdNA) is an important step in this direction.

The UK Foresight study stressed the importance of early education and teacher training. It found there is a need to move away from narrow, compartmentalised teaching towards the production of more flexible and adaptable skills, especially those which span creative, commercial and technical competencies. The need is deeper than this and must also ensure that technicians can be creative.

One of the UK Delphi surveys asked when there would be widespread availability of training in a combination of high-level creative and technical skills in computer graphics, computer assisted animation, etc. While 68 per cent of the sample thought this will happen by 2004, only 23 per cent saw it happening in this century, when the skills are really needed. The Delphi asked when teachers at all levels would be proficient in the use of authoring software, graphical design packages and multimedia toolkits. Only 39 per cent of the sample felt this would be the case by 2004.

d) Risk Assessment and Management

Risk is a factor of everyday life and nearly every decision an individual or society makes involves some element of risk. As problems become more complex, our decision-making and judgement must improve, and risk management becomes a vital skill. Risk is central to discussions about managing uncertainty in the future, and longer term planning. However, traditional perspectives on risk in S&T are no longer appropriate.

Risk management requires acknowledging that one decision can have a range of impacts with different levels of likelihood and importance, and this must be factored into decision-making processes (Box 15.6). It is therefore about improving judgement so that as decisions become more complex we can take account of a broader range of factors.

Risk management is not only an individual skill but one that will need to be developed by organisations in industry. As many risks are not able to be efficiently managed at the individual level, government involvement may be required.

While the issue of risk management has always been of central importance in the development of environmental and health policy, risk reduction is not a costless activity and the cost-risk relationships are usually not linear. Trade-offs have to be made, either implicitly or explicitly in the risk management process. For society to gain the greatest benefit from the resources spent on risk reducing strategies, managers need to know the costs and benefits associated with the range of measures at their disposal.

Distinctions have been made between risk assessment – the scientific or technical component – and risk management – the economic and policy component. In recent years some attention has been paid to the scientific aspects of risk assessment in Australia, focusing particularly on the integration of health and environmental impact assessment into a unified decision-making framework (NH&MRC, 1994). Compared with the United States relatively little attention has been paid to the economic aspects of risk analysis in Australia.

Box 15.6. A Risk Analysis Model

Risk analysis can be separated into four interrelated, and often overlapping, steps: risk assessment; risk perception; risk valuation; and risk management.

- *Risk assessment* is used to provide a numerical estimate of the likelihood of an adverse effect on humans, wildlife or ecological systems posed by a specific development. For health and environment it consists of four steps (hazard identification, dose-response assessment, exposure assessment and risk characterisation). The outcome of the process is a numerical estimate of risk, either as a point estimate or a range of probabilities.
- *Risk perception* refers to the way in which humans respond to risks eg those associated with an environmental hazard. This depends on a range of psychological factors such as the level of individual control over risk and familiarity with risks. Risk perception has become the subject of considerable research as it has a major influence on the design and implementation of risk management strategies. key issues for the design of policy instruments includes the observation that some risks appear to be more acceptable than others, differences between expert and lay perceptions of risk, and the role of information in changing attitudes to risk.
- *Risk valuation* involves evaluating the options available for reducing risk to assist in deciding which risks to reduce and to what degree. Valuing costs and benefits of reduced risks is formidable and controversial. While the costs of reducing risks can usually be measured with some degree of accuracy, the benefits are often elusive and difficult to quantify.
- *Risk management* is the process of forming and implementing a strategy for accepting or mitigating identified risks. It involves evaluating alternative policy options and selecting among them.

Traditionally commentators have argued the need to maintain a separation between risk assessment and risk management functions so that management issues do not influence scientific analysis. Recently however there is a recognition that both scientific and policy judgements are inevitably, and inextricably, involved in risk assessment and that they are not value free.

S&T has an important role to play in risk management. It can serve to inform the broader community's perceptions of risk as part of community decision-making. There is also a need to better consider the risks of S&T developments. High profile judgements such as that leading to the accidental release of exotic viruses can harm the community's image of risk management in S&T.

The UK foresight study rated 'Risk Assessment and Management' as one of three important categories in their generic S&T priority of 'social shaping and the impact of new technology'. This included the psychology of risk perception and study of behavioural responses to risk across issues in finance, food, health, travel and the environment. The community's perception of risk is a valid factor in S&T decisions.

A recurring theme throughout the Future Needs study has been that of adapting and managing a changing economy, society and environment to 2010. The capture of opportunities from change requires new patterns of economic activity and investment. The investments required are in many forms and include education, skills, R&D, infrastructure and the creation of new business enterprises.

Economic 'inertia', where patterns of activity become deeply entrenched, can be a liability in a period of rapid change or transient opportunity. The forces for change discussed in this report indicate potentially large scale social and economic transformations. The significance of potential changes ahead highlights the disadvantages of short-term thinking. Responding to such forces will require new patterns of investment, including in innovation, infrastructure and in a new wave of small, start-up firms in new technologies and industries. However, there is considerable risk in developing responses such as innovation.

Like any other form of investment, innovation is risky. It is justified by the conviction that the effort will result in a new product, process, or business approach that will add value the company. But the innovation might fail or yield less than the intended commercial benefit. With innovation the level of risk is higher: breaking new ground is always risky. To be sure that the assessment of returns is realistic, investors or their analysts should carry out their own sensitivity analysis, involving the type of issues set out in Box 15.7.

Box 15.7. Some Key Sources of Risk in Innovation

Risks for innovation include those arising from:

- *Competitors' actions*: (both national and international). What are they doing? Are they likely to launch a competitive offering?
- *Technology problems*: Does the innovation depend on a technology breakthrough? What could go wrong?
- *External influences*: When is the innovation going to yield commercial results and what will be the state of the business environment at that time? How dependent is the innovation on others; for example, is a new notebook computer project totally dependent on the availability of the next generation of memory integrated circuits from Japan?
- *Delay*: What will happen if key projects are late? Will a one- year delay mean that the company misses a crucial time window, or force a major customer to switch to a competitor?

Source: Dodgson and Rothwell 1994

ASTEC believes that well calculated decisions about risk require an adequate information base, including information about predicted, preferred and possible futures. R&D decisions taken with a strategic view on creating future competitive advantages and effective innovation will be critical to Australia's success in the future. The high risk in not having such a strategic approach needs to be continually reiterated and publicised.

It has been argued that the finance sector feels unable to judge the prospects of success for S&T related projects, or of survival for the firm as a whole, so firms cannot find enough collateral for their loans. Large firms may also suffer, at the hands either of banks or of stock markets, when confidence is low and/or information flows are defective. This can be made worse by external factors such as a recession or where small firms lack close relationships with one or more large firms which could guarantee loans or at least improve the information available to lenders.

Traditionally more weight has been given to indicators of current or past profitability than to information bearing on long-term prospects. This is generally due not to indifference to long-term prospects but to lack of the necessary information, or incapacity to evaluate it. This is made worse if the development is based on highly complex S&T. Given the ready supply of good investment projects, the finance community can afford not to support businesses it does not understand.

An approach to this issue is illustrated by the US where venture capitalists with expertise in a particular technological area take an equity stake and provide or find management expertise.

They help the company to reach a suitable size for stock exchange flotation and provide some warranty of quality for investors.

There is a need for novel sources of funds for the newly emerging technologies and complexes (and for R&D in government businesses). New sources of 'exit' are also needed for investors in start-ups. Valuable lessons can be learned from overseas experiences in over-the-counter markets, the third market in the UK, the National Association of Securities Dealers Automated Quotation (NASDAQ) in the USA.

Global integration and information technology are strongly influencing the environment of the finance sector and sources of funds. Factors in this changing environment include shifts in international economic activity and capital sources, particularly as a result of increasing strength in Asia as a source of capital, impacts of possible developments in China and Hong Kong, and the prospect of further integration of Australian and Asian capital markets.

Information technology is changing all aspects of finance. For example, the continued development of a 'cashless' society with electronic money, and new corporate 'loyalty' and branding schemes, can provide corporations with direct access to capital and market information. A more distributed and devolved ownership of capital, including the growth of non-bank sectors in the provision of financial services is changing the structures for deposits. Insurers, superannuation funds and other fund managers will compete strongly for savings. There are many uncertainties about future developments but there is a need to take the long-term perspective on risk assessment and management in the finance sector.

15.4. Building Effective Linkages and Networks

To meet the challenges of the 21st Century our S&T system will need to create effective linkages and networks. This includes boundary crossing between the S&T system and other systems, as well as a cross discipline boundaries within the S&T system.

This broad view therefore covers many links between knowledge producers and people involved in knowledge application, as well as the networks of infrastructure and legal frameworks supporting them. The facilitation of such linkages is an essential part of developing a dynamic S&T system which is able to generate wider benefits through the diffusion and application of knowledge.

a) Networks, Clusters and Precincts

The importance of networks has been increasingly recognised and addressed in innovation theory, government policy and industry practice.

The force of global integration suggests the possible emergence of a borderless world, strategies for such a world focus on linking to regional 'nodes', 'clusters' or 'networks' of activity, capability and competence (eg Ohmae, 1995). This concept, applied on a local scale is reflected in an important trend of the 1980s and early 1990s, based on the success of 'Silicon Valley'. This is to create technology precincts, such as the SA Technology Park, to foster clusters of complementary activities within a regional area thereby building a climate of creativity and commercial dynamism.

The development of the Cooperative Research Centres (CRC) program in Australia is another means to foster linkages. The CRCs cover a wide range of topics and provide a focus for developing the critical mass of individuals, firms, educational and other organisations needed for competitive advantage. Such networks enable small to medium enterprises to link together on a large scale to compete successfully with larger organisations. The CRCs can provide nodes to drive regional S&T cooperation.

The demands of innovation to 2010 require firms to adopt an integrated systems approach across all components of business. This new approach relies on building more direct external links which will extend locally, nationally, regionally and globally. It brings a greater customer focus to production, driving businesses toward new systems, such as being explored in the Intelligent Manufacturing Systems (IMS) Program. In manufacturing this will mean more flexible production; in services, niche and novel delivery strategies; and in agriculture, specialised high value and clean foods.

Networking is not however without its problems and is therefore critically dependent upon new approaches to management and a new set of management skills: Managers must aim to be: autonomous, proactive, empathetic, intuitive and creative, transformational, politically skilled, alliance oriented and mature (Limerick and Cunnington, 1993).

The possibility of successful innovation is enhanced through the regular use of multiple channels of communication. Networks offer a rich web of formal and informal channels, which have the advantage of high source credibility: experiences and ideas arising from within the network are much more likely to be believed and acted upon than those emerging from outside. Similarly, the demonstration effect is greater within groups of firms familiar with each other and against whose own experience some direct comparisons can be made.

Networks also provide a powerful mechanism for dealing with uncertainty and the idiosyncratic diversity of firms' needs. Designing policies which fit all contingencies is clearly impossible. An alternative is to design flexible arrangements which can be modulated by a network to shape it to suit the individual needs of its constituents.

Networks evolve organically and cannot be set up to order. Understanding the conditions which lead firms to cooperate and share in this fashion is critical to successful network formation. It explains why 'manufactured' networks, set up from the top down may often be less effective than those which emerge naturally from the bottom up.

Some networks tend to form naturally amongst communities of predominantly small firms with focused common interests, where cooperation is seen as an alternative way of dealing with external threats. In other cases, it may be necessary to employ some form of catalyst or animateur to enable the network to form. For example, the Plaza Programme in Japan or the network-forming policies in Denmark.

The skills to form and reform networks, whether from inside research institutions, or as an external catalyst will be increasingly important into the 21st Century. It requires much closer investigation to identify how these skills can be enhanced amongst the Australian S&T community more generally.

b) Australian S&T Networks

From amongst the vast range of possible opportunities for S&T in developing networks, several important issues were highlighted through this study.

Universities might have a potential role in managing networks and databases in a global S&T system. In a world of hyper-abundant 'content' the scarce resource will be 'context'. The most important skills will be how to sift and select relevant information. Universities, by their expertise, experience and infrastructure are in an ideal position to develop themselves as information highway managers. They can also play a broader role as distribution points in networked information flows. Prospective possibilities such as the introduction of global 'virtual universities' will increase the potential for such a role.

If universities wish to enhance their role as managers of the information super-highway they will need to consider a broad range of new skills as central to their core business.

Within the S&T system there are many barriers and boundaries that divide one group from another. Yet the new areas of discovery are those at the intersections. Some of our biggest problems of the future will require a multi-disciplinary approach. Multi-disciplinary and interdisciplinary work must be encouraged and monitored. This may require new tools of analysis.

Potential economic benefits of research can be realised through both small and large firms. Larger companies conduct most industrial research, while many smaller companies have modest research investments (DIST, 1995). Studies have indicated that small- and medium-sized enterprises appear to be under-represented in linkages with research agencies such as CSIRO by comparison with larger companies.

In agriculture, the diseconomies of scale have been overcome by encouraging small businesses to participate in collaborative research ventures. Organisations such as the rural R&D corporations can enhance the sustained economic contribution of agricultural industries to the national economy. This raises issues, such as:

- how do we maximise linkages between public sector strategic research and industry, including small industry to meet long-term needs?
- how can industry maximise the economic benefits of its own research and technology developed overseas to meet its long-term needs?

Firms are becoming increasingly integrated in their technology-creation activities: collaborative R&D with other firms, universities and research organisations is becoming more prevalent.

The effective interaction of the S&T system with other social institutions is a critical factor in helping Australia to benefit from the forces of change. Some of the biggest issues in S&T will be at the intersection of the financial, legal and S&T systems. Concerns were raised at the extent to which people are skilled across these boundaries to enable full consideration of issues and effective decision making.

ASTEC strongly supports a national dialogue on intellectual property, similar to that held on Ecologically Sustainable Development. A major concern in intellectual property is to ensure that adequate rewards are provided to the developers of intellectual property, but that no barriers are placed on its rapid diffusion. Attempts at overly stringent control of intellectual property rights (as seen in the approach of some universities and research organisations) may be counter-productive in the longer term.

The BIE (1995) suggests that global protection of intellectual property rights is one of the major forces driving towards stronger S&T linkages. This issue requires experts who are skilled in S&T and legal issues. However developing this expertise has perhaps not been as highly valued in the past. Australia needs to move quickly in this area. The value of all kinds of intellectual property rights has to be assessed, including ‘petty patents’ of more limited scope and duration than conventional patents and more appropriate to the needs of smaller firms.

15.5. Conclusions

We live in an era of rapid and continuous change. Many of the skills which will be required in the S&T system over the next 15 years are generic skills required in any organisation which is outward looking and open to change.

For the Australian S&T system to be ready for the challenges ahead requires new organisational systems and new skills. In particular, skills in management, international relations, I&CT and risk management will be vital.

The effective interaction of the S&T system with other social institutions is a critical factor in helping Australia to benefit from the forces of change. Some of the biggest issues in S&T will be at the intersection of the financial, legal and S&T systems. A common view identified by ASTEC is that the finance sector considers itself unable to judge the prospects of success for S&T related projects, or of survival for the firm as a whole, so that S&T-based firms cannot attract investment capital. Traditionally, more weight is given to indicators of current or past profitability than to information bearing on long-term prospects. This is generally not due to indifference about long-term prospects but to a lack of necessary information or the capacity to evaluate it.

Skills are required which combine expertise and knowledge from diverse areas such as S&T and financial, legal and intellectual property. Developing these skills may require new institutional mechanisms.

In addition to 'generic' skills, there are many specific skills needed in particular regions or sectors. These can be illustrated by international foresight exercises. In Japan, fostering and securing human resources emerged strongly as a constraint in the fields of Life Sciences and Environment. The UK foresight study identified a consistent theme of the need for new I&CT skills in the existing workforce, and of teachers and students. The UK study gave highest education priority to 'training the trainers', particularly in the fundamentals of mathematics and physics, as a way of achieving change. Manufacturing, construction and leisure and learning sectors in particular were identified as requiring investment in human resources to develop new skills and deepen understanding of business processes and consumer preferences.

ASTEC's Partnership studies also identified a wide range of skills needed in their sectoral areas – for example, the Urban Water Partnership highlighted inter- and multi-disciplinary S&T needs for developing a 'whole systems' approach. They also identified a need for universities and Cooperative Research Centres (CRCs) to better integrate the skills needed in planning, engineering and ecology programs into their courses for professionals working in the urban area. The I&CT Partnership identified the need for a broad base of skills related to digital technologies to provide the needed flexibility to meet changing directions in the industry. The Health Partnership on neurodegenerative disorders (NDDs) identified the need for a higher priority to be given to gerontology and aging skills development in medical schools. The Youth Partnership identified the need for young people to develop skills in media analysis to make sound judgements based on information obtained from different parts of the media, including the Internet.

Some specific skill needs were identified through Key Issue Roundtables, including the need for a core of people who have the skills to put genetic technology into practice. Such people will require multi-disciplinary clinical genetics skills, skills in natural resource management, eg in managing the localised and downstream impacts of a mosaic of intensive agricultural production within a framework of ecologically sustainable development, and skills to enable informed community discussion of highly contentious issues taking into account S&T, environmental and socio-economic perspectives.

Tapping into skills and knowledge through networks is also critical. This will be particularly important in inter- and multi-disciplinary projects in emerging technology areas. Networks provide opportunities for governments to encourage innovation through inter-firm and institution-firm linkages. As self-organising systems, networks can diffuse and modulate policy once it has been accepted, so that the task of the government becomes one of helping to construct and maintain networks and of designing robust and flexible policy which can be effectively adapted and used through networks.

Responding to the forces for change requires developing a sophisticated balance of skills, and those skills at the interface between the S&T system and other socio-economic systems require particular attention.

Area for Action: Developing Skills for Tomorrow

ASTEC considers it necessary to ensure that our scientists and engineers are capable of meeting the challenges of a 21st Century organisation. This will require an effective response from all organisations currently responsible for the education, learning and on-going development of people who are at present in these areas or who may seek future employment there.

ASTEC recognises the significant amount of training currently being undertaken, but has identified the need for a specific futures orientation, in particular to encourage organisations responsible for S&T (including industry, government, and relevant academies and professional organisations) to review how well they are building generic skills for managing change into the 21st Century. Such reviews, of course, would not be limited to the 'generic' skills identified by ASTEC, but extend to those identified as a priority for an organisation and take into account the appropriate balance between specific S&T skills and more generic skills.

Part E: A Culture to Manage Change into the 21st Century

The world is changing in profound ways into the 21st Century. These changes have the potential to enrich our lives and help us to achieve our national goals, yet they also threaten many things we cherish. We should not underestimate their power, nor the value of tools, such as foresight, to help us manage the uncertainty they present.

Science and technology (S&T) is a critical driver of these changes. It also offers the best hope of meeting the challenges ahead. We need to be more skilful in using S&T to help us shape the future.

This report has argued for an increased need for S&T into the 21st Century. We have also argued that foresight can help us plan for the future. S&T can be better positioned to help us meet a range of future needs by an improved understanding of socio-cultural, economic and environmental contexts. At the same time the community requires a better understanding of the capacities of S&T to give it a more central role in decision making.

Chapter 16 focuses on the importance of building a 'technate' community that can deal with a future of more pervasive and sophisticated S&T. A broad-based understanding is essential to the diffusion of ideas and enhancing the productivity and creativity of the nation. S&T will be critical to wealth creation, community well-being and environmental sustainability into the 21st Century.

Chapter 17 focuses on the importance of improving our capacity to prepare for the future through foresight. It is vital to build a better understanding of the future, even though we cannot predict it precisely.

Many other countries and organisations are engaged in developing skills to consider the future, including as part of their strategic planning. For industry these skills can provide opportunities for wealth creation as the rules of competitiveness change. For Government these skills can highlight the need for changes in role as new challenges arise. For the community they can identify issues of equity and inclusiveness.

This study has demonstrated that the community can benefit from a better understanding of S&T; foresight programs can assist Australia to meet the challenges of the 21st Century.

Chapter 16. Building Science and Technology into Australia's Future

16.1. Introduction

S&T developments across a vast range of sectors, will generate a confusing array of complex and sophisticated technological possibilities into the 21st Century.

Analysing this rapidly evolving array of S&T developments has identified a small number of critical technology areas that we must take into account. Australia's S&T capacities cut across these. For example, Australia has strengths in environment and genetics and biotechnology, but is relatively weak in manufacturing and new materials.

S&T is expected to become so pervasive in the 21st Century that it can no longer be considered separate from community goals. Our concept of S&T must expand to take social, environmental and industry priorities into account. Technacy provides a framework to do this.

16.2. Benefits of an S&T Literate Community

An S&T skilled community will bring benefits from a number of perspectives.

Australian industry requires a community with a better understanding of S&T to provide a labour force with more adaptable skills and the flexibility to deal with on-going rapid technological change. An S&T literate community was identified as essential for investment in new and technologically high value-added industries. It is therefore critical to innovation and wealth creation. Customers, who demand increased performance through S&T are also a vital driver for industry to develop innovative ideas.

International foresight studies have consistently identified the importance of demand. One of the six generic priorities from the UK study was 'social shaping and the impact of New technology'. This takes into account issues such as demographic change, the psychology of risk perception and the social acceptability of new technology.

The German repeat of the 1992 Japanese Delphi revealed that public acceptance of new technology, either for the society as a whole or for certain large groups, acts as a significant constraint on S&T development. And the I&CT Partnership identified domestic demand as the major uncertainty and driver for industry development in full service networks in Australia.

S&T research can be delayed by community concerns often based on a poor understanding of S&T. Some of the most difficult and contentious issues our society is facing today such as euthanasia, nuclear power, or biological control agents could be assisted by a better understanding of the S&T involved in issues.

The greatest benefit of a broad community understanding of S&T is the extent to which it could assist us to deal with the challenges ahead. New technologies can reduce the levels of disadvantage experienced by different groups. They can also provide targeted responses to environmental problems and suggest new innovations for industry. In our daily lives, a greater knowledge of S&T could give us a better understanding of our working conditions and change our decisions as consumers.

Our responses to many issues could be improved by the timely consideration of S&T aspects; however this requires a good understanding of S&T across the community to call for its use.

16.3. *Contradictory Attitudes to S&T in the Australian Community: High Hopes and Great Fears*

There is a view that technology will solve all our problems. Australia is known as a country that picks up technology very quickly. We buy mobile phones and new computers at a rate comparable, or even better than, most other countries. Recently concerns have been raised that our preference for new technology leads us to adopt uncritically new schemes and products with possibly serious implications for maintaining our privacy and consumer rights.

Recent studies (eg Woolcott, 1995) suggest that the Australian community is becoming increasingly cognisant of the importance of S&T to Australia's future welfare, particularly our economic future. They also report an increase in the proportion of people who consider that S&T is very important in everyday life.

A recent BIE study suggested that Australians are more optimistic about the benefits of science than the British, Japanese or French. It also found that Australians demonstrated a higher understanding and awareness of basic science than Europeans, Americans or Japanese. While the BIE points out that science awareness and understanding is only one of the ingredients necessary to successfully diffuse and exploit S&T in a society, they consider Australia has met this precondition better than other advanced countries.

In our minds at least technology is always on the verge of liberating us. Yet there is also a wariness in the general community of a future dominated by technology. This concern is reflected in the work of social researchers such as Hugh McKay, who found that:

> *'Australian consumers regard technology as creating the pathway to a brighter, more comfortable, more convenient and more efficient world for mankind. Yet they worry about their own tendency to 'go overboard' about new technology and they fear there is a kind of technological roller-coaster which may turn out to be unstoppable. The deepest underlying concern is that as we invent smarter and smarter machines and embrace them with increasing enthusiasm, will the machines designed to be our servants end up being our masters? Will we become the victims of technology?'*

This is supported by the results of research amongst Australian youth. While two-thirds of young people in the ASTEC National Opinion Poll considered S&T offered the best hope to meet the challenges ahead, many believed the most positive future will require a step back to the simple life – in partnership with nature.

Certainly there was considerable concern expressed throughout the study about the potential negative impacts of S&T. Cultural, heritage and environment groups; religious, ethnic and women's groups; groups concerned about privacy and consumer issues, and groups concerned about ethical issues such as the use of abortion and euthanasia raise concerns about S&T. It is clearly reflected in current calls for scientists to adopt the precautionary principle on environmental matters, and consider the ethical implications of new developments such as the use of aborted foetuses in clinical tests.

Females appear less supportive of S&T than males, and were less likely to believe that S&T will solve environmental problems without the need for lifestyle changes (ASTEC, 1996a). This suggests some basic gender differences in the perception and use of S&T.

Young people did not see S&T as a universal panacea. Indeed, there has been a decrease in support for S&T since the late 1980s, in a series of surveys. This is reflected in a declining proportion believing S&T has more benefits than disadvantages and a larger proportion seeing equal benefits and disadvantages (Box 16.1).

This can be interpreted as a growing maturity: a realisation that S&T is a very powerful tool that can be used to achieve a number of different goals. Consistent with this explanation, we found that young Australians who are optimistic about the quality of life in the year 2010 tend to view S&T more favourably than others.

Box 16.1. Perceptions of Technological Developments in Young People

Attitude	1983*		1987*		1988#		1995^		
Age Groups	14-19	20-24	14-19	20-24	14-19	20-29	15-17	18-21	22-24
% More Benefits	49	42	65	56	57	64	38	37	40
% Equal Benefits & Disadvantages					34	30	53	54	45
% More Disadvanrages					8	6	8	7	12

* Technological developments in Australia may have both benefits and disadvantages. Which one line best describes how you think technological developments will affect Australia? (Many more benefits than disadvantages, more benefits, equal benefits and disadvantages, more disadvantages, many more disadvantages than benefits; benefits totalled.)

Overall, do you think the scientific and technological advances of this century have had many more benefits, more benefits, about equal benefits and disadvantages, more disadvantages, many more disadvantages? (Benefits and disadvantages totalled.)

^ Thinking generally about the role and impact of S&T, do you think S&T have had more benefits, more disadvantages, about equal benefits and disadvantages?

Note: the 1983 and 1987 questions were part of broad-ranging attitude surveys; the 1988 and 1995 questions were included in surveys dealing specifically with the future and S&T.

The 1983 and 1987 data are from: Eckersley, R. Australian attitudes to S&T and the future. Commission for the Future. August 1987.

Sample sizes for the 1988 CFF poll were: 14-19, 130; 20-29, 238. For the YP poll, sizes were: 15-17, 307; 18-21, 290; 22-24, 203.

Source: ASTEC 1996a

The community's perceived problem with science may not be intrinsic to the nature of scientific research and knowledge. It has been argued that it could rest more with our immaturity in using a cultural tool as powerful as science. Perhaps with growing experience and wisdom, we can better use science to serve our best interests and deepest needs.

16.4. Community Literacy in S&T

The Roundtable on *the need for a technologically literate society in 2010* noted that the community's need to understand S&T, often called S&T literacy, has changed dramatically over time.

The definition and meaning of S&T literacy has changed as S&T has become more sophisticated. For example fifty years ago machines were comparatively simple, and technological literacy was focused on an ability to understand how a machine worked and do running repairs. The situation is quite different in 1996. We deal every day with complex technologies, which require highly specialised training and skills to repair, eg digital phones and microwaves. Understanding how technology works to enable 'running' repairs is no longer a priority, for most people. In the future our technological literacy is more likely to be a reflection of our ability to feel comfortable using technologies while not understanding them. Computer software, in particular, will increasingly be our 'interface' with machines.

Given current community needs, ASTEC has argued that S&T must be set in a broad social context, and include a consideration of ethical, equity and access issues; and be focused on the crucial role of improving decision-making based on better understandings of S&T. The flaws of technical understanding in modern industrial societies are particularly evident in cross-cultural delivery situations thus exposing the notion that S&T can be set apart from its social context.

As noted in Chapter 13, ASTEC considers our future needs to understand S&T will require an understanding that will allow society inter alia to:

- use S&T effectively in decision-making processes;
- discuss and adapt new scientific and technology developments;
- appreciate science as part of our culture;
- maximise the benefits of S&T in our daily lives; and
- build strong S&T systems and expertise, including an educated workforce.

Into the 21st Century communities will be required to deal with broader S&T issues, eg the role of technology in prolonging life as part of the euthanasia debate, community debates on environment versus development, and ethical and moral issues in relation to new S&T developments in genetic engineering such as xenotransplantation or modified foods. The community must be in a position to make informed decisions on issues such as these. High levels of S&T literacy will also be required to underpin investment decisions.

16.5. The Key Forces for Change and National Goals

The achievement of our national goals of an ecologically sustainable, inclusive, productive and creative society in the 21st Century will increasingly depend on our ability to use S&T.

ASTEC identified four major Key Forces for Change for the beginning of the 21st Century. These forces are the drivers and enablers of many new S&T developments. They require S&T to shape and respond to them. At their furthest extent *Environmental Sustainability*, *Global Integration*, *Applying I&CT* and *Advances in Biotechnology* imply a 'high tech' world for 2010.

The achievement of our national goals for Australia in 21st Century will depend to a large part on how we use S&T to respond to the Key Forces for Change. The application and development of technology will clearly play an important part in determining the future of Australia and the way of life of all its citizens.

For example, ecological sustainability in agriculture will require a sophisticated understanding of the on-farm and downstream impacts of different forms of production and technologies designed specifically for local environmental conditions. *Global Integration* and *Applying I&CT* will combine to bring about a more productive, 'intelligent' and adaptable global production system with data sharing protocols, artificial intelligence and robotics. *Advances in Biotechnology* can contribute to an inclusive society by extending the benefits of current expensive medical treatments through widespread use of novel therapeutic agents.

It is important to remember that these are possible futures – without an appropriate priority for S&T they may never be realised. However, we could end up the recipients of scientific efforts designed to meet other countries' priorities and a raft of expensive new technologies not suited for Australian conditions.

The importance of S&T is increasing in our daily lives, both from new products and services. Our decisions as consumers constantly require us to balance the risks and benefits of potential purchases. Our decisions as a community eg the placement of mobile telephone towers next the preschools, also require this balance. A knowledge of S&T will allow such decisions to be made more effectively.

S&T in 2010 will be more sophisticated, complex and pervasive. Technology is continually being refined, producing the complex combination of old and new technologies that people today encounter.

Applications of science help to shape the future as well as helping to provide ways of seeing it. They are transforming large parts of human life: communications, medicine, leisure, agriculture, manufacturing production. New science-based technologies can be harnessed for profit, for human betterment, for environmental management, for oppression, for greed, or for philanthropy. In the future, almost everywhere we look, we will see the use of understandings generated by scientific endeavours.

Decisions about the development and use of technology reflect a range of cultural issues and environmental factors. They are influenced, for example, by the values and experiences of different people and communities, by the political beliefs held by different groups, by the actual or predicted impacts of technologies on the environment and by the processes by which the decisions are made. Making decisions about technology often involves a complex mixture of consensus, conflict and compromise. (Statement on Technology for Australian Schools AEC, 1994)

People need to understand technology, to be confident and capable users of a wide range of technological applications and processes and to critically appreciate the consequences of technological innovation. People need to make informed decisions about the sustainable development of technology and its impact on people and the environment.

The role for S&T in society will become more significant, as we are required to address the complex problems of the future eg population growth in our global world. We need a community that values S&T information as an essential part of this decision making.

16.6. Developing a 'Technate' Community

For many years literacy and numeracy have been the cornerstones of western industrialised education. Yet many people have questioned the adequacy of this for the new technological age. There are basic skills in technology and problem solving which are required to support a technological lifestyle.

As outlined in Chapter 12, ASTEC considers that technacy, the technological equivalent of literacy and numeracy, provides a sound framework for developing a new vision of the role of the S&T system in achieving national goals, and improving understanding of S&T in the Australian community.

Currently the community does not rely on scientific and technological information for decision making and our education does not prepare us to be able to do this (S&T literacy Roundtable discussions). Technacy, as described in Chapter 12, provides a framework for this – a framework that can be applied to our education systems.

Technacy education seeks to begin learning with integrated education applied to the real world. It seeks to develop holistic solutions. Rather than simply adding to or rearranging the curriculum, the developers of technacy argue that the curriculum needs to be rebuilt on an alternative foundation using holistic learning responsive to community needs (Box 16.2).

Box 16.2. An Example of 'Technacy' in Action

The ATWORK program was established to deliver technacy education by and for indigenous Australians. The program is run by the Centre for Appropriate Technology in Alice Springs, which functions as a non-government organisation dedicated to research, design, develop and teach technologies appropriate to remote communities. The organisation is often involved in pre-feasibility studies for Australian government aid projects and programs for developing countries including Africa, China, Asia and the South pacific.

Considerable effort is directed in the ATWORK program towards imparting skills, knowledge and techniques that enable students to participate in taking control of their community technologies through an understanding of the natural, built and social context in which the technology exists. This is achieved through:

i) course modules that are community design-project driven; students draw their learning resources from the actual issues, problems and developments taking place in their own communities;

ii) an emphasis on the integration of a variety of technologies, materials and cultural knowledge in order to produce appropriate responses that actually support community functions and cultural activities;

iii) giving students skills in identifying, preventing and solving technological problems in their communities; ie we prepare them to become practicing, applied designers who investigate problems of a technological nature and take steps directly to make judgements and changes regarding the choice and design of technologies that support their chosen lifestyle.

The course is therefore directly involved in supporting the process of community development through technological empowerment with technacy education.

Source: ACAT

S&T education needs to better integrated into the curriculum at all levels as a skill for living. The education system needs to develop analytical skills so that as a new issue arises people are able to sensibly deal with it. The skills of judgement and discretion in selecting information should encourage curiosity and learning rather than just passing exams.

The community needs to understand the broader concept of technacy which incorporates social, environmental and S&T aspects. They need to be encouraged to use it to ask questions and make decisions about S&T issues. However we must also become more adept at understanding how S&T can resolve our economic social and environmental challenges in the 21st Century.

There is some concern about the roles of government S&T information agencies. To the extent that young people's concerns are based on a lack of understanding of the issues and their impacts, action needs to be taken to enhance young Australian's understanding of S&T, using both the formal education sector and more general community programs.

Current S&T awareness programs tend to rely on communicators who are S&T experts. The need for two-way communication suggests that such a model may not be the most effective way of building a long-term technacy skills base in the community. One alternative model is to more directly involve the community in S&T projects. This would help raise the levels of technacy in the community and facilitate linkages between S&T programs and community priorities.

16.7. Conclusions

The need to improve the community's understanding of S&T (both through the education system and more generally) and to address concerns regarding S&T developments were reinforced strongly by elements of the ASTEC 2010 study, particularly the Roundtables.

To benefit from opportunities in the 21st Century, S&T will need to be deeply embedded in our Australian culture. We must be able to make informed decisions about S&T issues which affect our future. This requires a community which appreciates science, can access and use technology and engage in robust debate about the implications of technological change.

Challenges such as genetically modified organisms, global information flows and medical breakthroughs will need to be matched by national scientific and technological literacy, a commitment to underpin national investment in research and technology, and a sophisticated national debate which values social, economic, environmental and ethical concerns.

While education is the crucial step to achieving change, this is not expected to be fully effective by 2010. Instead, the media, and the emerging Internet, have a critical ongoing role in providing information on S&T throughout our lives.

Ensuring S&T literacy and access to technology for a range of groups: young children and their parents, older people from a less technological society, business particularly small and medium businesses, decision-makers in government and the S&T community itself must be recognised as a central issue to the S&T process.

A significant amount of this is being done in this direction in curriculum development however, it might be appropriate for a review of S&T education in schools. Our children are the future, and to be ready for this future we must ensure they are well prepared to match S&T to their needs in 2010 and beyond.

Area for Action: Improving Science and Technology Skills in the Community

ASTEC considers it essential to integrate the role of S&T in economic, social and environmental decision-making into the 21st Century. This will require a greater community understanding of the role of S&T in society, which in turn will require improved S&T skills learned from childhood.

'Technacy', the technological equivalent of literacy and numeracy, is defined as competence in S&T problem solving that develops the ability to integrate the human, social, environmental and technical aspects of technological issues or initiatives.

Priority Action for the Commonwealth Government – 8

ASTEC recommends that as a priority the Minister for Science and Technology and the Minister for Employment, Education, Training and Youth Affairs, work with State and Territory governments to:

- incorporate 'technacy' in primary and secondary school curricula and teaching practice across Australia.

To initiate this process, ASTEC has proposed a study on primary S&T education, which would review the work done in preparing the statements and profiles for S&T and suggest any changes needed to achieve this objective.

Chapter 17. Embedding Science and Technology in Australian Culture

17.1. Introduction

In view of world-wide interest in foresight, ASTEC set out to test the usefulness of these techniques for Australia and ensure Australia is not disadvantaged by neglecting to take up the foresight challenge.

This task was consistent with ASTEC's role as an the principal source of independent advice to the Commonwealth government on S&T issues. ASTEC is in a unique position to provide advice to Government on foresight because of its independent status, its broad longer term perspective and its links to the S&T community and to industry.

Australia is experiencing a period of rapid change. However, if we knew the future we would be able to make better decisions for today. Foresight has the potential to provide a means of thinking systematically about the future. If foresight can assist us to shape the future, it would be a very valuable tool. Freeman, Chief Corporate Economist ICI, argues that 'Foresight provides the ability to influence the future, rather than predict it' (UK OST 1995b).

ASTEC's study was designed to suit Australian conditions. It has several unique features. In contrast to international foresight studies, it viewed future needs through a broad social context. It was pragmatic, rather than comprehensive, in its selection of areas to study and choice of methodologies. It used an open, consultative and iterative process.

Based on outcomes of this study, ASTEC considers that foresight is a useful tool. It has revealed many benefits in enhancing communication and consensus. It increased people's confidence to face the future, and was generally perceived as a worthwhile exercise, able to contribute to strategic and long-term planning. We found it to be effective across a range of situations.

The ASTEC study provides an indication of some of the benefits that can be achieved from foresight. Analysis of international foresight studies, and corporate experience, suggests many other benefits ASTEC was not able to explore fully.

ASTEC has concluded that foresight is a valuable tool for Australia to use in considering S&T. It can be designed to suit individual circumstances and fit in with other priorities such as corporate planning.

Initially government support might be required to ensure there is widespread information available. But we believe foresight should become an integral part of the planning activities of Australian organisations of all types and sizes. This chapter further explores the benefits to Australia in establishing a National Foresight Program.

17.2. Unique Features of the ASTEC Study

One purpose of this study was to evaluate the usefulness of foresight in the Australian situation. Given the range of possible benefits indicated by international studies, and their admonition that it is only through engaging in foresight that the full benefits can be understood, ASTEC developed a 'pilot' foresight study.

The ASTEC study has several unique features designed to test the limits of foresight. We were interested in the extent to which foresight could be used to view future needs through a broad social context. The importance of a demand-driven perspective was clear from theoretical studies and analysis of international experience, yet has proven to be a virtually impossible task in practice. This is particularly important for 'small' countries like Australia.

> '... *to guess correctly the direction of technological advance thus involves guessing the future of technology itself and the changing patterns of people's lives.*'
>
> McRae, 1994

Our study was pragmatic, in its selection of areas to study and choice of methodologies. Prior to this, national foresight had generally been conducted on an economy-wide basis at considerable cost. This comprehensive approach was beyond ASTEC's resources, we therefore chose to specialise in a small number of areas. We combined a broad cross-sectoral overview, with a small number of more detailed sectoral studies. We used overseas studies to provide information on potential global developments in S&T.

The study is characterised by an open, consultative and iterative process, which was necessary to develop a broad picture of future needs for Australia in 2010. The credibility of the study rests on its ability to accurately reflect the diverse opinions of all Australians – government, industry, S&T experts and the broader community. Many of these contributions were from people and areas not traditionally perceived to have a direct interest in S&T.

The terms of reference of this study required ASTEC to engage in extensive consultation, encourage the collective identification of important themes, and increase awareness and understanding of foresight.

Further details on the terms of reference, study methodology, processes and timetable, and an brief description of the many sub-elements of the study, are provided in Appendix 2.

17.3. Benefits of the ASTEC Study

There have been a broad range of benefits from this study. ASTEC has used internationally agreed critical success factors for the foresight process, to evaluate the study (Box 17.1).

Box 17.1 The Critical Success Factors in the Foresight Process

Martin and Irvine (1989) neatly encapsulated the process benefits of foresight as the 'five Cs':

- communication — bringing together disparate groups of people together and providing a structure within which they can interact and communicate;
- concentration on the longer -term — so participants look more systematically into the future then they might otherwise;
- co-ordination — enabling different groups to form productive R&D partnerships;
- consensus — so a clear picture of alternative future directions and research priorities can be formed; and
- commitment — generating a sense of commitment to the results among those who will be responsible for implementing changes in light of the foresight exercise.

To these, a sixth has been suggested:

- comprehension – to encourage those involved to understand the changes happening in their business, or professions, at a global level, and to exert some control over these events.

Source: SmithKline Beecham 1994

It has improved communication by bringing together disparate groups and providing a structure within which they can communicate. The formation of the Reference Group, the creation of a database of interested groups and broad participation in the Partnerships, Roundtables and other consultations were all examples of this.

The study allowed constructive communication even on difficult or contentious issues because of the long-term timeframe. While people and organisations may take 'hard line' ideological positions about issues in today's world, they are more flexible about possible futures. In fact, they were often able to discuss the detail and advantages of alternative futures their current 'positions' would not comprehend.

The range of people and views represented was considered one of the best features by all who were involved. Those organisations on the periphery of the S&T system noted these were unique fora in that all views including those of non S&T experts were given equal weighting. The formation of Partnerships to study sectoral issues had the unexpected benefit of allowing the partners to act in a unified way on other issues not connected with the study.

The study forced individuals to concentrate seriously and systematically on the longer term, eg environment and genetics. This was enhanced by the development of scenarios for several of the Partnerships. ASTEC noted a widespread preference to focus on 'business-as-usual' scenarios with incremental change. This tendency highlights the need for structured processes to consider other possible futures. To overcome this, the Urban Water Partnership extended the time frame of the study from 2010 to 2045.

Foresight is considered to enhance coordination between groups on their future R&D activities. Partnership studies suggest that on-going collaborative activity is likely as an outcome. This will be due in part to foresight creating a measure of consensus on future directions and research priorities. ASTEC was often surprised at the degree of consensus which emerged on many issues, eg on the Key Forces for Change and the importance of access and equity considerations to future S&T developments. Foresight appears to provide an opportunity for implicit understandings to be made explicit, discussed and agreed.

ASTEC noted that this study generated a sense of commitment to the results among those who will be responsible for translating them into research advances, technological developments and innovations for the benefit of society, particularly in relation to the Partnerships. This commitment will be tested over the next few years as decisions on research and planning are made.

The I&CT Partnership found the process useful and suggested that the four scenarios developed through it could be used in the short-medium term as a context for government policy and strategy development by industry. They considered there was a need for a common basis for discussion of the future and that further use of the scenarios could assist this.

ASTEC was delighted by the overwhelming commitment of people and organisations across Australia to ensuring that this study was a success. This included substantial financial contributions from our Partners, as well as the many other people and organisations involved in Roundtables and consultations, who gave significant, often high level, support to the process generally at their own cost.

All people who provided feedback, through Response Sheets, thought that the process had been useful. The opportunity to engage in a structured process to consider the future was appreciated. Participants also noted that the opportunity to consider the future made them more confident about their ability to face it. This was particularly noticeable in the workshops in the Youth Partnership, which recommended that more young Australians be given the opportunity to explore the future in this structured way.

Partnerships studies were designed to provide information on various foresight techniques, and they show a range of interesting outcomes.

The Shipping Partnership used a Delphi survey, which was highly successful in gaining consensus and improving communication across a range of stakeholders. However difficulties with the Delphi process, similar to those found by the UK, suggest such surveys may require extensive infrastructure, such as the Japanese have established over the past twenty-five years.

Foresight is a skill that improves with practice. This initial study has raised awareness and will be a sound foundation for future foresight work.

17.4. Evaluating the Usefulness of Foresight

Foresight has received a range of criticism, some of it justified. However, the strongest criticism comes from basic researchers who appear unwilling to recognise or invest in undertaking social-based processes, and who see it as a further potential erosion of their right to set the questions. They also consider it impossible to predict how scientific knowledge will develop, suggesting that foresight is based on the now discredited linear view of innovation.

Although ASTEC considers strengths across a broad science base are essential for maintaining a long-term technological capacity, the importance of involving the broader community is only likely to increase into the 21st Century. Science cannot remain separate from society and expect to be highly valued by the community and industry.

ASTEC was concerned at the beginning of this study that many suggested foresight techniques were extremely resource intensive, in time and or money. Scenarios, in particular were said to take months. This appeared to exclude both senior management and smaller organisations from participating. Furthermore the field appeared daunting – dominated by jargon, high priced 'niche' consultants and specialists, and complicated procedures which required high levels of expertise.

In contrast, ASTEC is now able to report that foresight processes are very resilient. Even a short interlude to consider the future in a structured way can be useful in planning and provide many of the potential benefits outlined earlier. Whilst specialists are useful, particularly in developing scenario workshops and large scale foresight exercises, they are not essential.

This flexibility is demonstrated by ASTEC's Roundtables on Key Issues, which showed that a half-day structured process could produce valuable results, although more time would be required for detailed analysis of specific issues. Thus, carefully crafted exercises can ensure the benefits of participating in foresight are available to senior management and that small and medium-sized enterprises can also be included.

Despite the range of activities and large information base ASTEC developed as part of this study there are many aspects of foresight that ASTEC has not yet explored. Foresight has a range of potential benefits for many different groups. It can be done in many ways – at the sectoral level, in relation to specific technologies, as part of international collaboration, in the public and private sectors. There are many options to consider in developing a foresight program. Appendix 1 provides more background information on foresight and outlines some of the different options for foresight programs.

The Partnerships identified some useful guidelines for organisations wanting to undertake foresight. Guidelines for a Partnership Scenario workshop are shown in Appendix 2.

There is strong anecdotal evidence for the usefulness of international foresight work in both the public and private sectors. Shell in particular is seen to have benefited from the contemplation of alternative futures. However comprehensive evaluation of foresight studies are rare.

The latest evaluation of the Japanese Delphi (1995) found that about 70% of respondents to the survey had bought the NISTEP report for use in support of R&D and technology development or the formulation of business plans. Of these about 95% considered the information was worthwhile, with almost 59% rating it as extremely important and necessary. About 73% indicated they had found it useful or very useful.

NISTEP concluded that while it was difficult to evaluate the impacts of the survey their results suggest concrete influences on Japan's R&D activities, as well as on technology developments in general.

Recently the Science and Technology Committee of the UK House of Commons, in reporting on the foresight program in that country, concluded that 'the completion of the first stage of the Foresight Programme within two years was a remarkably impressive achievement'. The Committee was particularly impressed by the success of the initiative in creating networks of people who, without the program, might not have been in communication with each other. While it warns against using the foresight findings in too directive a way the Committee considered the infrastructure issues identified by the sector panels and the Steering Group are most significant.

In a similar vein the Australian House of Representatives Standing Committee on Industry, Science and Technology recently (1995) concluded that:

> *'the Australian Government should closely study the various foresighting methodologies and the experience of other countries with them. There is a need for Australia to use such studies to help provide better direction to R&D investment both in the private and public sectors. Foresight analysis has the potential to greatly enhance Australia's innovation performance. The information and analysis provided by a foresight program is essential to the decision-making process that allocates resources between competing interests.'*

HoR 1995

The Committee recommended that the Government make a commitment to introduce technology foresight following the completion of the ASTEC study, to adequately fund such analysis on an on-going basis, and to disseminate the findings widely to industry and research institutions. They also argued that technology foresight should involve a high level of consultation with industry, researchers and community groups.

Through this study ASTEC has become convinced of the power of foresight as a tool to consider longer term futures. It has proven useful, not only in promoting consideration of the longer term, but also in building communication and consensus, and ensuring S&T is focused on 'needs'.

Therefore, ASTEC believes it is valuable for Australia to adopt a national foresight program, the features of which will be discussed below.

17.5. Foresight and National Vision

Australians have a strong interest in their future, one that is broader than S&T. S&T needs to be drawn together with other perspectives if Australia is to develop comprehensive future strategies.

There is a widespread desire for a strategic vision for Australia. This has emerged through a range of processes. Australians believe that if strategic vision is creative and far-sighted it can help organise and focus a nation's efforts and facilitate achievements not otherwise possible.

Australia is in a period of change. Change has increasingly challenged the framework of national life. And in recent years the pace of that change has measurably accelerated – in crucial areas such as cultural diversity, economic restructuring, internationalisation and aboriginal reconciliation. Australia has come a substantial way down the path of reform. But there is still much more to be done.

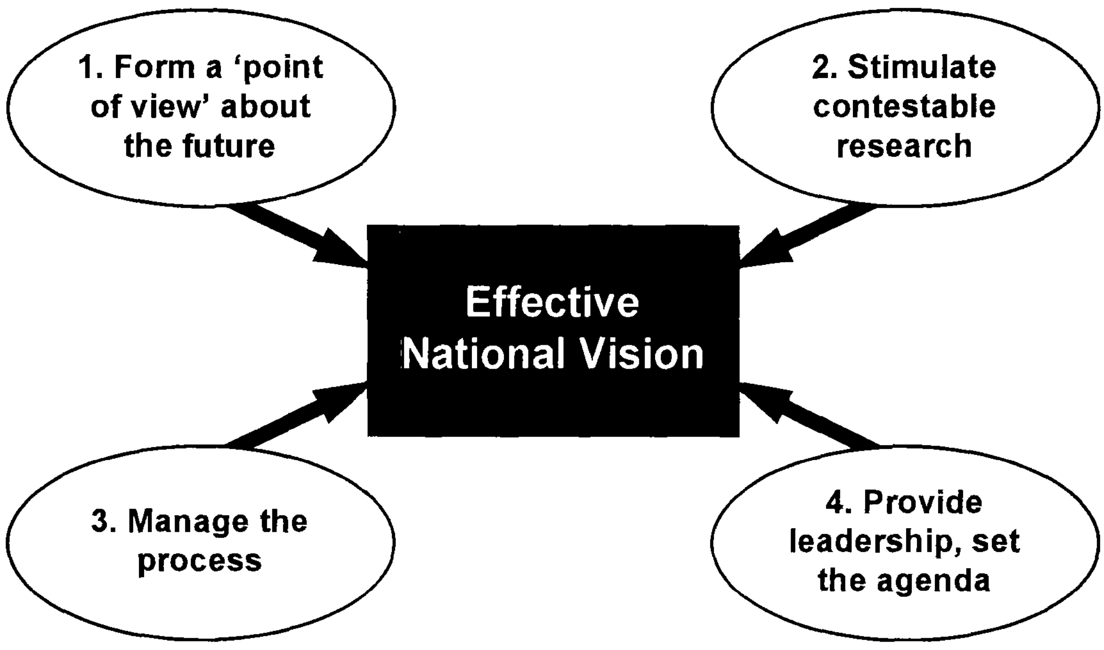
At the threshold of a new century there are important choices to be made which will shape our future. Australians consider these are not choices for leaders or governments alone.

It has been argued that Australia as a pluralist society would derive little benefit from the economic planning popular in developing countries. Neither do Australians expect to have such a process imposed on them. But as evidenced by their enthusiastic participation in this study they want a structure within which to discuss the issues of tomorrow.

People enjoyed the opportunity to consider the future and believed this should be extended to issues broader than S&T. The opportunity to discuss and consider the future appears to 'empower people', allowing them to build the confidence that they will be able to satisfactorily manage the changes ahead. The concept of alternative futures was well-liked.

A framework for developing an effective national vision has been suggested by Carter and Pappas (1995). This is illustrated in Box 17.2. It indicates that the first crucial issue is to form a 'point of view' about the future. It is at this crucial first stage that foresight can play a key role. To be successful, a broad national process to build 'a sense of national vision' would need to be based on foresight and the consideration of alternative futures. This study has shown that developing a view of the future based solely on a 'preferred future' will not be sufficiently robust to accommodate the uncertainties of rapidly changing circumstances.

Box 17.2. Framework for Establishing a National Strategic Vision



Source: Carter and Pappas 1995

In addition a national vision process would require a transparently public and open process. It would need to be both an opportunity for an exchange of ideas between sectors and interests, and for the community to speak to Australian governments and decision makers. If decisions are to emerge from the process, then the process itself should be informed, public and open to widespread participation.

Australians have a strong commitment to preparing for the future – a commitment that at this stage cannot be implemented. ASTEC considers the Commonwealth Government must take a leadership role in developing an ongoing national dialogue on preferred futures for Australia which:

- takes account of our pluralist society and goals of being creative, productive, inclusive and ecologically sustainable;
- is based on developing and understanding possible futures and building broad agreement to preferred futures;
- is built on the outcomes of sectoral processes such as that of the BCA and the Visions Group process;
- is flexible, inclusive and open particularly ensuring the inclusion of young people;
- is a basis for real change with effective linkages to feed into Commonwealth Government policies and programs; and
- involves the media, through enlightened self interest in developing this vision.

In the longer term ASTEC believes a future-oriented, Australian community is achievable and that the Commonwealth Government in partnership with industry and the community can bring about a change to ensure longer term futures are an integral part of the culture of national decision making.

Part of this national broad vision building process must focus on S&T.

17.6. An S&T Foresight Program for Australia

As part of this study, ASTEC requested views on the most appropriate national S&T foresight program for Australia. We received a range of ideas and opinions, from experts in a number of areas of research and industry, especially through a questionnaire in the 'International Perspectives' report (see Box 17.3). Respondents were asked to indicate their area of expertise and to identify whether the issues might have specific relationships to certain fields.

Box 17.3. Issues in International Perspectives Report

As part of this study, ASTEC requested views on the most appropriate national S&T foresight program for Australia. The issues addressed were:

Issue 1: Are the results of overseas foresighting activities important to current research and future developments in your area? Could a country obtain a competitive advantage by systematically considering the future? How could foresight better enable Australia to secure the maximum benefits from its investment in S&T.

Issue 2: Do you think the Critical technologies approach is useful? If so, how and when? A comparison of the results of seven different studies from US, Germany, Japan and the European Union reveals a high degree of consensus about the broad headings. How relevant do you consider the technologies identified by these studies are to Australia?

Issue 3: A critical issue in Delphi is the generation of the forecast questions. These predetermine the range and detail of topics and therefore the extent of the survey. Given this limitation do you think the Delphi survey technique is useful? If so, how and when? Some key findings from the most recent Delphi survey are provided in this report. Do you agree with the findings, particularly in your area of expertise?

Issue 4: Developing and managing an appropriate balance between supply and demand is considered to be an important criterion upon which the success of a foresight exercise can be judged. ASTEC has chosen to use a foresight model which stresses demand factors. A different balance may be appropriate if Australia makes an ongoing commitment to S&T foresight. In your area of expertise, what is the most appropriate balance between supply and demand to 2010?

Box 17.3. Issues in International Perspectives Report (cont'd)

Issue 5: In the longer term, targeted studies in particular areas may be most appropriate and cost effective. If so, how should the areas for detailed study be chosen? What criteria are the most important? How could we ensure interdisciplinary and newly emerging areas are given adequate consideration?

Issue 6: The current ASTEC study seeks to involve not just S&T experts, but also government, industry and the broader community. In your area of expertise, what is the most appropriate level of consultation to match S&T to future needs? If you believe broad consultation is appropriate, who should be involved? What could these people/organisations contribute? What might be the most effective mechanisms?

Issue 7: ASTEC chose a 15 year time horizon for this study in order to maintain a realistic basis for discussions of future needs. If there was an ongoing commitment to foresight some areas may benefit from a longer or shorter time frame than fifteen years. In your area of expertise what is the most appropriate time frame over which to consider the future? In your area of expertise, how often do you think foresight exercises should be repeated to provide an accurate picture of future developments?

Issue 8: The current ASTEC foresight study is designed to incorporate Australia's needs within a global context. What specific national characteristics do you think should be taken into account by ASTEC in this exercise? If Australia was to conduct foresight on an ongoing basis, would there be value in Australia's participation in an international exercise eg the extension of the Japanese Delphi? Could it be used as the basis for a more limited Australian exercise?

Issue 9: The ASTEC study is seeking to involve industry as a key player. How best could industry contribute to the ASTEC study? What benefits would there be for industry? What special issues/priorities should be taken into account to ensure the most effective industry involvement? Is there ongoing potential for industry involvement in foresight exercises? What are the particular advantages and disadvantages to industry of foresight conducted at a national, regional, sectoral or organisational level?

Source: ASTEC 1994c

The results of this survey show that overseas foresighting activities are considered important to current research and future developments in various areas and that a country could obtain a competitive advantage by systematically considering the future. All responses considered the results of foresight activities were important although found this difficult to quantify.

In particular, the fields of minerals processing, joint planning for universities, S&T education, design, population, pollution, finance, rates and manner of moves to sustainable development, molecular genetics, wholesale patenting of genes, food industry issues, education and social sciences, and innovation were identified as benefiting from clear advice of overseas foresight activities and outcomes.

Some saw this as 'knowledge of overseas targeting decisions' which will help Australia to generate spin-offs or confirm the wisdom of our 'niches' in relation to market opportunities.

Although most of the technology comes from overseas, Australia has special priorities and expertise not developed elsewhere and these must be taken into account. Systematic consideration through foresight would also need to take the past and the present into account to ensure it was realistically building new strengths.

Support is indicated for broad futures studies at a high level – national or regional, as well as detailed activities at a sectoral/firm level. Australia must adapt foresight and research to suit our size and distinct strengths in sub-components of overseas critical technology categories. Foresight might also help identify potential collaborations.

It was generally agreed that demand should be the emphasis of foresight to take account of the socio-economic context of S&T. There was strong support for foresight processes with broad representation. Most suggested that it should be at an expert level, and that it reflect supply and demand – but particularly involve research, industry and community. There was support for specific questionnaires and surveys.

There was strong support for wide industry involvement (large and small), together with input from other parts of the S&T system, through a variety of mechanisms, ranging from current industry groups and CRCs to new committees or institutional structures, such as a CRC devoted to foresight.

The identification of critical technologies was seen as most valuable to industry. Mineral processing and food processing were put forward as examples of areas in which it could be most useful. European focus on minerals processing was supported as was the high priority for composite materials and IT. It was noted that this technique did not cope well with the unexpected eg Fullerenes, and that the 1986 DIST effort to identify critical technologies and promising areas for research had failed.

There was support for a variety of foresight approaches, including scenarios, Delphi and critical technologies. Delphi techniques were seen as particularly useful in identifying global research directions, but need to be balanced by sensible non-expert opinion. It was suggested that the greatest potential may be in scenario analysis. Benefits from the combined use of multiple techniques were acknowledged. It was agreed that different methods have advantages, but that across all areas there was a need to involve customers as well as scientists and technologists.

In general there was support for a regular cycle of foresight with a longer term perspective (10 years plus), similar to ASTEC's current 15 year timeframe. Responses also indicated a number of Australian specific features which need to be taken into account in foresight processes- most notably weaknesses (such as a relatively small manufacturing base) and a resulting need for caution. However, support was expressed for Australian involvement in international foresight exercises, where the gains were likely to outweigh any potential disadvantage.

17.7. A National S&T Foresight Program

ASTEC has done a lot to make individuals and organisations aware of the value of foresight and to engender a generally positive feeling about it in the S&T community. But there is a big gap between awareness and cultural change. The S&T community has barely started to consider foresight through the ASTEC exercise and will need assistance and support to make a change.

It is worthwhile noting that, of more than one thousand people questioned as part of the ASTEC study, less than 2 per cent had previously undertaken foresight but everyone considered it worth doing more often. The CRC's in particular have shown a great deal of interest and support for ASTEC in its consideration of foresight and the role they could play in promoting a longer term culture should not be ignored. The ARC and CSIRO have also developed considerable expertise in this area and will be very useful in promoting cultural change.

Recognising that Australia has a pluralist S&T system a national S&T foresight program must embed the consideration of longer term possible futures into the planning processes of organisations such as:

- Commonwealth Science agencies (eg CSIRO, Great Barrier Reef Marine Park Authority), and other research agencies (eg Defence Science and Technology Organisation, Rural R&D Corporations) and Commonwealth funding agencies (eg Australian Research Council, National Health and Medical Research Council) to ensure they consider future trends and challenges in their priority setting processes;
- industry organisations, large and small companies to encourage them to include foresight as an input to their strategic planning processes;
- Commonwealth departments to ensure they consider longer term needs and possible futures in setting priorities for their S&T activities; and
- education institutions at all levels to consider how they might build foresight skills as an integral part of their education processes.

The Commonwealth Government needs to consider the most appropriate mechanism to take on-going responsibility for oversighting technology foresight in Australia including whether an existing institution could take on this role.

Foresight will not become common in Australia without Government assistance at least in the short-term. At least initially Australia will need an institutional structure to foster this longer term perspective. There are useful overseas examples of different structures for S&T foresight:

- in Japan the long-term commitment to foresight has led to the National Institute for Science and Technology Policy (NISTEP) devoting substantial resources to a long-term foresight program – NISTEP is a statutory authority at arms length from government;
- the United Kingdom established a number of sector-based Panels for the first foresight program, which they now wish to continue – this was overseen by a main panel and supported from within the Office of Science and Technology;
- the United States has mandated biennial investigations to be undertaken by a small National Critical Technologies Review Group supported by the Office of Science and Technology Policy in the Office of the President; and
- the Netherlands has established an Independent Foresight Steering Committee, within the Ministry of Education and Science, to shape and supervise the foresight process as well as providing advice to the Government on the issues involved. It does not itself undertake foresight activities but provides a general framework within which others can do so.

As set out previously ASTEC is convinced that it is critical to ensure that the advice of international studies on potential global trends and developments in S&T is disseminated in Australia. The first priority is to build a detailed knowledge of potential global trends and developments in each sector and related area of S&T. This can be used to open up channels of communication and information, ensuring that the outcomes of other studies are available to groups in Australia in an easily accessible way.

This sectoral foresight experience could be organised in many ways. For example, the formation of industry/sector panels to run workshops/seminars at which the results of overseas foresight activities relevant to a particular sector could be discussed. Initially these could be conducted in the areas of the UK sectoral panels and key members of the UK studies could be brought to Australia to discuss outcomes with sectoral representatives. There may be other more appropriate fora or processes.

ASTEC believes that a national foresight program should have the following features in the longer term. It should be:

- set in the context of broader national discussions of preferred futures to ensure that S&T remains relevant to broader national economic, social and environmental goals;
- embedded into normal operations as part of the culture of organisations in the Australian S&T system – linked to strategic planning processes, and providing input to priority setting;
- linked to international S&T foresight initiatives, and facilitating widespread knowledge of the outcomes of international exercises;
- building on existing Australian foresight initiatives and experience eg CSIRO, ARC;
- based firmly on demand, involving the broader community and taking into account the broader social context, including ethical issues;
- widely publicised with information freely available and contacts between groups encouraged;
- targeted to suit the needs of particular groups and issues/sectors; not unnecessarily constrained by existing methodologies or locked into particular structures and with a time frame to most appropriately scope the task; and
- recognised as an iterative process that must be repeated to take account of new information and changing priorities.

Over the last 18 months, ASTEC's expertise in foresight has been sought by other organisations wishing to commence their own foresight. Information on foresight is relatively hard to find, and it takes considerable effort to understand the vantage points of the various groups involved. Foresight is a relatively new area of interest which combines a number of previous skills – scenario development, trend analysis, Delphi etc., within a new framework. The advice provided to organisations from existing experts may reflect traditional areas of expertise which is not always suitable for the task at hand.

ASTEC is only too well aware that it is a daunting task to commence foresight with no previous experience.

ASTEC has assisted many organisations by sharing our experiences and lessons we have learnt. These organisations ranged from Commonwealth departments to community groups, and were interested in issues ranging from agriculture to criminal activities. These organisations benefited from the opportunity to discuss their objectives, the full range of foresight techniques, and failures and successes in other organisations, with an adviser with no special interest in particular techniques.

Without this support and encouragement many organisations may have found foresight too difficult to undertake or have wasted resources on techniques unsuited to their purpose. This function of general advice must be maintained and enhanced if foresight is to become more widespread. It is more efficient if information is freely available and organisations across Australia are able to learn quickly – not forced into 'reinventing the foresight wheel'. This is a role for government.

Furthermore, it is an expertise that will be required more broadly in government. To develop a forward looking national culture will require a strong national capacity to integrate longer term issues in decision-making, in a climate of 'possible future options'.

A critical part of any foresight program is the so-called 'Pre-foresight' stage. It is important for organisations about to embark on foresight to give sufficient time and resources to this stage, to ensure that preparations and data gathering are adequate. The UK House of Commons Committee noted that the speed with which the recent foresight program was accomplished in that country led to some flaws in the process. The Australian House of Representatives report recommended that the government 'adequately fund' foresight analysis on an on-going basis.

The Commonwealth government can demonstrate leadership in this area, by requiring departments and agencies, including R&D funding agencies, to establish mechanisms to test policies and programs against long-term trends; to develop long-term plans and report on progress against these as part of their annual reporting within a long-term framework and to encourage the participation of State governments through developing a longer term focus in the Council of Australian Governments.

Agencies could use the ASTEC key forces of change – *Global Integration*, *Environmental Sustainability*, *Applying I&CT* and *Advances in Biotechnology* – as a starting point for their own more detailed work on critical trends most appropriate to their own areas.

It is equally important that industry adopts a longer term futures approach. To build competitive Australian businesses into the 21st Century will require high levels of innovation and competitiveness. A forward-looking approach is critical to successful innovation, which seeks to obtain future profits from innovative investments today. Businesses can benefit from exploring foresight and linking it to innovation plans. Overseas, foresighting activities are considered important to current research and future developments in various areas, and countries are seeking to obtain a competitive advantage by systematically considering the future. We must ensure that we are aware of such developments, and further investigate the six generic critical technology areas in an Australian context.

The value of sectoral foresight studies was highlighted by overseas foresight and by ASTEC's Partnerships. ASTEC considers that work of this type can bring benefits to Australia. In particular, there could be real benefit from an industry-driven program, with minimal Government facilitation, to investigate Australia's future competitiveness in a number of key industry sectors identified in this study, such as Agri-industry.

It is important that any program for S&T foresight is set within a broader perspective. The need has emerged for a national process for Vision and Planning – to help realise the preferred futures for Australia as a creative, productive, inclusive and ecologically sustainable nation.

Australia has special priorities and expertise not developed elsewhere and these must be taken into account. Systematic consideration through foresight, taking account of the past, the present and the future can help ensure that we take a realistic approach to building on strengths and meeting our future needs, including making the best use of all available technology.

Managing and adapting to change can be a difficult process. Foresight helps people to understand the nature of change and to place it within a comprehensible framework.

Area for Action:
A National Program of S&T Foresight

ASTEC considers that foresight can help provide better direction to R&D investment and has the potential to greatly enhance Australia's innovation performance. The information and analysis generated by foresight can contribute to more effective decision-making and resource allocation.

To build a national capacity for foresight will require a broad ranging program facilitated by the Commonwealth Government, particularly in the initial development of a skills base and the provision of infrastructure. Government, industry, research and educational organisations, professional societies, peak bodies and community groups will need to be encouraged to undertake, or be involved in, foresight exercises.

ASTEC suggests that to carry foresight forward, support will be required to:

- *develop expertise and a skills base in foresight and to provide expert advice on the conduct of foresight studies;*
- *disseminate widely the outcomes of international foresight studies to relevant organisations in Australia; and*
- *promote discussion of the implications of foresight for Australian industry, the economy, society and research.*

Each body must make its own decision about the extent of its use of the foresight process in its strategic planning and organisational development, and what management actions should follow. However, there is great value and importance in ensuring that the learning and the outcomes are more widely shared. This could be reinforced by requiring all government and publicly funded organisations to report on their strategic plans and the use and outcomes of foresight analysis. Secondly, an annual forum could be established, as a mechanism for dissemination of learning and encouragement for the adoption of foresight processes.

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Appendix 1 More about Foresight

This appendix provides more information about the processes used in foresight. It is intended to provide enough information on the more technical aspects of foresight to assist non-experts to understand foresight and even to plan their own study.

It examines what foresight is and the main elements of a foresight process. The emphasis adopted is for applying foresight to strategic priority setting. In this context it is important to learn from international experience, and discussion throughout draws upon the lessons of a variety of studies.

a) What is 'Foresight'?

Foresight is a very broad concept. This is illustrated by the Macquarie Dictionary, which defines 'foresight' as: 1. care or provision for the future; 2. the act or power of foreseeing; and, 3. perception gained by or as by looking forward. Foresight is therefore about perceiving the future and taking account if it. The motivation for undertaking foresight is therefore to make us better prepared for the future, and to help us shape the future by developing effective and realistic strategies.

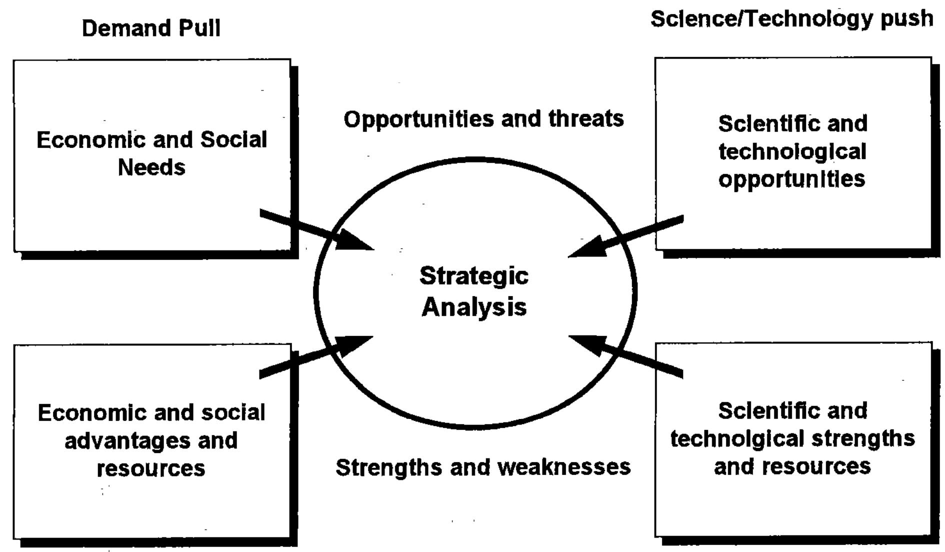
Foresight also refers to the growing field of science and technology or research foresight. This field seeks to use various types of information about prospective scientific, technological and other developments as inputs to decisions on priorities and research directions. It seeks to factor-in possible economic, social and environmental contexts to S&T investment decisions. It focuses attention on both the possible implications of prospective S&T developments for policy, and the implications of policy for prospective developments in S&T.

This approach has been encapsulated in Box A1.1, which presents what are considered to be the essential ingredients of a foresight exercise (eg Martin and Irvine, 1989). Most notably, foresight is a strategic analysis. It uses information from both science and technology push (eg technological forecasts) and social and economic demand-pull (eg market trends and potential needs). Foresight considers opportunities, threats, strengths and weaknesses. It is an exercise in judgement.

Foresight is an area of experimentation. It has clear application in planning for strategic research and technology development. Martin and Irvine suggested that the scope for formal foresight techniques is greatest in evaluating on-going socio-economic needs for research, ie, in strategic fields linked to industrial technologies or R&D aiming to meet longer term challenges in areas like health or the physical environment. From this view it is particularly useful for public sector strategic research organisations and industry.

Many of the methods of foresight had their origins in technological forecasting and assessment. This field developed its modern form in the 1950s and 1960s through work in Rand Corporation for the US defence sector on Delphi surveys and scenario analysis (eg Herman Kahn). Such forecasting tools have subsequently been taken up by private companies, such as Royal Dutch/Shell (eg Pierre Wack), and by government agencies such as the Japanese Science and Technology Agency.

Box A1.1. Essential Ingredients of Foresight



Source: Martin and Irvine 1989

However, despite its promise the first phase of technological forecasting fell into disrepute in the 1970s and 1980s following its failure to accurately predict outcomes. This was graphically illustrated by Schnaars in *Megamistakes* (1989) who estimated that nearly 80 per cent of business and product forecasting over the preceding three decades had been wrong.

Recent interest, however, has a different orientation. It has grown in response to a number of factors including the rising costs of research at a time when we are becoming aware of many opportunities from the application of science and technology. There is a strong perception that choices have to be made, and research priorities selected. More and more funding bodies are beginning to develop more explicit funding priorities and strategies. Further, many decisions involving investment in S&T have long lead times. These indicate that having an informed view about the future might b a considerable advantage in directing investment and avoiding costly mistakes.

The foresight approach, unlike forecasting, does not attempt to estimate or predict what the future *will* be. Foresight provides the opportunity for researchers and others to 'rehearse' alternatives for their own future. It looks toward potential S&T developments and impacts in the context of evolving research needs.

Foresight assumes that actions taken today, whether or not consciously taken with long term perspectives in mind, will shape the future. Further, it recognises that many aspects of the future are beyond our control. It is therefore a process which is intended to explore internal and technical changes in the context of evolving external events and needs. It provides an opportunity for organisations to think seriously about significant technical trends and their relationship to socio-economic needs.

Within this general view of foresight, there are many purposes for which it can be used. A currently accepted working definition of technology foresight is:

> *'systematic attempts to look at the longer term future of science, technology, economy and society with a view to identifying emerging generic technologies likely to yield the greatest economic and/or social benefits.'* OECD 1996

This emphasises the potential of foresight to assist researchers and those making public investments in research to identify new technologies with particularly high long-term benefits for society, or that help meet societal goals in the longer term. Under this definition a direct link between foresight and priority-setting is to be expected.

International experience has shown that there are a number uses for the outputs and results of foresight that go beyond this definition. These include to:

- identify fields and targets regarded as important in the long-term (up to 30 years);
- set priorities within broad fields of technology (eg, within I&CT or biotechnology);
- set priorities between broad fields of science and technology (eg, between biology and engineering); and
- identify fields of 'technology fusion' which may be overlooked because they fall across or between administrative or discipline boundaries.

International experience has also revealed that foresight can have other important benefits. The *process* benefits of foresight are often cited as being as critical. Involvement in foresight can overcome vested interests, expand the mind-sets of participants, and help participants develop new strategic perspectives on research activities and user needs.

These aspects of the foresight process have been summarised as 'the 5 Cs': (eg Martin and Irvine, 1989)

- *communication* – bringing together disparate groups of people together and providing a structure within which they can communicate;
- *concentration* on the longer-term – forcing individuals to concentrate seriously and systematically on the longer term;
- *co-ordination* – enabling different groups to co-ordinate their future R&D activities;
- *consensus* – creating a measure of consensus on future directions and research priorities; and
- *commitment* – generating a sense of commitment to the results among those who will be responsible for translating them into research advances, technological developments and innovations for the benefit of society.

In view of the apparent diversity if foresight exercises, eg from national-level bodies to individual companies or research agencies efforts have been made to develop a classification system. The typology developed by Martin and Irvine (1989), which is based around seven dimensions each with a range of values, provides a very useful framework.

Using their typology ASTEC's study can be classed as a long-term, holistic, national-level exercise with an emphasis on demand-pull, stressing the functions of direction setting, anticipatory intelligence and communication and education. It did not seek to identify specific technological areas for priority or selective attention. Rather, it sought to provide an information base and useful insights for strategic long-term S&T planning. ASTEC's study, therefore had an emphasis on developing a foresight process for strategic planning.

Recognition of the diversity possible in foresight exercises illustrates that it is more than the application of some specific techniques. Foresight requires the design of a process that is specific to the needs of core participants. It would be unrealistic to expect all potential objectives of foresight to be achieved in one exercise using one methodology. It is important to decide which of the various possible objectives have the highest priority and design a methodology to achieve those specific objectives.

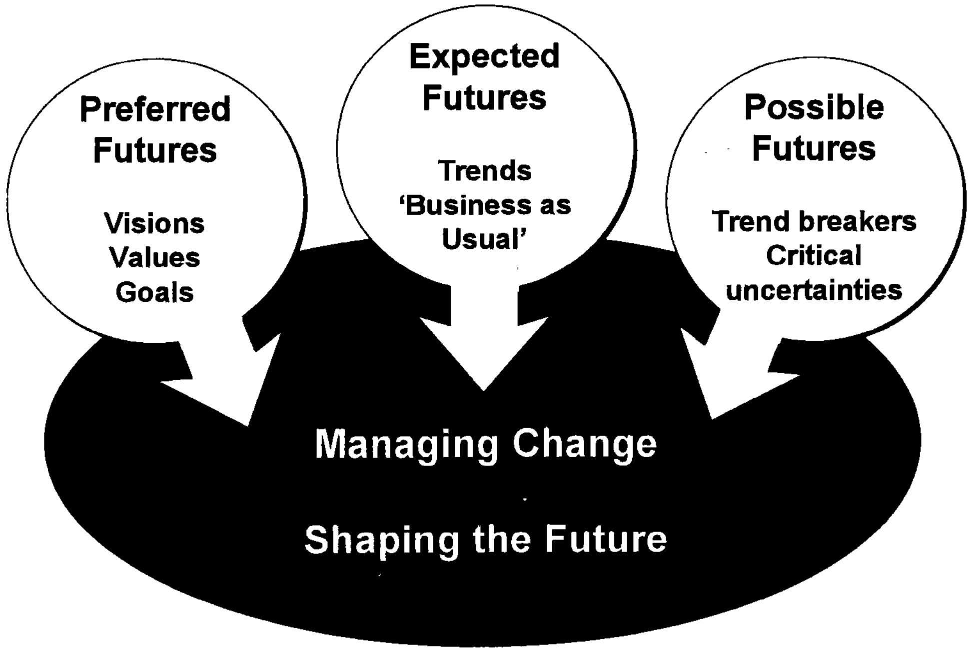
There are many possibilities for adopting or adapting overseas approaches, and for using the results of their work. In recognition of Australia's national and regional circumstances Australians need to adopt foresight in a manner that is appropriate to our institutional and industrial structures, our society and environment.

ASTEC built on the lessons of previous international and Australian experience, explored appropriate methods, and sought to draw upon 'futures' thinking in general.

A broad approach was adopted, and rather than attempting to identify specific technologies ASTEC emphasised building of pictures of the 'demand context' for science and technology over the next 15 years. The emphasis was on how to develop strategies to manage uncertainty more effectively, and to promote organisational learning. The development of such contexts gave scenario analysis a more prominent role than some other foresight exercises. Scenarios are also help assist one of the most important aspects of foresight – its broad consultative nature, in particular the involvement of both users and producers of research.

There are two main approaches to thinking about the future: exploratory forecasts – beginning today and extrapolating future possibilities, and normative forecasts – beginning with a future goal and working backward to the present. ASTEC's approach suggests that exploratory forecasts come in two main types. That is, those concentrating on expected futures (derived from business-as-usual and extrapolation techniques), and those looking to possible futures and exploring the dimensions of uncertainty (eg scenario analysis). Strategies to manage uncertainty require consideration of both types of exploratory forecast to ensure a robust context is placed on normative goals.

Box A1.2. ASTEC's Approach



Source: ASTEC

ASTEC's approach is summarised graphically in Box A1.2 (see also Box 1.2), which shows the combination of information and opinion to build perspectives on:

- *expected futures* are the analyses of experts based on current trends and extrapolations;
- *preferred futures* are those we as a community want to achieve – individual values, strategies of corporations and community organisations, and government policies; and
- *possible futures* provide a range of options for a world which might change significantly over time – focusing on critical uncertainties and trend breakers.

Looking to the future in this way requires combining trends (expected futures), scenarios (possible futures) and visions (preferred futures), as a means to better strategies (ie planning to link expected, possible and preferred). Often these ways of looking at the future are seen as separate fields or distinct strands in futures thinking. Each approach is traditionally associated with different primary objectives, roles, tools practitioners and organisations, eg Box A1.3.

Box A1.3. Traditional views on futures thinking

	Preferred	Expected	Possible
Objectives	educate, win support, guide choice	analyse, evaluate, systematise	open up, alert, stimulate
Roles	value-driven	analytically-driven	image-driven
Tools	participative	structural	perceptual
Practitioners	leaders, reformers	analysts, modellers	visionaries, 'special' individuals
Organisations	advocacy groups	'think tanks'	individuals

Source: after Amara, R 'The Futures Field', Institute for the Future, Menlo Park California, 1980.

Foresight suggests that robust strategies require the creation of a dialogue between the three strands of futures thinking. Foresight explores evolutionary trends and detects early warning signals of the 'unexpected', and it involves agreeing on preferred outcomes. How such a dialogue takes place in practice through foresight is an evolving process. At present processes tend to rely on qualitative techniques, however, it is likely that in the future more quantitative methods will be widely used – perhaps using software systematisation.

For those considering undertaking a foresight exercise, a suggestion for a generic view of the main steps involved is shown in Box A1.4 (see also Martin and Irvine 1989 for an outline of a process with priority setting objectives). The accepted approach to undertaking foresight is to use a three stage approach:

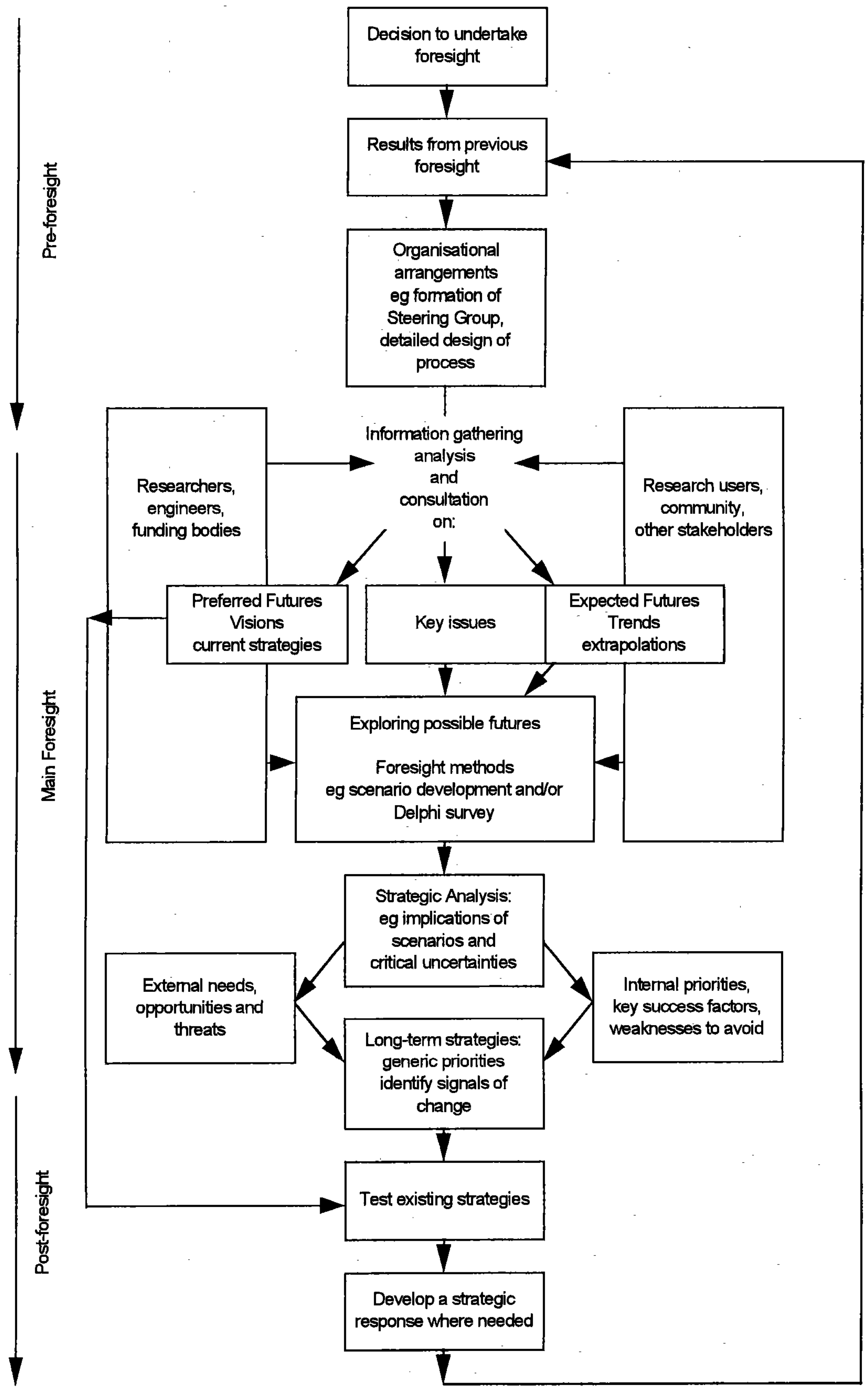
- a pre-foresight – to organise the process, clarify details and involve participants;
- a main foresight stage – to undertake data gathering and analysis; and
- a post-foresight – to disseminate results and implement decisions.

The pre-foresight stage begins with the decision to undertake an exercise. Preliminary preparations, including the formation of administrative and organisational arrangements for the process are then undertaken. Important among these is the formation of a Steering Group to design and guide the process. It is important to take account of previous foresight exercises, both in terms of design and findings so that organisational learning can be maximised.

The main foresight stage begins with gathering information for background papers. This will include gathering forward-looking information on perceptions about important long term issues, visions and current strategies, and trends and expected futures. This provides a sound base of information for subsequent steps. Information gathered on current strategies and visions can be re-injected later in the final strategic review stage. A set of open-ended questions developed by Anderson (1994) can be used as part of this initial stage.

The next phase is to explore possible futures through a main foresight process. Scenario analysis provides a useful approach, as it draws upon information on a variety of trends. Some underlying trends will be 'pre-determined factors' – likely to be similar across a number of plausible futures. Other trends and issues are more uncertain, and it is upon these that scenarios will eventually focus. That is, scenarios focus on the dimensions of 'critical uncertainties' – factors that are both very important to outcomes and very difficult to predict.

Box A1.4. Stages in foresight for strategic planning



Source: ASTEC

Information on key issues can also inform the degree of importance that can be attached to uncertainties. Scenarios are constructed by laying out sequences of plausible events, including actions and re-actions, focussing on critical uncertainties over a pre-determined time period, say 15 years. The scenarios are not intended to be predictions, and the eventual outcome will not be like any of the scenarios. The real future will probably contain elements from each scenario. The purpose is therefore to highlight critical factors, trends and forces for which strategic preparedness is needed. Scenario analysis and a number of foresight methods are discussed below.

The final stages are to undertake a strategic analysis of the findings. A number of approaches are possible. For example, one is to explore the scenarios by 'leaping forward' into the worlds that they imply and to explore their implications for S&T or other factors. Returning to the present these alternative contexts can widen perceptions of external opportunities and threats, and focus attention on internal success factors and weaknesses to avoid. Important outcomes are the testing of current strategies in the context of each scenario, and then determining steps to achieve visions or preferred futures. In this way areas where change is desirable can be identified, and better strategies formulated to link preferred and possible futures in the post-foresight stage.

b) Important foresight tools

There are a number of important foresight tools that can be used in the main foresight stage. International experience has demonstrated that the choice of methodology is not a critical issue, and there is no single preferred technique for foresight. However, it is possible to distinguish advantages and disadvantages between various techniques. This section briefly discusses the uses, advantages and disadvantages of the two main foresight tools 'Delphi' surveys and scenario writing. It is not intended to be comprehensive. Rather, it illustrates these important techniques in the context of the experience of countries where they have gained prominence.

Readers attention is drawn to a summary of international foresight experience: *Matching Science and Technology to Future Needs: An International Perspective* (ASTEC 1994c), which provided a summary overview of important international foresight exercises to that time. More detailed information on techniques can be found in other sources, such as:

- Millet, S M and Honton, E J (1991), *A manager's guide to technology forecasting and strategy analysis methods*, Columbus Ohio, Battelle Press.
- Martino, Joseph P (1983), *Technological forecasting for decision-making*, 2nd edition, North-Holland, New York.

Reviews of international experience include, for example:

- Martin, Ben R, and Irvine, J (1989), 'Research Foresight', Pinter Publishers, London.
- NISTEP and Fraunhofer Institute for Systems and Innovation Research (FhG ISI) (1994), 'Outlook for Japanese and German Future Technology: Comparing Japanese and German Technology Forecast Surveys', Science and Technology Agency, Tokyo.
- OECD, (1996), 'STI Review: Special Issue on Government Technology Foresight Exercises', No 17, OECD Publications, Paris.
- UK Cabinet Office (with the Office of Science and Technology and the Office of Public Service and Science) (1993), 'Research Foresight and the Exploitation of the Science Base', HMSO, London.

i) Delphi Surveys

An important component of foresight is to define expected and possible futures for science and technology developments through exercises that focus on 'technology forecasts'. One technique widely used for this is the Delphi survey approach. This technique is a specialised methodology of technology assessment which obtained quantitative and qualitative data.

Delphi surveys allow groups of experts to be consulted on a range of possible future developments in their respective fields. The questions include such issues as the expected time of realisation of the development, and demand and supply variables connected with the development such as ranking of importance, and other factors including technical, institutional, cultural, cost and funding constraints, or the need for international collaboration etc. An example of the appearance of a Delphi survey question is shown in Box A1.5.

Box A1.5. A Delphi Topic Statement – ASTEC Shipping Partnership

Topic Statement		Degree of impact 2010		Period within which the event / development will have first occurred					Necessity of collaboration				Australia's current position versus other countries												Constraints on occurrence in Australia									Comments
													Scientific & technological capability			Innovation capability			Production or service delivery capability			Expoitation & Commer-cialisation potential												
	Degree of expertise (1-5)	Wealth creation	Quality of life	1995 - 2000	2001 - 2005	2006 - 2010	2011 and beyond	Never	None	Within Australia	APEC	Global	Australia at leading edge	Australia average performance	Australia lagging behind	Australia at leading edge	Australia average performance	Australia lagging behind	Australia at leading edge	Australia average performance	Australia lagging behind	Australia at leading edge	Australia average performance	Australia lagging behind	Social / ethical acceptability	Technological feasibility	Technology transfer	Industrial / commercial	Lack of funding	Economic viability	Standards	Regulatory / Policy	Commonwealth State issues	*for example, amplifying response as necessary eg event times, collaboration features or other contraints*
Surface combatants capable of hybrid amphibious operation with speeds in excess of 50 knots have been developed.																																		

Source: ASTEC 1996c

The Delphi technique was first designed by RAND in the US in the late 1940s for military purposes. It originated as a method for obtaining expert opinion by a structured communication process. Its use in technology forecasting became public in the early 1960s.

Delphi has four main characteristics: anonymity (no physical contact between participants), iteration (several rounds), controlled feedback (the results of the previous round are provided to respondents), and a statistical presentation of the group response (average and spread).

Typically, the main steps in a Delphi survey are:

- the establishment of a working group, and if necessary other expert groups, to explore an issue area and nominate a series of questions or 'Topic Statements' for the survey;
- a 'Round 1' survey is prepared and circulated by post to the panel(s) of selected experts;
- replies are analysed and a 'Round 2' survey is conducted, this includes information from Round 1, eg average realisation time, importance etc. This gives the opportunity for respondents to re-evaluate their response to the first round in the light of the views of others, and those whose replies fall outside the normal range are invited to state their reasons;
- further Rounds for additional clarification may be employed if thought necessary; and
- finally the information is then summarised and presented with an average value with some measure of dispersion, and analysed by expert groups and individuals etc.

Japan, in particular, has considerable experience in such forecasts. Perhaps the best known exercises are those of the Science and Technology Agency (STA), conducted through the National Institute of Science and Technology Policy (NISTEP), which have been carried out every five years since 1971. These surveys aim to outline trends in innovation to contribute to government policy and planning, and to provide private enterprises with information relevant to their own research and development. The fifth survey (1991) was repeated in Germany and an extensive comparison of results yielded many insights (NISTEP FhGISI, 1994). These included the remarkable similarity in general expectations, illustrating the global nature of information transfer on many of the topic statements, and intriguing differences in expectations between Germany and Japan, including for example a generally higher confidence in the resources of Germany in developing basic research knowledge without the need for international collaboration. Delphi also formed key components of the UK technology foresight program through sector-based panel. a survey has also recently been conducted in France.

The Delphi technique has a number of advantages. It allows for both narrow and wide-ranging views of long-term future trends in technology. The Japanese surveys illustrate the latter, and have been characterised as 'holistic' covering a very broad range of fields – the fifth conducted in 1991 obtained views on over 1100 developments. Delphi used for specific fields is illustrated by the experience of UK sector panels. The Delphi method is also particularly suited to long time frames over 10 years, and the NISTEP surveys have used a 30 year time frame. The process allows the gathering of views from a very large number of people. In this way it can not only achieve better statistical reliability but also promote the process benefits of the '5Cs', especially 'consensus'. Delphi allows respondents to change their minds on topics without being personally identified, and it gives those with firm views an ability to stick by them. As the recent use by Germany of the Japanese Delphi questionnaire illustrates, essentially the same Delphi surveys can be applied in different countries – with the proviso that some topic statements with local relevance will require modification. This suggests that international collaboration on Delphi surveys will become more frequent in coming years as the international and global character of science and technology becomes more pronounced (Bourke and Butler, 1995a). For small nations participation in such surveys might provide a glimpse of the expectations of the technological leading edge.

A key disadvantage is that large scale Delphi surveys can be costly and time consuming, and these expenses cannot be avoided. They require involvement by large numbers of people for the results to be statistically significant. A critical part of a Delphi survey is the process by which the questions are developed as the choice of questions to a large extent determines the value of the results. This requires considerable attention to setting topics. In the case of NISTEP's 1992 survey this involved a 30 member Steering group and 13 working groups developing lists of possible topics. Analysis of the data to address policy relevant information may require considerable further investment, eg to develop 'Delphi scenarios', or to use the 'topic cluster' analysis of the ASTEC Shipping partnership.

Despite these potential limitations the ASTEC Shipping partnership did prove to be a useful exercise despite its relatively small scale. Attention is also needed in the distribution of outcomes, as anecdotal evidence indicates that awareness of the results of Delphi surveys can be low outside of the expert groups involved.

A sixth STA Delphi survey is currently underway, with results expected to be available in 1997.

ii) Scenario Analysis

Scenarios are considered to be one of the main tools for looking to the future. They have been extensively used in ASTEC's foresight study as well as those in the UK and the Netherlands. The method is well suited to using foresight for strategic planning purposes.

Scenario workshops provided the key main foresight element in four out of ASTEC's five partnerships. The fifth Partnership, on maritime S&T priorities in Australia, used a Delphi survey as its main foresight stage. The following discussion is drawn from the I&CT partnership workshop handbook prepared by Dr Michael Blyth, then Manager of Strategic Planning and

Evaluation at CSIRO. Dr Blyth has also been involved in foresight studies in the CSIRO, and gained experience working in Group Planning area of Shell International Petroleum Company in London, who are the recognised world leaders in the development and application of scenario planning.

The term scenario can be used very broadly and originates from 'a sketch or outline of the plot of a play', and therefore has a number of connotations. Scenario analysis as used in foresight has its origins in the use of gaming in operations research and planning in the 1950s. It achieved popular attention through the work of Herman Kahn, whose book 'The Year 2000' released in 1967, defined a scenario as 'a hypothetical sequence of events constructed for the purpose of focusing attention on causal processes and decision points'.

Scenarios are not predictions or forecasts of the future, nor are they science fiction. Scenarios are stories about the future, and each comprises a number of 'plots'. Plots within a scenario are based on the key variables, like the key characters in a story or film. According to Schwartz (1991) in *The Art of the Long View*, 'in most good scenarios, plot lines intersect, just as a good film often includes several sub-plots'. A scenario planner considers the converging forces in the plots and attempts to understand how and why they might intersect. From that analysis and understanding, coherent pictures of alternative futures are constructed – these are scenarios.

Scenarios address:

- issues, trends and events in the current environment that are of concern to the organisation's decision makers;
- elements in the environment that are determinable and somewhat predictable – predetermined events or variables; and
- elements in the environment that are more uncertain, trend breakers that affect a system in unpredictable ways, but with understandable dynamics – turning points in the business environment, identifiable in the present although often as weak signals of change.

Scenarios are therefore an interpretation of the present as well as an archetypal image of the future. They present an internally consistent story about the path from the present to the future. The test of a good scenario is that it is plausible to a critical mass of managers in a group or business, it is internally consistent, it is relevant to the topic or issue of interest, it is recognisable from signals of the present (the early, weak signals of change), and it is challenging, containing some elements of surprise or novelty in directions where the organisation's vision needs to be stretched (encouraging managers to 'think the unthinkable'). However, there should be links to the existing organisational mental maps and what managers believe is currently going on in their world. While, it is useful to construct a 'surprise-free' scenario by extrapolating current trends into the future, this is best thought of as a reference point. The emphasis as scenario wring as it has developed is on the exploration of critical uncertainties as a means to prepare for un-expected turning-points and possible developments in key variables.

The plausibility of scenarios is assisted by the use of forecasts in their construction. As stated earlier scenarios are not forecasts, but forecasts are used to provide an understanding of the forces shaping particular outcomes and events. Explanations and analyses of what happened in the past can also provide insights into how the future might unfold. Scenarios combine individual forecasts and other future-relevant information to make a plausible, coherent stories about how the future may unfold from identifiable events and trends in the present.

While scenarios focus on the critical uncertainties they also embody predictable or 'pre-determined' elements as part of the story. Predetermined elements do not depend on any particular chain of events. If it seems certain, regardless of what might occur in the future, then it is a predetermined element. Predetermined elements include *slow changing phenomena* such as population growth and the building of physical infrastructure, *constrained situations* such as government regulations or goals, and *decisions or events already in the pipeline*, such as the Australian government's reduction of tariffs and the size of the teenage population in the next decade.

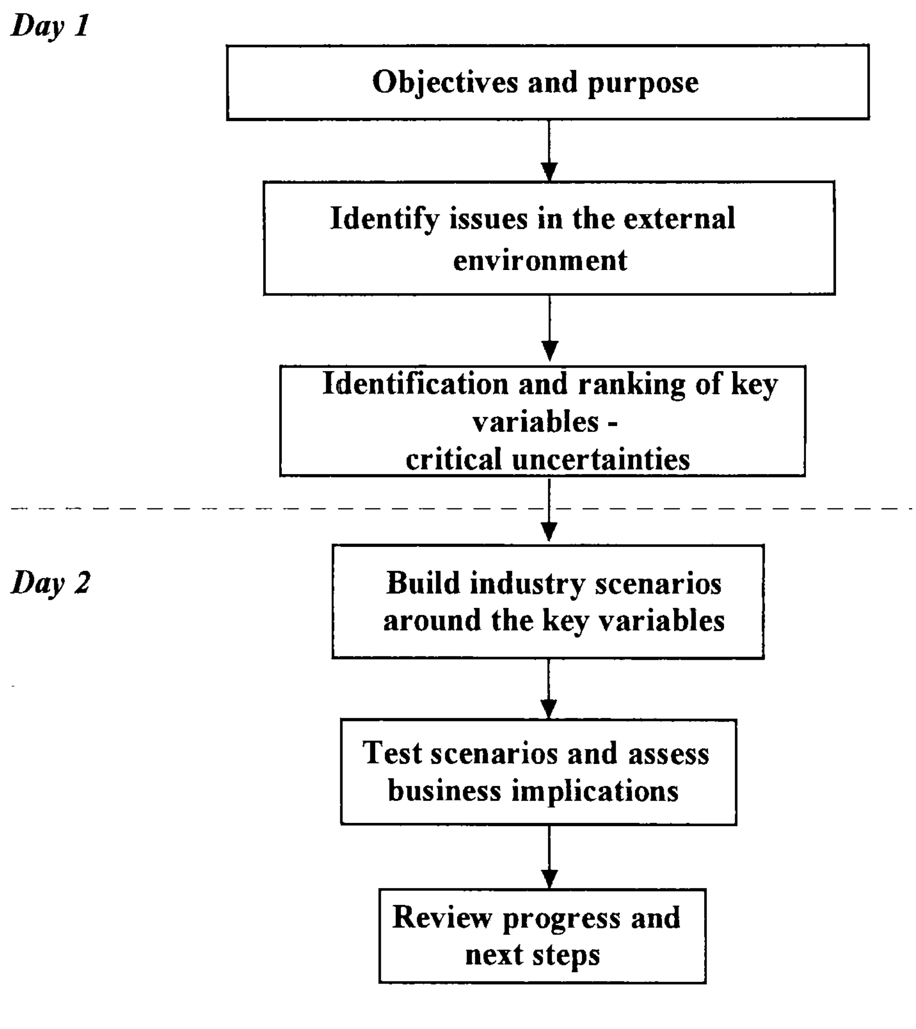
The ASTEC scenario workshops were aimed at supporting the partnership's achievement of its agreed objectives. The objectives of a partnership might include: the identification of S&T underlying the development of focus issues, and for demand factors, identification of opportunities and skill needs over the foresight period. For each ASTEC Partnership specific objectives were set for the scenario building workshops.

In the case of the I&CT Partnership, the workshop aimed to:

- identify the issues driving the development of broadband interactive networks in Australia and overseas over the next 10 years;
- build scenarios of the development of broadband interactive networks in Australia and overseas for the period 1995 to 2005;
- identify key industry implications for Australia; and
- agree on further actions.

The general process used is outlined in Box A1.6.

Box A1.6. Main elements of the workshop



Step 1 is to select the topic and agree objectives and the specific focus or purpose for the scenario building workshop. Normally agreement is reached on the broad topic or issue to be addressed by the planning exercise prior to the workshop.

Step 2 is to review key issues and influences. This exposes workshop participants to as many of the possible issues and factors which may have some influence on the topic of focus in the horizon year and to bring participants up to a common level of awareness and understanding.

Assessments of relevant issues, trends and events in the political, economic, social, technological and business environments and other important areas of influence are considered. These assessments may be based on information and data sourced from various publications and studies as well as from interviews with influential or remarkable people in relevant fields. Interviews are often helpful in gaining perspectives which differ to those of the organisation. This session of the workshop focuses on the material prepared for the workshop.

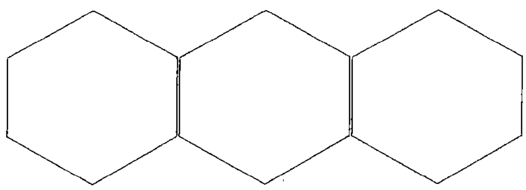
Brief presentations by experts on each key area of influence are made to the workshop participants as a 'warm up', ensuring that they are all brought to the same level of knowledge on the issue under consideration.

Step 3 is to identify the variables which are likely to be key drivers relevant to the topic or issue. A variable is a property or feature of the environment whose condition, or value, over the planning period, or at the end of it, is important to your business.

Participants spend about 10 minutes alone thinking quietly about those variables, issues, trends or events which are likely drivers or influences on the topic. The aim is to project thinking about the business into the horizon year, and identify four or five aspects of the future for which information is required in order to formulate effective strategy. The focus is on variables of high uncertainty and high importance.

Participants post their nominated variables on a white board for all to see (eg using hexagons as shown in Box A1.7). Variables are nominated until there are approximately 40 to 50, or the group is satisfied that all possibilities have been exhausted. Some discussion and clarification may follow to ensure that participants understand the meaning of each nominated variable.

Box A1.7. Thinking with hexagons



The use of hexagons to generate and assemble the many nominated variables is most effective. It is a technique which Shell uses in their scenario workshops. Variables, issues and trends can be readily recorded by participants on blank hexagons, which are then displayed on a magnetic white board for all participants to see. Furthermore, hexagons facilitate variable clustering. Individual hexagons representing a single theme, issue or variable can be moved until they fit together. These clusters can be discussed, broken up and reformed easily. The hexagons effectively and quickly capture a group's perception. Once the variable clusters are agreed they can be photographed for the record, and the hexagons reused.

The next stage is variable clustering. Fifty variables is far too many to use in defining futures or building scenarios of the future. To achieve a more manageable set, the individual variables are clustered. Clustering is based on similarities among the variables. For example, there may be several variables which describe different aspects of economic growth, such as income growth, export performance, exchange rate levels, etc. These may be grouped and labelled 'economic growth'. Clustering does not lose the underlying details or richness of the variables. In fact, later in the exercise when story lines are created, participants will draw on these underlying or component variables. Clustering may take some time to complete. It is an important learning component of the exercise. In the process, new variables may be identified and these can be included. Once the clustering has been agreed, the variables can be ranked.

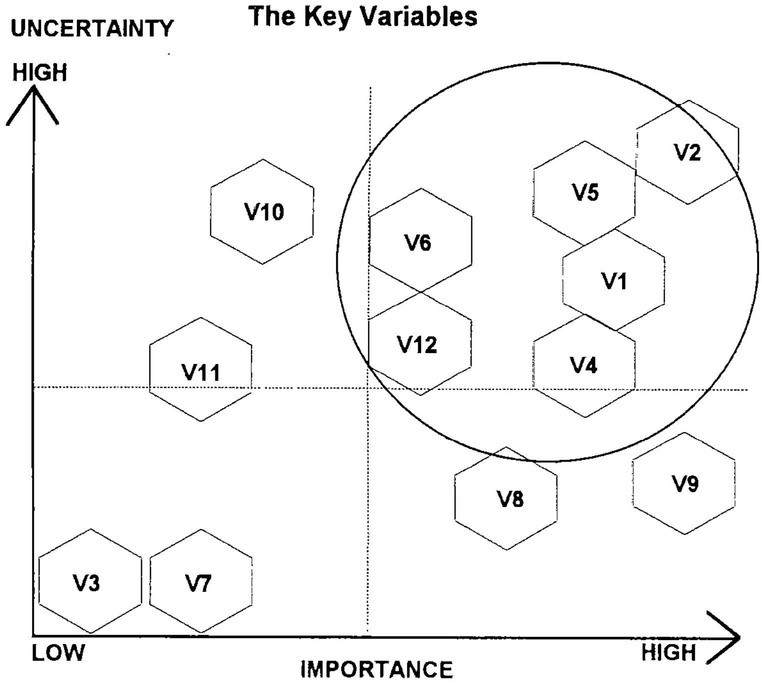
The further stage of variable ranking is intended to agree on the most important and most uncertain variables - the 'critical uncertainties'.

The variables are ranked by their relative importance to the topic and by their relative uncertainty. All agreed variables are important, but some are more important than others. Some variables may be more certain than others, regardless of what the future holds. These are generally referred to as predetermined variables and may include the growth of populations, particular government policy decisions and regulations, the numbers of teenagers in the first decade of the next century, and the construction of physical infrastructure.

Ranking is performed by the group as whole. When ranking the variables first determine the most important and place it to the far right-hand-side of the horizontal axis. Next determine the least important and place it at the far left-hand-side of the horizontal axis. Then order the other variables in between these two limits, according to their relative importance. Next, maintaining the relative positions for importance rank the variables in the same way by their uncertainty against the vertical axis. The magnetic hexagons facilitate this aspect of the exercise. The final agreed ranking is then recorded.

Box A1.8 demonstrates the results of assessing the relative importance and uncertainty of 12 variables. The top-right quadrant of the matrix contains the key variables (V2, V5, V6, V1, V4, V12), which are the variables about which the scenarios are written.

Box A1.8. Critical Uncertainties



The scenarios may also include the two variables in the bottom-right quadrant (V8, V9), which although more certain, are regarded as important to the issue being considered. They are 'predetermined' variables.

The second day of the workshop commences with ***Step 4*** – the writing of the scenario story lines. The purpose is to develop as many story lines as possible using the key variables - to describe sequences of events over the scenario period.

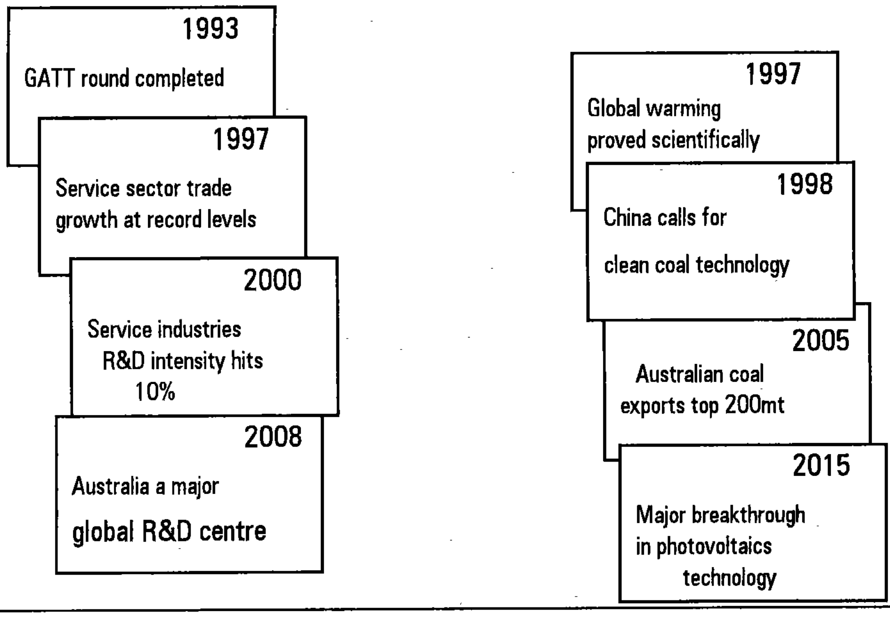
Creating 'story lines' is the first stage in building scenarios once the key variables have been selected. Participants think about the key variables in terms of what might happen – not will or should – over the scenario period. A 'story line' is a series of causally linked events which describe the behaviour of a part of the underlying business environment.

Initially, each participant works alone, using the relevant key variables to develop strings of causally linked events. Participants should work quickly generating many possible story fragments, pausing only to check that there is a plausible logic in each story line. These are referred to as fragments of stories.

The fragments are gradually woven together. Some fragments will be dropped, others will be introduced as the stories develop, and others will be enhanced or enriched. An effective way to weave these together is by recording a series of events. An 'event' is an incident of importance to the organisation/business expressed in the form of a newspaper headline. A year is added to the event to gives some perspective to the sequence (Box A1.9).

When developing story lines participants can draw on the detailed variables and information behind each key variable to keep within the bounds of the key variables and maintain a plausible logic. While each story line follows a time sequence, it need not start today and end in the horizon year. A story line may branch, although it is not useful to have greater than one branch within each fragment, as it gets too complicated. In such cases it would be better to commence a new fragment.

Box A1.9. Examples of story fragments and events



An important point is that story lines should exclude reference to specific organisations or companies. It is important to decouple events in the external environment from steps that the organisation might take in response, as this will prejudice any subsequent generation of strategic options. The 'Rules of the game' for developing story lines are shown in Box A1.10.

Individuals mix and match their story lines within their groups, building up a number of major sequences. Retain all fragments as they may fit with story lines of one of the other groups. The group then shares its sequences with another group and the story lines are further developed.

These final sequences are displayed for all participants to observe and comment upon prior to the identification of broad themes which emerge from the story lines.

Box A1.10. Story lines – Rules of the game

1. fragments must contain at least 3 events;
2. events must be causally linked;
3. events should not describe an action by your organisation;
4. the test is plausibility, not possibility;
5. the first event does not have to occur in the first year;
6. the last event does not necessarily have to happen in the horizon year;
7. story lines can branch, preferably only once;
8. story lines should address the key variables;
9. don't 'grind axes' or 'ride hobby horses'; and
10. be original, novel and 'push the envelope'.

Groups and individuals may assume a particular role, such as that of government, industry leader, community group, or lobbyist, and assess events external environment from that perspective. This helps people out of their existing mind sets and to re-assess assumptions about the external environment. It is important not to develop overly elaborate plots or story lines. They should be focused on the key variables – by definition a scenario is an outline of a plot, not a complete script.

The next stage is to create the scenarios from the themes which emerge from the story lines.

The fragments of story lines are then analysed for contrasting or divergent themes. Story-line fragments are merged and pruned and the themes developed into scenario stories. The scenarios must pass the test of good scenarios and must be owned by the group. They need to be plausible; recognisable from the signals of the present; relevant and of some consequence; challenging; and internally consistent.

The final scenarios may stem from a single statement about the present state of the world (the interpretation of the present), and then branch as the scenario period unfolds. Scenarios may emerge from an alternative interpretation of the present. Two to four scenarios are ideal. Avoid three, especially if they are variations on a theme - high, medium, low. Scenarios should not be linear, but multi-dimensional.

Each scenario must briefly described in about 200 words. The scenarios may describe the business environment in the horizon year or they could emphasise the dynamic nature of the scenarios, bringing out possible future discontinuities or branching points or the uncertainty in the interpretation of the present. This should straight forward, basing the description on the sequences of events.

An evocative name is selected for each scenario. The name should capture the essence of the scenario and easily allow differences between the scenarios to be recalled.

Step 5 is to assess and test the scenarios and their implications for business. The purpose of this is to establish that the identified scenarios exhaust the scenario possibilities, that each scenario is significantly different from the others and that each describes a plausible and consistent pathway to a plausible and possible future.

The scenario variables are discussed in some detail for each of the scenarios. The outcome of each variable must be logically consistent with the outcome of all the other variables in the same scenario. If not the scenario has failed the test. Furthermore, the outcomes or terminal values of the set of variables in one scenario must be significantly different from those in the other scenarios – if not, the scenarios do not address the uncertain variables. This may be done in the form a word picture, where symbols indicate the pattern or trend for each variable over the scenario period. Variable patterns can be recorded as indicated in the following table.

A second test, if time permits, is to identify opportunities and threats there might be for companies and organisations in each scenario. An opportunity is an external situation which if properly exploited, will improve the performance of the company or organisation. A threat is an external situation or force which will adversely affect the performance of the company or organisation unless appropriate action is taken. The purpose of doing this is to establish whether each scenario contains good and bad, desirable and undesirable features.

Once the scenarios have been agreed, described and tested, it's worth taking time to identify a few indicators which may be monitored in a continuous fashion and which may warn of the onset of a change in the external environment, and a shift towards a particular scenario unfolding. Often these will be weak signals at the time, but having 'rehearsed the future' participants are aware of their potential impact and can take actions to ensure the best possible outcome. Use the key variables and issues to help you pin-point leading indicators of change that can be readily monitored.

Finally ***Step 6*** is to agree action and next steps. This will identify critical tasks to be completed between this workshop and the next workshop on strategies. The outputs required are:

1. Documentation of the main outcomes, especially the scenarios;
2. an agreed timetable for completion of tasks and allocate responsibilities;
3. agreement on further work to be completed for each scenario;
4. dissemination of finalised scenarios to participants for comment;
5. assessment of existing strategies and policies against the scenarios;
6. generation of new strategic options; and
7. determination of opportunities for response and input from others.

The next stage in the overall process is to convert the scenarios into strategies. This can be achieved at another workshop to address internal and external implications. An outline of one approach to this process is shown in Box A1.11.

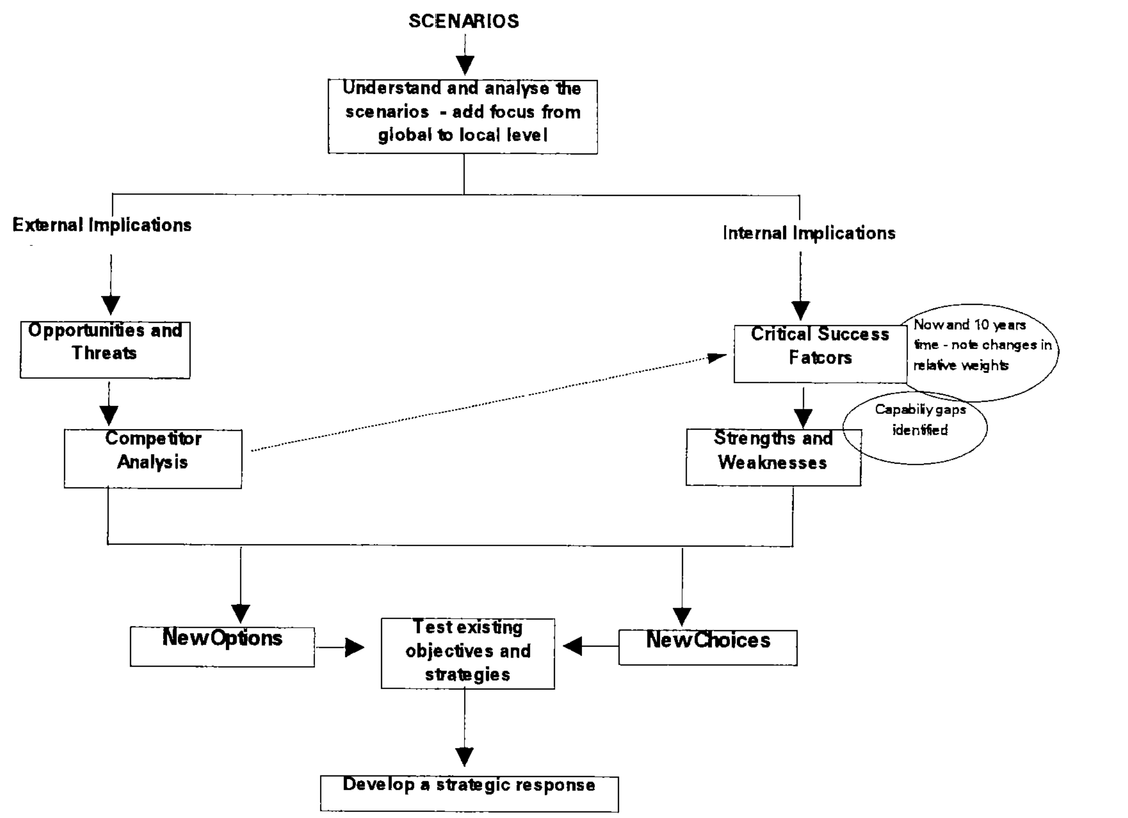
iii) Combining Techniques

A number of other techniques can be used as the focus of foresight.

Morphological analysis involves systematic investigation of large scale problems by identifying, indexing, counting and parameterizing a collection of all possible devices (processes) to achieve a specified functional capability. This attempt to break up a problem into its basic parameters allows all possible combinations of underlying parameters to be investigated. In this way novel recombinations can be seen that may not have been initially conceived. It requires a well structured problem and has been applied to specific areas of technology.

Relevance trees are an orderly 'normative' approach starting with a particular goal or objective. The branches (alternatives) are then traced to a number of tips which represent deficiencies in the existing state of science and technology. That is, this method identifies deficiencies that need to be overcome to reach a particular goal. It is useful for situations where distinct levels of complexity or hierarchy can be identified where lower levels involve finer distinctions of sub-divisions. Recent work in Germany on technologies of the early 21st Century have this approach.

Box A1.11. Scenarios to strategies – towards implementation



Other approaches to looking towards the future can provide valuable information, either in their own right or as input to one of the other methods. These include traditional trend analysis and extrapolation, which is well suited to certain kinds of variables, such as those related to decisions that have already been made. Another, is the use of expert panels and focused discussion groups. These have been particularly important in 'Critical Technology' exercises such as those developed in the US.

A simplified comparison of the techniques mentioned above and a number of other methods is shown in Box A1.12.

Different foresight studies have had different emphasis on preferred, expected and possible futures. US 'critical technology' studies use specific criteria to select technologies according to potential economic, social or other benefits, which emphasises preferred futures. Whereas, the Japanese Delphi surveys cover a broad range of possible future developments, with respondents nominating a value for potential benefits, which emphasises possible futures.

A useful model of a foresight process which seeks to combine the advantages of different methodologies is provided by a non-government foresight project carried out by the Unit for Policy Research in Science and Medicine (PRISM) of the UK Wellcome Trust. Unlike many studies which have been at the national level, this study was an experiment in a micro-level study of the specific field of cardiovascular research. The ASTEC Urban Water partnership study was based on a modified PRISM methodology. The process used in the PRISM study is outlined in Box A1.13.

Box A1.12. Comparison of some important foresight methods

Technique	Approach	Advantage	Limitations	Appropriate use
Delphi survey	large group judgement	individual influence free process	construction of topic statements, resource intensive	testing and confirmation, stimulus for debate, mass involvement
Scenario analysis	construction of alternate possible futures	'anti-forecast' decision guides, explores uncertainty	plausibility, viewpoints of writers, imagination	strategic contexts for organisations sensitive to external factors, identify inter-connections
Morphology	analyse components of a system	can find new combinations and possibilities, compare and contrast	looks at individual parts in parallel, exhaustive analysis of each part limited	structures thinking about a problem, search for new solutions
Relevance tree	logical requirements to achieve an objective	needs driven, brings out new options	assumes all factors can be defined, requires distinct levels of hierarchy, may miss cross connections	clarifies sub-components of an issue, identifies dependencies
Trend analysis	extrapolation of historical data	simplicity, reliable historical base	unexpected events, non-linear change	short-term, or 'pre-determined' factors
Expert group discussions	focussed discussion by experts	economical, targeted	available expertise, influence factor, criteria for choices	examination of issues, taps expert views, review of relative positions in critical technologies

Source: ASTEC

A particular feature of the PRISM approach is the combination of informal and formal Delphi opinion gathering and scenario workshops.

The informal information gathering used a set of seven open-ended questions adapted from those used by Royal Dutch/Shell foresight. These questions were (PRISM, 1995):

1. If you could talk to someone who actually knew the future of your research filed, a genuine 'Delphian' as if such existed, what sort of questions might you wish to ask?
2. If things went very well in your research, looking at it optimistically, what sort of achievements might be possible?
3. If things did not go so well, what do you see as the pitfalls which might limit research success?
4. Looking at the ways research is now carried out, what changes might be needed to help ensure that the optimistic targets are achieved?
5. Looking back, what do you see as the most significant events which have advanced research in your field to its current state – and what have been the major disappointments?
6. Looking forward, what do you see as the most immediate and pressing actions needed to strengthen your research field?
7. If all of the constraints, financial or otherwise, could be removed, what more would you suggest should be done in addition to what has already been mentioned?

These interviews were transcribed and then issues raised were categorised. The results of these open-ended questions were used to prepare the Delphi survey by helping to identify specific future possibilities and needs.

In addition, the study used bibliometric techniques as part of the information gathering phase, to benchmark and profile existing strengths and weaknesses in cardiovascular and related research. PRISM observed of the work: 'Opinions can be influenced heavily by anecdote and personal experience, and it is crucial, therefore, that some basic facts are established about the field under review at the outset.' To achieve this benchmarking the study used a medical research database (Medline) and the Science Citation Index to compare the UK share of publications in the field with the shares of others. An activity index was calculated of the ratio of cardiovascular research publications to total science. In addition, measures of citation impact and institutional origin were prepared, giving a rank order of major institutions producing contributions.

Box A1.13. PRISM – Combining techniques

Stage 1. Data Collection and Analysis

- Funding and Labour Force Data;
- Data from other countries on the field;
- Publication and citation analysis.

Stage 2. Interviews with stakeholders (researchers, administrators, industry, health service)

- Identify research users and consult with them on key issues affecting the future of the field, using seven open-ended 'trigger' questions;
- Information classified into 11 categories (research topics, infrastructure, exploitation, etc).

Stage 3. Delphi opinion survey

- Sample of 400 basic, clinical and industrial researchers;
- Questions reflect results from interviews: identifying promising fields, timing of developments , and impact; views on current organisation of research; and assessment of issues raised by research users.

Stage 4. Panel-based scenario analyses of those developments most likely to influence research over the next 10 years

- Future organisation and infrastructure of research;
- Research opportunities; and fields ripe for advance;
- Scenario development – benchmark, growth and shrinkage, and meetings to review scenarios and secure consensus on promising lines of research, and explore policy options.

Stage 5. Synthesis and Final Report

Source: PRISM (1995)

In summary, the objective of foresight is to look towards the future, using a variety of forecasting and other creative inputs, as a means of exploring evolutionary trends. This understanding, including a recognition of early warning signals, can create consensus and assist the achievement of preferred outcomes. Foresight has great promise for helping businesses and researchers to identify new markets, products and services, and consequently to help generate new employment.

Foresight in this context does not require the use of a specific methodology, indeed the use of a mixed methodology may be beneficial by building of the strengths of different techniques – there is no single preferred technique for foresight. However, commitment and involvement is essential from all interested groups, with the process being as important as product. Foresight exercises are a process more than a single event, and for them to be as useful as possible they should be iterative, involving a broad participation of producers and users of research, and administrators and the wider community.

Appendix 2 More about ASTEC's Study

ASTEC undertook this study to investigate the potential benefit of science and technology (S&T), including engineering, foresight studies to Australia. The terms of reference of the study are shown in Box A2.1.

Overseas experience suggested that it is only by doing foresight activities that one can fully appreciate the benefits. The Council did not attempt to conduct a large scale foresighting study for Australia, such as has recently been done in the United Kingdom, but rather sought to explore a variety of approaches. ASTEC's principal objective was the wide consideration of foresighting amongst S&T experts and in the broader community. The Council sought views on many issues, including the usefulness of continuing activity on foresight.

Box A2.1. Terms of Reference

Given the Government's objective to improve Australia's long-term economic competitiveness and our social and environmental well-being, by maximising the contribution from science and technology; and, noting the importance of adopting a forward looking approach:

A. Examine possible national and global changes to the year 2010, specifically:

   i) Australia's key future needs and opportunities which rely on, or could be significantly affected by, scientific developments and the application of technology; and

   ii) potential mismatches in the supply of and demand for science and technology in Australia.

B. In addressing A:

   i) engage in an extensive consultative process in accord with international best practice in foresight designed to match science and technology to national objectives;

   ii) encourage the collective identification of important themes for future science and technology planning in both the public and private sectors; and

   iii) increase awareness and understanding of the value and methods of future-oriented analysis.

C. Provide an information base which can assist government and industry to make better informed decisions on the development and application of science and technology.

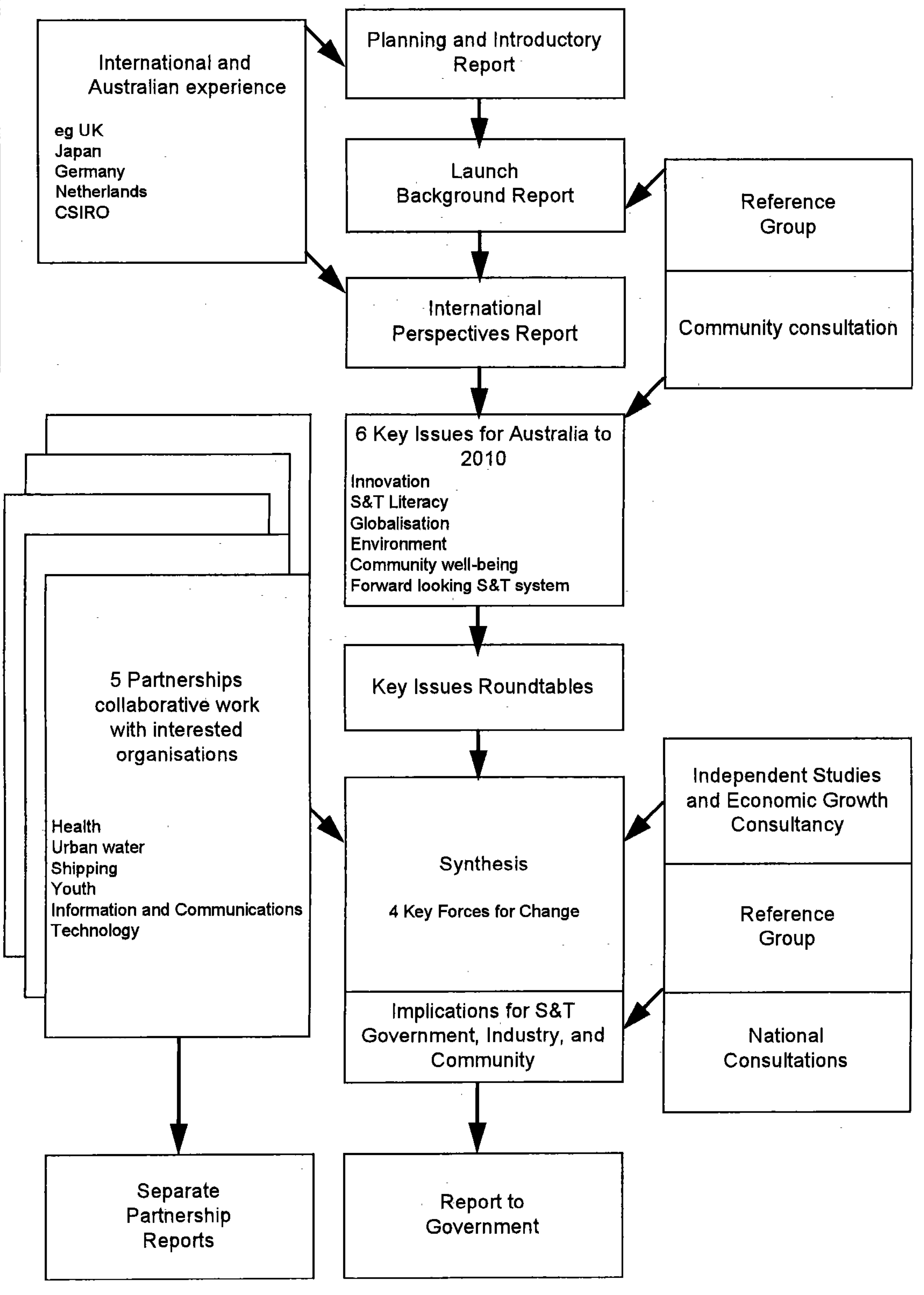
The study, conducted in the period from September 1994 to December 1995, brought together the outcomes of many mini-studies, a broad range of consultations, extensive literature reviews and analysis of overseas foresight experience. These numerous components, shown in Box A2.2, are more fully explained below.

These components can be subdivided into four broad groups:

1. Consultation mechanisms;
2. Key Issues Roundtables;
3. Consultancy Studies; and
4. Partnership Studies.

Each of these is discussed below.

Box A2.2. ASTEC Study Components



The initial phase of the study involved exploring similar work being done by other organisations in Australia and overseas in an 'Independent Studies' stream. This recognised that strategic forward-looking analyses have been conducted by a wide range of bodies for many purposes and that there could provide useful insights. The examination of previous work allowed a broader evaluation of the usefulness of overall processes and identified priorities for further work..

a) Consultation Mechanisms

i) Reference Group

ASTEC established a Reference Group, consisting of about 30 eminent Australians, as the major advisory body for this study and to ensure that the views of key groups were considered. The members are listed in Box A2.3. ASTEC also worked with the Prime Minister's Science and Engineering Council and the Coordination Committee on Science and Technology to ensure that its work was widely known and understood within the Commonwealth Government.

Box A2.3. Membership of Reference Group for Future Needs Study

Dr Don Williams AO (Chair)	Chair, ASTEC
Professor Ron Johnston (Deputy Chair)	Deputy Chair, ASTEC
Dr John Bell	Deputy Secretary and Chief Science Adviser Department of Industry, Science and Tourism
Mr John Ralph AO	former President Business Council of Australia
Mr Colin Benjamin	Director Horizons Network
Professor Paul Bourke	President Academy of the Social Sciences in Australia
Professor Max Brennan	Chairman Australian Research Council
Ms Patricia Caswell	former Executive Director Australian Conservation Foundation
Ms Lyndsey Cattermole	Managing Director Aspect Computing Pty Ltd
Dr Edwina Cornish	Managing Director Florigene Pty Ltd
Mr Bob Davidson	former Adviser Office of the Minister for Industry, Science and Technology
Sir Gustav Nossal AC CBE	President Australian Academy of Science
Ms Helen Disney	Deputy President Australian Council of Social Services
Ms Barbara Gibson	General Manager, Corporate Advisory Group ICI Australia Operations Pty Ltd
Professor Graham Johnston	former President Federation of Australian Scientific and Technological Societies
Mr Bruce Kean AM	Company Director

Box A2.3. Membership of Reference Group for Future Needs Study, cont'd

Dr A R Kjar	President Australian Industry Research Group
Dr Warwick Anderson	Deputy Chairperson Medical Research Committee National Health and Medical Research Council
Professor Ian Lowe	Head of School of Science Faculty of Science and Technology Griffith University
Sir Rupert Myers KBE	former President Academy of Technological Sciences and Engineering
Professor Mary O'Kane	Vice-Chancellor University of Adelaide
Sir Arvi Parbo AC	President Academy of Technological Sciences and Engineering
Dr John Webster	Chief Executive The Institution of Engineers, Australia
Mr Charles Perkins	former Deputy Chair Aboriginal and Torres Strait Islander Commission
Professor Michael Pitman MBE	former Chief Scientist
Mr John Plunkett	former Chairman Industry Research and Development Board
Mr Peter Robson	former Senior Vice President Australian Council of Trade Unions
Mr Phillip Ruthven	Executive Chairman IBIS Information Pty Ltd
Mr Peter Laver	Corporate General Manager Broken Hill Proprietary Ltd
Ms Penny Sharpe	former President National Union of Students
Dr Ric Simes	former Senior Adviser Prime Minister's Office
Professor Ralph Slatyer AC	Distinguished Scholar in Residence Research School of Biological Sciences, ANU
Mr Ian Spicer	Chief Executive Officer Australian Chamber of Commerce and Industry
Dr John Stocker	former Chief Executive CSIRO
Mrs Deborah Thiele	Chair Agriculture and Horticulture Training Council of South Australia

ii) Initial consultations

As part of a process of building a picture of the future demand for S&T, ASTEC asked people to share their opinions on priority issues for Australia over the next 15 years and to say how S&T could help. This process was initiated by the former Minister, Senator Peter Cook, in September 1994, when he launched the Future Needs Study with a call to all Australians to become involved.

The *Background Report* on the study (ASTEC 1994b) sought to raise awareness of foresight, and ASTEC invited anyone with an interest in what Australia will be like in 2010 to participate in the project. A number of alternative ways to do so were suggested and tear-out sheets were provided to encourage people to reply. The sheets invited people or organisations to share relevant experience of any foresight work either completed or planned, to keep in touch with the progress of this study by being on ASTEC's mailing list, or attending an introductory seminar, and to advise ASTEC of future technology, market trends and other issues of relevance. ASTEC also asked for responses on the most important issues, problem or opportunity facing Australia to 2010; why these issues would be important and how S&T could help.

Almost two-thirds of the responses listed environmental issues as a priority to 2010 - the need to fix environmental degradation and implement ecologically sustainable development. A second theme to emerge was a growing concern about Australia's place in a changing world. It was clear that Australians no longer see themselves as isolated from problems overseas. Tensions about Australia's place in a global community underlies responses on a range of issues, from problems caused by an increasing global population to the threat of new information regimes to our cultural identity and optimising our opportunities in Asia.

Almost a quarter of the early responses focussed on issues specifically related to S&T. These included the need for new technology to be accessible to small and medium sized enterprises, developing a more technologically literate society, valuing our scientists more, technological innovation and sovereignty, the need to be a clever country and the commercialisation of new technology. A similar number were concerned about economic growth and employment issues. There were also concerns about health, education, aging, the loss of an Australian identity and a range of other issues.

iii) Targeted consultations with particular interest groups

Members of the Council conducted a wide range of consultations during the course of the study, meeting with senior staff of companies, research organisations, bodies representing the business and scientific communities and government departments, both Commonwealth and State.

In addition, ASTEC consulted with member organisations of the Federation of Australian Scientific and Technological Societies (FASTS). The focus for the FASTS consultation was the use of open ended qustions along the lines used in the UK PRISM study (see Appendix 1). There are clearly varying perceptions of opportunities in different fields. Often these are quite specific to the discipline fields, and therefore represent 'niche' opportunities and threats. However, some broad areas of change were common to a number of sectors, most notable being the generic role of information technology. However, even in this 'generic' area there were many specific applications suggested amongst disciplines. Other themes emerging are the growing importance of multidisciplinary research, particularly for applications in areas of health, food and the environment. There is also a note of concern about the low level of demand from industry for research especially basic research. Related issues are perceptions of declining support for basic research, and pressure for short-term research at the expense of longer term research. There are also areas where certain underlying skills may be declining, eg. taxonomy.

Many areas of importance appear to be linked strongly to those identified in ASTEC's other consultations, including an important roles for information technology; resource-based science and technology in environmental science, ecology, land management and mining; the future potential of biotechnology, and international influences.

The exercise also showed that very few of the Australian scientific societies consulted are in a strong position to undertake foresighting perhaps indicating a weakness in the potential infrastructure for foresight. This is illustrated by the response rate and comments about the difficulty some societies had in obtaining comments from members.

iv) National and regional consultations

Most face-to-face consultations, including the roundtables, took place in the major cities on the east coast. To ensure that direct contact was made with a wider section of the community in the latter stages of the study and a series of 'national consultations' was conducted during August and September 1995. Meetings were held in Perth, Hobart, Adelaide, Townsville and Alice Springs. These meetings exposed people to some of the initial findings of the Future Needs Study. Many people were involved in these meetings which, although short, provided much valuable information.

b) Key Issues Roundtables

ASTEC established a process by which it sought to gain a broad overview of future needs for S&T in Australia. This process drew upon the consultations and on the views of members of the Council to identify a series of key issues. There were issues that would be of importance to Australian society and to the economy and which had strong implications for S&T. Deciding on these key issues required exploration, from a broad perspective, of the forces of change in Australia and the role that S&T can play. ASTEC brought together information from other studies and provided mechanisms so that people could share their knowledge and understanding of:

- emerging scientific and technological opportunities;
- existing scientific and technological strengths and resources; and
- evolving socio-economic and environmental needs and threats.

ASTEC used this overview process to identify six 'Key Issues for Australia to 2010', or areas of future opportunities strongly influenced by scientific developments and the application of technology. The six Key Issues identified by ASTEC were: the need for innovation and entrepreneurship, the need for a technologically literate society, the need to capture opportunities from globalisation, the need to sustain our natural environment, the need for continuous improvements in community well-being, and the need to build a forward-looking S&T system. Each is briefly discussed below.

i) Key Issue 1 - The need for innovation and entrepreneurship

A paper was prepared for presentation to a meeting of the Prime Minister's Science and Engineering Council. The Council was assisted in its preparation by Professor Mark Dodgson (ANU) and Professor Peter Sheehan (Victoria University), and additional advice was provided by Professor W J McG Tegart (Canberra University) and Dr Colin Adam (CSIRO). The paper is summarised below.

Technological innovation is the single most important factor affecting the international competitiveness of industry and it has a profound influence on social welfare and the quality of life. It is therefore essential that Australia evaluates and assesses the forces which shape and direct technological innovation.

Unfortunately, there is evidence that Australia does not have a strongly innovative culture. This is indicated by comparing Australia's research and development expenditure, the share of high-technology in production and trade, Australian patent applications in foreign countries and Australia's use of advanced machine tools and other advanced manufacturing equipment with the performance in these areas of other OECD countries and Pacific Rim industrialising economies such as Korea or Taiwan.

There is a rich and substantial international literature on innovation and ASTEC framed the issues it raised in the context of some of the most relevant and valuable analytical concepts currently available, including:

- the long-term historical development and impact of technology: *technological waves of development*;
- the profound and continuing uncertainty that accompanies innovation, the consequences this has for institutions and infrastructure, and the need to consider new 'lenses of analysis' in such a rapidly changing and turbulent activity, such as *networks* and *complexes*;
- the need for radical managerial and organisational changes in economies if technological opportunities are to be translated into economic growth: managing the *fifth generation innovation process*; and
- the way in which technology is increasingly a global issue affecting international trade, political and economic relationships; a move to what the OECD calls *techno-globalism.*

This analysis led to the identification of the following challenges.

- *Shaping Australia's long-term opportunities*

  How much will the future resemble the present? We can take advantage of changing 'techno-economic paradigms' to shape our future through increased economic growth from S&T. Australia must develop a national capacity to detect, interpret, understand and respond to long-term trends. Australia needs an institutional structure to foster this longer term .

- *Managing risk and uncertainty to grow new businesses*

  Can we picture the structure of Australian industry in 2010? Immense transformations are taking place within business, and we might expect these changes to continue into the 21st century. Firms that fail to adapt to these new patterns may not survive. Some experts consider the focus in the 21st century will be in the services sector, some in a more efficient, technology-based manufacturing sector, whilst others argue Australia's competitive edge will be in value added resource-based products.

  The right business environment, and especially the role of financial institutions will be critical. We must promote a better understanding of risk and encourage a more calculated approach to risk-taking in growing our new businesses to 2010.

- *Supporting the technologies of tomorrow*

  ASTEC's work to identify Australia's strengths in areas of long-term growth have revealed the following critical technologies for Australia: telecommunications; computers; transportation; health services, medical research and pharmaceuticals; agri-industry; biotechnology; and environmental management. Specific initiatives must address the need for long-term research on critical technologies. Any institutional arrangements for technology foresight should allow a prominent role to be played by CRCs.

- *Creating infrastructure for national and global networks*

  Effective national networks are crucial for overcoming diseconomies of scale in Australian industry. Participation in global networks is hard-earned. The capacity of companies to make effective use of networks will hinge crucially upon access to information about technology, nationally and globally. Australia must establish mechanisms to provide easily accessible information on new technology developments. This could also provide an opportunity to build our capacity to manage complex science, technology and innovation databases, and allow us to become an information node on global and regional networks.

- *Enhancing research and development in government enterprises*

  The role of government enterprises may be integral to innovation in smaller economies. This view provides new challenges for policy-makers. Policies to address this issue need to take account of the many different types of organisations falling into this class. ASTEC recommended a review of the potential role of government enterprises in fostering innovation, including consideration of the potential contribution of research and development to Government programs for micro-economic reform.

- *Educating innovative managers for the 21st century*

  Achieving the vision for Australian enterprises and their managers set out by the Karpin Task Force will be critical to innovation in the 21st century. Enterprise education is the main arena whereby enterprise and entrepreneurship can be encouraged across an entire society and the range of business organisations. ASTEC supported the Karpin recommendations aimed at achieving cultural change in Australia's youth and teachers of the young and saw a particular need for courses to provide managers with the skills necessary to meet the challenge of new technology.

- *Delivering on regional leadership in 2010*

  There is a need to manage our changing relationships with countries of our region, so that we optimise the benefits of Australian S&T. If we aspire to regional leadership in S&T, we must be prepared to turn rhetoric into actions in terms of government support, industry links and cooperative policy development. Current S&T programs should be reviewed to ensure that we are not missing opportunities with some of our regional neighbours. Policy development on intellectual property, and Australia's contribution to the development of regional standards, will be critical to effective regional cooperation. A national dialogue on intellectual property rights would allow Australia to become a regional leader on this matter.

ii) Key Issue 2 - The Need for a Technologically Literate Society

This issue was discussed at a roundtable, where participants considered how well prepared Australians are for a future dominated by technology, where there may be difficult decisions to be made which would be assisted by a greater understanding of the science and technological issues involved.

Many new technologies will be developed or be in widespread use by 2010. There are others which may be constrained by cultural factors and which will require decisions from the Australian community before they can be supported, implemented or rejected. Participants considered what Australians will need to know and understand about these topics, and what would be required, as part of their basic cultural values, to make informed decisions.

Participants at the roundtable discussed these issues in relation to three scenarios described by Colin Benjamin which emphasised alternative futures- a 'market driven' world emphasising economic development; a world which emphasised 'equity and social values'; and a world which focused on 'ecological sustainability', emphasising community and environmental values over development.

Much of the discussion at the roundtable centred on the need to redefine S&T literacy to take account of our needs in a more technologically sophisticated world. Literacy in S&T is different to a detailed technical knowledge. Rather it is an understanding that will allow society to use

S&T effectively in decision-making processes, discuss and adapt new S&T developments, appreciate science as part of our culture, maximise the benefits of S&T in our daily lives and build strong S&T systems and expertise, including an educated workforce.

Participants considered the S&T literacy needs for 2010 exploring the scenarios and identifying priorities, gaps and required actions. A range of ideas emerged from discussions. In particular, there was concern about access, with the view being presented that current socio economic gaps between groups in society would determine their access to new technologies, particularly information and communications, and that this would further entrench and extend inequities. It was noted that older people, and particularly older women, may be excluded and marginalised within a more technological society.

There was extensive discussion of the value and meaning of requirements for S&T literacy in the future. Participants noted the meaning of technological literacy is changing over time and that it has moved from a working understanding of how tools, such as cars, work. It now requires competence in utilising such tools and an ability to make decisions. This requires a much higher level of understanding - one which integrates human-social, environmental, scientific and technical issues - seen as important for both individual and community decisions.

Scientific and technological literacy was identified as a basic requirement for investment in new, productive industries. It was noted that only people who are S&T literate will invest in new and technologically high value added industries. It is therefore critical to innovation and wealth creation.

The meeting questioned how a younger generation surrounded by technology might differ in its attitudes and decision-making to the current generation and whether aging people in 2010 would have greater opportunities due to technological advance, or would be alienated by fear of it. An improved dialogue between S&T experts and the broader community was seen as critical to developing a more S&T literate community, and the meeting noted the links between S&T literacy and intellectual property in trying to manage the flow of new ideas. Concerns were raised that an S&T literate community was an important foundation for the future, but the processes to achieve it, for example, education and attitudinal change, would require a much longer time frame than 2010. Alternative processes to improve literacy, such as a greater role for the media and certain other groups, were also discussed.

There was general agreement that education must include S&T literacy as a 'core competency' (in the way encompassed by the definition of technacy in the foreword). S&T needs to be integrated into other areas of education as a skill for living, where emphasis is given to the social context and ethical issues. The education system must give students the curiosity, analytical skills and judgement to make informed decisions on new S&T issues as they arise, yet the current focus on assessment in education was seen to be working against this. Questions were raised about the teachers of S&T - both about the adequacy of their education, and capacity to take on this expanded role, and the status they, and the teaching process more generally, are accorded.

iii) Key Issue 3 - The Need to Capture Opportunities from Globalisation

Globalisation can be viewed as a state where there is an increased potential for elaborate and previously non-existent international interactions (eg, trade in goods, investment and novel services), both on a bilateral or multi-lateral basis. The emergence of globalisation has been facilitated by S&T, eg, through information technology and transportation; by policy actions, eg, reduction of trade protection; and by the changing nature of economies eg, an increasing interdependence. These trends are set to continue. Capturing the opportunities from globalisation is assisted by many current activities, but developing highly innovative opportunities will require the development of new skills, practices and support structures over the next 15 years and beyond.

The ASTEC roundtable succeeded in clarifying the issues surrounding the impact of, and opportunities from globalisation. It also identified a number of specific opportunities and identified some impediments for which recommendations were suggested.

Participants emphasised the importance to Australia's future of information technology and the service sector, including government services, and the greater integration of services and manufacturing. While opportunities will continue to emerge from technological developments in areas such as biotechnology, these were considered to be largely over the 15 year horizon.

The capture of opportunities requires appropriate knowledge, skills and support structures to support international interactions. For example, creativity is required in the identification of opportunities based on un-met needs of other nations, regions or firms, and on understanding the social, economic, environmental and cultural contexts of other nations. A region's economic framework may render inappropriate many conventional Australian business practices eg, warehouse distribution systems.

Many recommendations were related to building on areas of strength in the Australian economy, both in value-added products, but also prominently in services. A view emerged that globalisation will not mean the end of national identities. Rather, Australia has a number areas of national expertise and strength which are candidates for export. Conversely, Australia has an increased opportunity to absorb and adapt services and technology from other nations, including non-traditional trading partners.

The roundtable provided support for ASTEC's critical technology and industry areas listed in the 'Innovation and Entrepreneurship' key issue paper. The list, after some amendments, comprised:

- Agri-industry
- Value-added mineral products
- Engineering infrastructure
- Biotechnology
- Information and Communications Technology
- Materials technology
- Environment Management
- Renewable and other energy
- Transportation
- Education Facilities and Service
- Health Facilities and Services, Medical Research and Pharmaceuticals
- Travel and Tourism

A paper prepared by Professor Tegart (Tegart 1995b) suggested four areas of opportunity which cross-link to this list:

- energy supplies and technology;
- educational facilities and services;
- medical facilities and services; and
- tourism and travel.

The roundtable broadly supported all these areas of opportunity.

An important feature of the future to 2010 that was identified was the possibility of a greatly increased importance for the development and trade of integrated systems. This refers to the idea that there will be widespread implementation of integrated economic activities, for example, so that manufacturing and services (including government services) are sold as an integrated package. Under this scenario the development of Australian abilities in 'total system management' becomes critical. This was discussed under four headings: design, marketing, distribution processes linked to manufacturing, information systems, knowledge and skills, and education.

The roundtable suggested that the identification of specific opportunities required people with insights, skills and experience. The Australian people and their talents are a key resource in capturing opportunities from globalisation. Important advantages included Australia's ethnic tolerance and multi-cultural society, our proximity to Asia and our developing Asian-Australian communities. Australia also has relatively good access and ability to adapt global technology through its traditional links to Europe and America.

A number of themes emerged in discussion. These included:

- a view that Australia has scientific and technological strengths in a number of areas which have longer growth prospects;
- over a 15 year time frame building on strengths and setting directions is critical, and continued attention is required to develop a global strategic orientation in Australian companies, especially SMEs;
- developing 'critical mass' in research and industry provide opportunities from new organisational forms, but that these should be 'bottom-up' to account for entrepreneurship;
- globalisation is a two-way street where nationalism meets globalism and 'cultures' are shared. A strong sense of optimism noted was that Australia has its own culture and valuable social and institutional structures and experience that can benefit other countries, particularly in APEC, eg, exports of culture, sports, government processes and services.

To recognise opportunities and to develop the necessary skills and knowledge to make them a successful reality by 2010 will require continued attention by governments educators and industry. Several of the opportunities identified by the roundtable illustrate that there is considerable inertia to overcome, and that efforts need to continue in order to allow mechanisms to develop which facilitate the capture of opportunities.

iv) Key Issue 4 - The Need to Sustain our Natural Environment: 2010

The discussion was based on a scenario for 2010, developed by ASTEC. The scenario, which does not necessarily reflect either ASTEC's view or preferences for what the future will be, describes a future in which:

- a paradigm shift has occurred in handling the relationship between the environment and development;
- values have been placed on environmental costs so that environmental impacts and benefits are now costed into decision-making frameworks;
- in general, activities which have negative impacts on the environment are no longer considered economically 'profitable' or socially acceptable; and
- an educated and aware community can make more informed decisions about environmental risk;

The meeting discussed three case studies relevant to the scenario. One group considered tourism development in an area of high conservation value in 2010. Two separate groups discussed managing a response to greenhouse enhanced climate change in 2010. And a further two groups considered resource management in the Kimberley region in 2010. The S&T needs and gaps that emerged from discussions varied across the case studies. Following their discussions, findings from each group were presented to a plenary session. The meeting concluded with a general discussion among all participants.

Overall, participants considered many issues raised by the scenarios were being dealt with today, and that much of the S&T required was already being developed. Energy was and issue for all groups. Four themes which emerged from all groups were: the critical role of Information and Communications Technology (I&CT) systems; improving S&T education, the development of 'full footprint' costs and impacts; and the need for a local focus in S&T.

The group noted the tensions between the need for both more strategic S&T whilst promoting good basic research; the tensions between supporting both a global and a local focus; the different roles of science vis a vis technology in implementing ecologically sustainable development (ESD); the need for better links within the science community and with other areas eg. economics; and the need for an improved focus on prediction.

It was agreed that society must have some decision making framework to understand the compromises and trade-offs that are involved in ESD. In this regard, scientists need to improve understanding of what the tolerances and the capacities are and what measures can be taken to minimise or reduce impacts. Whether this will be achieved by the introduction of environmental economics and resource accounting is not clear. Some argued that current economic frameworks are so limited that this would be a very inadequate way to integrate environmental values into decision making frameworks. They considered there was a need to search for better mechanisms.

v) Key Issue 5 - The need for continuous improvements in community well-being

The roundtable participants considered a future where mapping of the human genome had been completed by the year 2000 and where the genetic origins had been established for the many of the major causes of morbidity and mortality in the twentieth century. Participants discussed these issues in relation to three scenarios described by Colin Benjamin which emphasised a future whose primary focus was economic development, social issues, or the environment. The following points are drawn from the subsequent discussion.

Participants confidently expected that the genetic origins of some diseases would have been identified and that it would be possible to predict whether an individual is at risk for cancers (notably lung, bowel, breast and prostate), adult onset neurodegenerative conditions, common multi-factorial problems such as ischaemic heart disease, asthma, diabetes and hypertension. There was also an expectation that there would be the ability to screen far more extensively for genetic risk and to better understand gene environment interactions, and intervene to modify them and that this increased knowledge would allow public health measures to be very directed. It would be possible to screen and ascertain high risk groups in terms of genetic profile and environmental influences within the whole population. This information would allow individuals to undergo interventions before triggering factors take effect and thus avoid onset of the disease.

Participants identified several critical issues for Australia to 2010. These included increasing community knowledge and understanding. It was noted by many participants that it is very important that the legal, ethical and social issues which arise out of the development of this knowledge be discussed and debated by an informed public, so that when decisions are made about issues - such as informed consent, privacy, choice regarding testing, discrimination, level of information provision, confidentiality, group verses individual good - they are made in the best interests on all members of society.

A range of problems were discussed including access and equity and concern that pressure groups might gain disproportionate access to resources unless there was a national approach and an informed dispassionate advisory body to oversee further developments. Confidentiality of records and quality control in the provision of genetic screening procedures and at the counselling and clinical end of the spectrum were also seen as issues that the community, and particularly the professional community, must address. Participants said that, wherever possible, individuals should decide whether they would undergo genetic testing and to whom the information would be made available. The protection of individual rights was raised in the context of an earlier era which saw people sterilised on the basis of their IQ test results. Participants were concerned that genetic information might be built into a picture of an individual and that similar outcomes might result. Attention was also drawn to the eugenic implications of the technology.

There was concern that attention to screening might divert efforts away from identifying environmental triggers that predispose and push people who are vulnerable into particular disease states. Participants considered that a national coordinated approach was important, as currently there are different arrangements being made in different States. There was a concern that funding for prevention is not readily available. Participants noted a need for licensing of technicians, laboratories and tests to ensure there is proper evaluation, field testing and quality control, similar to drug trials.

In considering the role of DNA diagnostic laboratories, there was strong concern expressed that unless great care was taken these laboratories would be concerned with the acute, the rare, the interesting and the private instead of the common, the chronic, the uninteresting and the public.

The roundtable identified the S&T which would be required. This included the necessity for comprehensive multi-disciplinary clinical genetic units and DNA diagnostic laboratories around Australia. It was noted that, in terms of therapy, it is important that a DNA pharmacotherapy industry is nurtured in Australia. Participants also noted that the current conceptual model, where the gene cause and the environmental factors are crudely put together, will be inadequate and will be replaced by a deeper analysis of the information contained in the genome, a much better understanding of how the whole system works in a detailed informational computational way, as well as new measures of what we now call quality of life. When better methods to assess and aggregate risks were added, this might be called vital calculus. There is also likely to be the development of refined modelling of life style options where people with particular genetic predispositions in a particular lifestyle environment can be modelled in a very detailed way.

The skill base and intellectual property areas were identified as important areas. Australia will need to generate its own intellectual property and a core of people who have got the skills to put genetic technology into practice if we are to be in a position to derive advantage of the new technology either commercially or diagnostically.

The roundtable identified several uncertainties, including the extent of progress in identifying the genetic bases of some diseases with complicated multiple gene causation and various environmental triggers. Another uncertainty was the implications of, and extent of pressure to search for, the genetic bases of characteristics other than disease, ie intelligence, personality, character and social behaviour. There might be a demand for very detailed screening, beyond screening for abnormalities, which would provide quite detailed descriptions and predictions and advice based on them - sometimes called fate maps -for those who can pay for them. The issues of germ-line therapy was discussed and participants expressed their opposition to any consideration of it, however considerable concern was expressed about the possible use of such therapy. Lastly, consideration of whether the whole enterprise of genetic testing is appropriate, whether the community wants it or wishes to fund it, was raised. It was suggested that allocating research and development funding to this area may actually be excluding other possible futures.

Participants also identified several trends. It was generally agreed that the technology for genetic testing is going to get cheaper and simpler and that there will be widely distributed means, possibly even desk-top means, to provide individual genetic information ranging from results of screenings to quite detailed descriptions, predictions and advice. Lastly, participants noted that as human genetics proceeds there will be a growing number of stimuli to agriculture and food industry to develop foods that address particular genetic problems and these may be taken up by agriculture and food scientists.

vi) Key Issue 6 - The need for a forward looking science and technology system

The roundtable on the key issue of 'the need for a forward looking S&T system' obtained views and opinions on a number of issues related to Australia's S&T system. This can be considered as one which has sufficient capacity to meet the Australia's core future needs for S&T, and which has the mechanisms and flexibility to adapt to and manage change.

Thinking for the roundtable was stimulated by a challenging 2010 scenario with the following key features:

- world-wide belief in the values of a market economy combined with strong pressure for smaller government;
- globalisation and the disappearance of effective national borders on science, technology and industry;
- recognition of the critical value of S&T, particularly to industry;
- widespread use of new information technology for speedy access to vast intelligent databases and immediate interactions with collaborators around the globe; and
- breaking down traditional boundaries between disciplines and types of research.

Discussion was partly undertaken in three groups, which addressed different aspects of the S&T system: education, discovery and application. A more detailed report on each group's considerations is included in the main body of this report.

The roundtable raised concerns that, while technological developments are often difficult to anticipate, social, legal and regulatory aspects might be readily identifiable as potential impediments to a beneficial application of S&T, for example, the management of intellectual property in a global, information technology-rich, environment. A novel suggestion was to develop a framework that allowed ready access to information and knowledge, but which also ensured compensation to the originator, perhaps by a system based on citation indices.

Participants considered the issue of environmental awareness and new 'green' regulations. These might change S&T requirements by reducing rapid product obsolescence and use of resources. In a globalised world, 'S&T-aware' consumer organisations could become powerful market forces, forcing transnational companies to interact with them. It will be important in such a case that the S&T community also considers how to interact with community groups.

It was suggested that S&T have a lot to offer developing countries to achieve a better quality of life and meet basic human and social needs – clean food, water, transportation, shelter etc. This might require the development and application of appropriate technological solutions, using simple or sophisticated technology. This idea led to discussion of a general need to better understand the social context, including impacts, of technology.

Much discussion centred on the negative aspects of a global market-driven S&T system, particularly the impact this would have on public good research. A balanced approach to managing change was suggested, requiring the maintenance of a 'national benefit' component of our S&T system, with more attention by governments to longer-term policy and practices, particularly to manage a more networked, integrated and multi-disciplinary S&T system.

The roundtable considered that Australia's multicultural society had a distinct advantage in terms of being well placed to develop cultural sensitivity in relations with. The need for greater cultural sensitivity was particularly important for managers. Australia is well placed to meet our regional neighbour's needs, and cultural sensitivities that may hinder some ties are not generally regarded as a threat to science links. Science and technology links may provide the bridge upon which commercial links can be built.

Important areas of concern were the social implications of technology, including the continued trend to urbanisation. Also, in a more market-oriented system, there may be a greater equity divergence, which may impact especially in the medical and health services area, where the benefits of medical research may flow mostly to wealthy citizens.

Intellectual property was regarded as a key issue that has not been resolved. It was suggested that a breakthrough would arise if the intellectual property system would allow anyone to readily access intellectual property, provided that their use was audited and paid for. This would promote the more rapid diffusion of knowledge and innovative technologies and consequently generate social benefits. This becomes increasingly important in the context of the information Superhighway. The Superhighway can offer large social gains only if its information content is of high quality. Current intellectual property arrangements were seen as being based on an antiquated view of technology that would be inadequate to support Australia as an information provider on the highway.

Regional competitiveness opportunities identified for Australia included the provision of services - health, education and acting as an information technology base. It would be important to have appropriate marketing for Australia in terms of identifying customers and service and delivery arrangements, including transport. Specific Australian foci can be developed in technology areas where we have strengths and/or special needs eg, telecommunications.

Risks to the Australia education system were suggested from this type of development. Including the development of an education system with no 'old style' universities left. However, with much teaching being done by remote systems, universities may be able to develop new sources of income. Indeed, funding for research might increase if large corporate multinationals become highly protective of their technological information.

It will be a major skill to derive directions for science from market needs and demands. There was a view that markets should not completely dominate humanitarian approaches. In this regard, there is a need to ensure scientific knowledge is not restricted to specialists. There is a need for broad S&T literacy, including a need for S&T knowledge in business courses for managers and for science to be included in primary education.

The issue of the importance of adequate access to capital was prominent. Consideration is required for new sources of funds (both domestic and international) for newly emerging technologies, research and development by government and the finance growth opportunities. New sources of 'exit' are needed for individual and institutional investors in start-ups in order to reduce perceived risk. There is a need to take the long-term perspective on finance.

In summary, the roundtable supported the view that there is an uneven performance in forward looking activities in the Australian S&T system and more needs to be done. However, some parts of the S&T system have been active in promoting a future-orientation. The CSIRO is an outstanding example, having supported 'Australia in 2020' and specific foresight activities in a number of Divisions, as well as CSIRO's feasibility-attractiveness matrix analysis. Much priority setting activity and many strategic plans lack a forward orientation, and the focus of much foresight-like work is dominated by an analysis of current systems.

c) Consultancy Studies

As part of the study, ASTEC commissioned two further consultancies, in addition to the work conducted by Professor Tegart for the globalisation key issue. These were on the contribution of S&T to economic growth, by Professor Peter Sheehan and others at the Centre for Strategic Economic Studies at the Victoria University of Technology (Sheehan et al 1995) and the outcomes of international foresight studies, Professor Paul Bourke and Ms Linda Butler of the Research School of Social Sciences at the Australian National University (Bourke and Butler 1995a).

i) Economic growth consultancy

The objective of the consultancy was to test the hypothesis, based on new growth theory, that there is the potential to boost Australia's economic growth through government policy initiatives which facilitate scientific research and development and the transfer of new technology. The consultant was asked to review measures of economic welfare and comment on their appropriateness and to identify the effect of S&T on economic growth in aggregate and by industry sector, seeking to identify those factors within S&T that have the most impact on economic growth. There was also a requirement to assess the adequacy and effectiveness of existing policy measures and to identify policy initiatives to facilitate S&T and its impact on growth and welfare.

The study found that Australia has achieved substantial gains over the past decade in applying S&T to generate economic growth. While Australia's innovation system is far from adequate to support the transformation of the economy into one able to compete successfully in a range of knowledge intensive industries, good progress has been made in this direction. Thus, in taking steps to foster improvements, the natural starting point is to build on those policies that have contributed to this success.

The consultant identified these as the existence of powerful incentives for private business to undertake research and development, principally the 150 per cent taxation incentive and the syndicated research and development program, the strong focus on the commercialisation of public sector research results, continuing support from the Commonwealth budget for research and development, and effective industry policies specifically encouraging research and development, such as the partnerships program and factor (f).

Enhanced measures were recommended in each of these areas, together with policies to address three areas of deficiency in the present arrangements, incentives for public businesses to undertake research and development relevant to their business needs, a foresight program, and a new emphasis on the internationalisation of Australia's research and development base.

Recommendations to address the areas of deficiency were proposed. It was said that the role of government enterprises may be integral to innovation in smaller economies. This would provide new challenges for policy-makers, who would have to take account of the many different types of organisations falling into this class. A review of the potential role of government enterprises in fostering innovation was suggested, together with an incentive scheme, with features such as a cash rebate for expenditure on research and development undertaken in pursuit of the business objectives of each enterprise.

The role of foresight was addressed by saying that Australia needs an institutional structure to foster a longer term perspective. There is a need to consider the best institutional arrangement for Australia, and whether an existing institution could take on this role.

The final area of deficiency identified by the consultant was the need for a new emphasis on the internationalisation of Australia's research and development base. There are strongly held views on this proposal, suggesting a need to consider more carefully the role of public good research before a recommendation can be framed.

Finally, the consultant sought to quantify the increased performance of research and development that could be achieved by a combination of these measures, concluding that research and development expenditure could be expected to grow at an average annual rate of eleven per cent (in constant prices) between now and 2002-3, compared to a base case (the continuation of current policies) of four per cent. The increased rate of growth over this period would result in research and development expenditure as a proportion of GDP being 2.5 per cent in 2002-3, compared with base case expenditure of 1.7 per cent, an increment of 0.8 per cent. Preliminary estimates suggest that the effect of this increase in expenditure on research and development would be an increase in the annual rate of growth of GDP of at least 0.75 per cent. The cumulative effect of this higher rate of growth over the period to 2002-3 would be six per cent of GDP, or $37 billion in 1994-95 prices.

ii) Consultancy on recent foresight studies

ASTEC commissioned Bourke and Butler to review various international foresight studies to determine whether there was any agreement between these studies on critical areas of S&T. They were then to use the techniques of bibliometric analysis (drawing on the Performance Indicators Project bibliometric database) to provide a profile of Australia's relative strength in those areas of S&T shown to be of importance.

Bourke and Butler concluded that the important issue for countries like Australia is to discover how far it makes sense to pay attention to foresighted lists of technologies and likely future developments in which our chances to participate are severely constrained. A major theme of their report was that Australia needs a 'niche foresight' approach which would project forward from activities in which Australia has an identifiable comparative advantage, consider possibilities which may exist in Australia, not necessarily clearly evident at this time, for developing into the fields deemed to be 'critical' elsewhere and consider possibilities for wholly innovation developments with no recognisable existing Australian base.

After examining the 1995 US Critical Technologies Review and the Fifth Japanese NISTEP Technology Forecast Survey, the basis chosen for analysis was the list of the British ;Generic Science and Technology Priorities' contained in *Progress Through Partnership: Report from the Steering Group of the Technology Foresight Programme 1995*. The British list was seen to be of special interest for its generic, interdisciplinary character and because of some structural similarities in the research and development systems of the United Kingdom and Australia.

These generic priorities are:

- harnessing future communications and computer power;
- building business from biology and genetics;
- the synthesis and processing of new materials;
- the need to shape new technology with due regard to its social acceptability;
- greater precision and control;
- technologies to secure a cleaner and more sustainable world; and
- better management of the total business process.

Australian S&T performance in these areas was then examined using a bibliometric profile of recent Australian shares of the Science Citation Index. Two procedures were followed. Journal sets were constructed, related to the classifications of the Science Citation Index and derived as closely as possible from the generic fields. Key word searches were then conducted for terms derived from the vocabulary of the generic technologies.

The results of the bibliometric procedures confirmed the broad expectations that the Australian presence is at its strongest in the areas such as environmental and earth sciences, biomedical sciences, water resources and energy, with some science and engineering based strengths in fields such as optics and robotics.

Bourke and Butler emphasised that, within the constraints of the project. They were providing an indicative and preliminary report on a major subject, urgently needing further work.

d) *Partnerships*

The different techniques and tools of foresight – such as Delphi techniques, trend analysis, or scenario building – were tested in a number of foresight studies in 'real' situations. These sectoral foresight studies, called partnerships, sought to achieve concrete results in specific areas of interest through engaging a number of agencies in exploring a specific sectoral issue to 2010.

Each partnership was made up of a committed group of organisations who used individually designed foresighting processes to identify scientific and technological opportunities and requirements over the next 15 years. They aimed to demonstrate that:

- foresighting is useful to a wide range of groups in their long-term planning;
- specific S&T capability will impact on realisation of preferred future;
- broad participation in foresighting results in cohesive sector strategic planning; and
- foresight methodologies can be tailored to individual sector/area needs.

Partnerships identified their objectives, methodology, depth of analysis, resources and constraints through a negotiation process involving a steering committee of agency representatives.

As part of their foresighting, partnerships collected the following information:

- a review of future needs and demands for the specific sectoral issue, involving a compilation of background statistical information, monitoring of forecasting techniques and an assessment by research users and other stakeholders of the demand factors in coming years;
- an analysis of research and technological opportunities for the specific sectoral issues, involving expert panels and workshops, in addition to information gathered from the above step, and the use of Delphi techniques, patent information and publication data; and
- investigation of sectoral issue strengths and weaknesses, including review of factors such as the existing environment and resources, likely competitiveness of science-based industry sectors, current and projected government policies, and, other socio-cultural factors.

There were five partnerships covering:

1. Urban water – lifecycles;
2. Information and communications technologies – full service network implementation;
3. Health – neuro degenerative disorders;
4. Youth – expected and preferred futures; and
5. Shipping – maritime science and technology in Australia.

i) *Urban Water Partnership*

Australia is the driest continent on earth but its population has had one of the poorest records for water-use efficiency. One of the biggest challenges for Australia will be to turn this record around. The economy and the well being of all Australians is heavily reliant on how well we can learn to better manage our part in the water cycle. Change will not be driven by science, technology, politics, industry or the community alone but by a combination of all working in close partnership. For much of Australia's history, the water cycle was viewed as a something that managed itself. It is only in recent decades, largely as a result of pollution problems and growing environmentalism, that attitudes have shifted and there is now a serious reappraisal underway of the real value of water. One result is that the water industry is being given a new mandate of higher responsibility and accountability and is now embracing change and pursuing innovation as never before.

As in the past, major change will depend upon a sound base of scientific knowledge, along with workable technologies. However, unlike the past, many of the new solutions will not necessarily be the direct products of science or technology, but will be found at the complex interface of science, technology and society. Environmentally sustainable solutions will increasingly depend on how well society as a whole can use new knowledge and adapt and apply cost efficient water management techniques.

Many of the technologies that can achieve much greater efficiency within the urban water cycle already exist. The necessary innovation will come in finding cost efficient means of applying them and methods of winning community support for more conservative practices in water use. Some of the greatest savings will continue to come from low level innovations being adopted on a wide scale, from moves to lower water use approaches, to home gardens, to even better shower taps. There is also still much scope for minor incremental improvements in infrastructure, such as better corrosive resistance of pipes and better pipe damage assessment and repair techniques. New technologies can also assist in the development of sophisticated demand side management practices that could include household water metering systems that provide real time pricing. Washing cars and watering paths during a drought should become price prohibitive.

There are many signs that the way in which society thinks about and uses water is undergoing revolutionary change. This is being driven by new scientific theory and will continue to open up huge potential for new technology and cost efficient innovation for many years to come. There are also signs that Australia is well placed to take on the challenges of new innovative and sustainable approaches to managing urban water systems, and that any success it has may help assist in coming to terms with problems in this area that are worldwide.

The Urban Water Partnership aimed to use foresight techniques to identify investment opportunities in S&T to provide cost effective, adequate and safe water in urban environments in an environmentally sustainable way, in the coming decades. Membership of the partnership is shown in Box A2.4.

With an international context, the detailed aims were to:

- assess demand and opportunities for S&T for the water industry, including emerging technologies and the needs of industry;
- assess the likely developments in the structure and dynamics of the S&T systems as it relates to the water industry;
- assess the potential mismatches between supply and demand for water industry S&T in Australia;
- assess the ability of Australian S&T to adjust to changes; and
- skill the Australian water industry and research groups in foresight techniques.

The partnership therefore had two objectives:

- to test the use of foresighting techniques for long term planning; and
- to assess the contribution of S&T to long term issues in the urban water system.

Box A2.4. Urban Water Partnership Members

The Urban Water Lifecycles Partnership is comprised representatives of Australia's leading water research groups and industry bodies. Its members, who also formed the Steering Committee, were:

Mr Don Blesing (Convener)
Australian Science and Technology Council

Dr Don Bursill
Cooperative Research Centre for Water Quality and Treatment

Professor Peter Cullen
Cooperative Research Centre for Fresh Water Ecology

Mr Chris Davis
Australian Water and Waste Water Association Inc.

Mr Alan Dodds / Mr Jeff Brown
Sydney Water Board

Dr John Langford
Water Services Australia

Professor Tom McMahon
Cooperative Research Centre for Catchment Hydrology

Professor Michael Knight
National Centre for Groundwater Management,
University of Technology, Sydney

Mr Cary Reynolds
ACT Electricity and Water

Dr Bob Wasson
CSIRO Division of Water Resources

The chosen methodology was based on a modified PRISM (Policy Research In Science and Management) methodology, used as part of the recent UK foresight study. The process was advanced by a sequence of essential activities structured into six stages:

Stage 1: Building a Picture of the Urban Water System;

Stage 2: Interviews with Experts;

Stage 3: A Survey of Interested Parties;

Stage 4: Scenario Development;

Stage 5: Regional Workshops to Test Scenarios; and

Stage 6: Evaluation of the Urban Water Foresight Process

As a result of its experience the partnership made a number of findings concerning the foresight process shown in Box A2.5.

Box A2.5. Urban Water Partnership Findings on the Foresight Process

Finding 1

An agreed understanding of the subject being studied must be developed and adequate time needs to be allowed for this. Once properly defined, each foresight study needs:

- to design a unique process fit the purpose of the study, including a set of methodologies, a range of tools and linkages with external expertise to ensure that these can be objectively assessed; and
- to ensure that the process remains flexible to meet emerging issues.

Finding 2

Consultation with a broad range of experts from the area will build credibility and improve coverage of all important issues.

Finding 3

The time frame for any foresight study needs to be beyond the sector's current planning timetable, to escape a 'business as usual' focus.

Finding 4

Organisations undertaking technology foresighting should give their studies a user and community context. The usefulness of long-term outcomes will be decreased if studies do not take account of the views and contribution of these groups.

Finding 5

National scenarios are effective in identifying national issues, but need to be modified to take account of regional differences.

Finding 6

The outcomes and impact of major foresight studies which identify S&T and investment opportunities in the future must be evaluated.

Finding 7

Further foresight studies in this area will be useful.

A facilitator, with many years' experience in scenario development, was engaged to design the detailed process and direct the main foresight scenario workshop. Initially, the group was presented with five draft 'challenge scenarios', developed from the earlier interviews and other material. These were a starting point in the development process with each setting out a different context for future water supply in Australia. Groups analysed and discussed these on the basis of their plausibility, internal consistency and technical accuracy. Workgroups then moved through the two day development process and produced four comprehensive scenarios setting contexts for future systems.

These final urban water scenarios are an attempt to describe how the major economic, social, political and technological driving forces might plausibly combine to shape its future, based on how these forces are behaving now and have behaved in the past. They are stories about future urban water systems which tie together the elements of the present system shown in Box A2.6.

Box A2.6. Urban Water Partnership scenario summaries

Market World

The Australian public sector has been fully privatised. Water is provided by a large number of retail suppliers drawing from a common 'spine' supply that is fed by various water sources and producers. In this scenario rampant privatisation of the urban water system required government legislation to guarantee minimum access for needy consumers. Access and equity considerations were ignored by the market in its rush to make money. Environmental and health concerns are minimised and addressed through market-based mechanisms. Data secrecy acts as a limit on S&T. Innovation is directed towards cost reduction and ownership by global companies neither guarantees 'public good research' or that research which is undertaken will be done in Australia.

Eco-Event

The steady build-up of ecological problems and crises worldwide has driven dramatic change. In Australia, all infrastructure projects are required to follow ecologically sustainable development principles. In this scenario change is driven by ecological problems and crises worldwide. While this may act as a catalyst to a range of innovation in the urban water system with long-term benefits for Australia, water is not the only environmental product that has been badly affected. In this scenario, the disasters lead to the full internalisation of environmental costs. The price of water has risen but this is offset by successful demand management and innovative technology for water re-use. Innovation is targeted to meet rising environmental standards. This scenario gives prime concern to environmental considerations with lower priority for economic, social and health concerns.

Public Health Crisis

There are overriding concerns about threats to public health. The threats include the emergence of new pathogens, the drug resistance of existing pathogens, and the exposure of people through air travel to increasingly frequent international epidemics. This future is driven by the rapid spread of epidemics globally and a perception that public health problems are out of control. Whilst this scenario would focus innovation in health related S&T, it would be a trade-off against national environmental quality. Issues such as environmental water balance and recycling water and bio-waste nutrients would be a low priority. This scenario also proposes heavy social restrictions eg on pets and recreation.

Slow Deterioration

The current system in decay. A future in which there are no overriding events to force change and little public money is available for maintenance and repairs to the existing system. The scenario has no positive features. Lack of public finance and no particular crisis to force change lead to a continuation of current thinking and slow spiralling down of services for Australian communities.

The analysis of the scenarios indicated that the present strategy of splitting the urban water cycle into different elements has outlived its usefulness. There is a need to develop a whole system or life cycle approach to encourage people to think in a more systematic way, to see water from the start of the cycle, with it falling as rain, all the way through storage, treatment, use and disposal to a receiving water, where its further impacts must be managed.

While there is considerable knowledge of individual components of the cycle, such as water use in the home, relatively little work has gone into studying and quantifying the life-cycle as a whole. Modelling of the whole life-cycle will allow all the implications and interactions of any management initiatives to be evaluated and gaps which are not currently apparent to be addressed. For example, if the goal is to reduce the load of heavy metals reaching coastal waters, will more be gained from recycling sewage or constructing urban settling ponds? Study of the life-cycle as a whole will put issues into perspective and allow assessment of priorities.

As a result of its analysis of the scenarios the Partnership made a number of recommendations (shown in Box A2.7).

Box A2.7. Urban Water partnership - recommendations

Recommendation 1

All those involved in the planning and management of water in the urban environment, as well as the researchers who provide the knowledge base to underpin their work, should embrace a whole system, integrated approach that covers the life-cycle of urban water from source to disposal. In particular, models and tools for whole system analysis should be developed, enabling improved S&T planning and management.

Recommendation 2

In educating professionals to work in the urban area, Universities and CRCs should look at better integration of the skills needed in their planning, engineering and ecology programs.

Recommendation 3

Improved long-term monitoring of all components of the urban water life-cycle should be implemented. With the division of the urban water industry into smaller, more commercial units, ongoing public access to data is at risk, as is sharing of data between agencies. Steps should be taken by State and Commonwealth Government through COAG to ensure ongoing access to life-cycle date (ie water and mass balances).

Recommendation 4

The outcome of this foresighting study should be used by both research funding and research performing organisations to identify opportunities for urban water research.

Recommendation 5

Governments should recognise the importance to Australia of efficient urban water systems and assist the establishment of collaborations amongst private and public sector organisations for research and development in urban water matters. Any structural reorganisation needs to ensure that companies can follow World Best Practice and have access to, and utilise, leading edge technology. It also needs to ensure that structural incentives do not operate to encourage companies to disinvest in technological innovation in their own best interests.

Recommendation 6

The Government should ensure that monitoring is undertaken by responsible parties so that:

- broader societal needs such as access and equity concerns; environmental and health issues; and the maintenance of a domestic base for S&T are taken into account within the trend to privatisation; and
- decay of the urban water system is responded to in an appropriate manner.

ii) Information and Communications Technologies Partnership

Australia's telecommunications systems – developed for telephony by incremental evolution over 100 years – are entering a period of great change and uncertainty as the range of services multiply due to technological advances. By 2000, many Australians will have an opportunity to access one or more networks that can provide one-way broadband services. The increasing deployment of optical fibre, initially to support pay television, will provide a pathway for further evolution to a full service network (FSN) – a network infrastructure that can provide two-way bandwidth-on-demand, sufficient for any conceivable communication or information service (including multimedia).

Australia will face major opportunities for the development and use of innovative new services and systems as FSNs are deployed. Australia needs to be in a state of readiness to exploit these opportunities. The foresighting exercise conducted by the information and communications technology (I&CT) partnership has sought to understand the forces that will shape the future development of FSNs, to identify the skills needed for network deployment and to explore how Australia can take full advantage of opportunities for innovation.

The partnership focused on one part of the information and communications technology sector, namely the future evolution of broadband interactive networks. The objectives of the partnership were:

- to foresight the S&T underlying the development of broadband interactive networks in Australia and overseas, and the demand for such networks;
- to identify opportunities for Australian development of innovations in this area; and
- to identify skill needs for this area to 2010.

The partnership (Steering Committee membership is shown in Box A2.8.) undertook the following activities to seek a wide range of expert views about relevant issues:

- collection of a wide range of current information about broadband network issues;
- preparation of a set of background papers identifying global trends in policy and technology, Australian industry trends, demand issues, and the S&T which underpin full service networks;
- an informal survey of interested individuals which canvassed hopes and fears about how full service networks may develop;
- a series of two workshops (for a total of three days) comprising experts in research and development, industry, government, education and social issues, to explore scenarios for the future of full service networks and Australia's future capacities and opportunities; and
- circulation of the draft scenarios to workshop participants for further comment and refinement.

Box A2.8. Steering Committee Membership

Dr Mark Sceats (Chair), Australian Photonics Cooperative Research Centre *

Professor Don Nicklin, Australian Science, Technology and Engineering Council *

Mr John Vines, Australian Science, Technology and Engineering Council *

Mr Chris Eccles, Australian National Training Authority *

Mr John Burke, Centre for International Research on Communications and Information Technology

Mr Alex Gosman, Australian Electrical and Electronics Manufacturers Association

Dr Maurice Haddad, Bureau of Transport and Communications Economics

Dr Peter Tucker, Department of Industry, Science and Tourism

* indicates the core partners

The partnership developed four scenarios to indicate the range of possible futures for which Australia needs to be prepared. The partnership found that the main driver of change in the scenarios will be the volatile consumer demand for new services. This will generate waves of opportunity, and there will be winners and losers. The uncertainty of demand for the wide range of new services makes prediction for 2010 impossible. The scenarios (a brief summary is provided in Box A2.9) encouraged partners to think about a longer time horizon.

The study found that foresighting needs to be an ongoing process. To be fully effective as a foresighting tool, the scenarios should be reviewed regularly and the indicators of change monitored, in order to adapt relevant strategies and policies to the changing environment.

Box A2.9. Information and Communication Technologies Partnership Scenario Outlines

Riding The Wild Surf

In this scenario, business and industry lead the way in take-up of broadband and narrowband interactive services. By 2010, Australian industry and business are large and successful users of broadband interactive networks, giving them an edge in the globalised economy. A highly competitive telecommunications services sector has developed and there have been many winners and losers along the way. An important stimulus to rapid industry take-up was an early reduction in ISDN pricing, which stimulated development within the on-line services industry. Government is a medium-level user of communicative broadband network services in cases where the services can contribute to clearly demonstrated efficiency gains (cost savings in public expenditure). Residential demand for distributive broadband services (pay television) has grown slowly but steadily. Residential demand for narrowband interactive (eg on-line) services has grown steadily, but this has not led to growth in demand for communicative broadband services. Access to interactive services (both broadband and narrowband) is considerably lower in the less lucrative markets, such as rural and remote areas.

Navigating The High Seas

This scenario sees a high take-up of broadband interactive services in all main sectors – business and industry, government and residential. There is an internationally competitive telecommunications sector. An early drop in ISDN prices stimulates the development of the on-line services industry. Government promotion of standards development for inter-operability has minimised consumer confusion. Government programs for promoting community use of on-line services (including special programs for rural and remote areas) have contributed to rapid adoption, as has the development of innovative and effective designs for human interfaces to the technology (assisted by the efforts of Australian researchers). There have been significant changes in social behaviour (eg in the organisation of work, ways of doing business, recreation and attitudes to the use of computers) which have contributed to a high acceptance and use of computers and interactive services. Much of this change has been driven by young people and their favourable experiences with the new technologies and services in schools, TAFE colleges and universities. A number of new, unforseen interactive services have emerged, which have contributed significantly to the growth in use.

cont'd

Box A2.9. Information and Communication Technologies Partnership Scenario Outlines, cont'd

Drifting in the Doldrums

In this scenario, there has been a slow take-up of most services in all sectors – business and industry, government and residential. Australia is very much a slow follower of overseas developments and opportunities for Australian development of innovations have been missed. Confusion and conflict about the multitude of standards and services has led to consumer frustration and a slow take-up of distributive pay television and narrowband on-line services. Growth in use of the Internet began to taper off due to congestion and user frustration in not being able to find the information they wanted. ISDN prices remained high into early in the 21st. century. Slow economic growth has contributed to the slow take-up of services, as has a perceived lack of government policy leadership in areas such as access, facilitation of standards and innovation.

Shipwrecked

This scenario is a 'disaster' scenario in which a series of difficulties subvert what was a promising beginning in the roll-out of an advanced FSN. The nature of the difficulties relate to: growth in demand for services not being as fast as originally anticipated; serious fraud using the newly introduced electronic cash; major disruption of the network, both intentionally by 'cyber-terrorists' and unintentionally by accidental destruction of key switching nodes; and difficulties in choosing an efficient upgrade path to the next generation of network technology.

The Partnership considered that Australia will face major opportunities for the development and use of innovative services and systems as FSNs are deployed and needs to be in a state of readiness to exploit these opportunities.

Riding the Wild Surf and Navigating the High Seas both contain features that will seem attractive to many Australians. A vigorous market place with falling real prices for bandwidth and strong business adoption of ICT are positive features of Riding the Wild Surf, although the growth in social inequality and the emergence of information rich and information poor are clearly undesirable. Most of the features of Navigating the High Seas would also be seen as very desirable. On the other hand, the other two scenarios, Drifting in the Doldrums and Shipwrecked, are as undesirable as their names imply.

Analysis of the scenarios leads to the view that the main driver of change will be the demand for new services. There are actions that the Government can take now that will encourage both business and residential demand for services and thereby make a desirable future more likely.

The study identified a number of actions necessary if Australia is to realise the opportunities offered by broadband interactive networks to 2010 (Box A2.10).

Box A2.10. Information and Communication Technologies Partnership - recommendations

Recommendation 1

The partnership recommends that the Government facilitate the emergence of the following conditions during the next five years, in order to take full advantage of the opportunities offered by the development and use of FSNs:

- a competitive market for ISDN services;
- open access standards for new broadband services and deployment of open systems for networks;
- a well-informed marketplace of consumers who are adequately trained to use and take advantage of narrowband on-line services in residential, government and business sectors; and
- an innovative culture, supported by strong linkages between centres of research excellence and industry, which will lead to adoption of appropriate new ICT products and services developed in Australia.

Recommendation 2

The partnership recommends that the Government regularly review the extent of use of network services and be prepared to deal with any barriers to adoption.

Recommendation 3

The partnership recommends that the Government commission a detailed study of the import requirements implied by the widespread deployment and use of FSNs and identify ways in which local manufacture can meet this demand.

Recommendation 4

The partnership recommends that the Committee of Officials on Information Services, the Information Services Policy Board and the Office of Government Information Technology be asked to investigate and recommend on appropriate standards for the security of networks and the information they carry.

Recommendation 5

The partnership recommends that the Government establish procedures to monitor changes in access to services and address emerging areas of inequity through community service obligations or in other ways.

Recommendation 6

The partnership recommends that the Government conduct regular foresighting of developments in ICT to up-date and revise the findings of this study.

Recommendation 7

The partnership recommends that the Government work with industry and research agencies to establish demonstrations, trials and test beds. These activities should aim to demonstrate the application of communicative and interactive broadband services and provide environments in which new products and services can be developed. Furthermore, these activities should be linked with demonstrations, trials and test beds in other countries where appropriate.

(cont'd)

Box A2.10. Information and Communication Technologies Partnership - recommendations, cont'd

Recommendation 8

The partnership recommends that the Government develop and implement plans which:

- aim to help Australia sustain the growth of its ICT industry and move to production of the next generation of components and systems;
- foster and promote broadband technologies, as a national priority area for research and research training, and support improved linkages between Australian industry and publicly funded research organisations; and
- provide a range of incentives for building private sector investment in the research and development of broadband technologies.

Recommendation 9

The partnership recommends that the Government support a new research initiative for the study of human and social factors in the use of new information and communications technologies and services.

Recommendation 10

The partnership recommends that the Government work with the Australian Bureau of Statistics and relevant industry and professional bodies to define data needs relating to consumer use of new interactive and broadband networks and services and propose a coordinated approach to collecting the data.

Recommendation 11

The partnership recommends that, noting the substantial growth in employment in the ICT sector and emerging skill needs, the Australian National Training Authority, in collaboration with State and Territory systems, develop further measures to ensure a sustained increase in the level of training in ICT. Measures will be directed towards:

- training to support an internationally competitive ICT industry;
- ensuring that delivery of training makes best use of multimedia and communication networks;
- enhanced cooperation between industry and the VET system, emphasising industry endorsed standards and course outcomes of a uniform high standard; and
- international recognition of ICT qualifications.

Recommendation 12

The partnership recommends that the Bureau of Transport and Communications Economics, in collaboration with interested members of the partnership steering committee, conduct further development and analysis of the scenarios, with particular emphasis upon economic, social and market development aspects.

iii) Health Partnership – Neurodegenerative Disorders (NDDs)

To assist in identifying a focus for the health partnership, ASTEC canvassed over 200 health and medical organisations to identify the key health issues in Australia to 2010. The survey identified six key health issues in Australia to 2010 (Box A2.11.) and these formed the basis of discussions with potential partners.

Box A2.11. Issues identified in the health survey

1. Social Policy Issues

Concerns were raised about: the escalating size and cost of health services, the consequences of aging population being supported by a reduced proportion of taxpayers, the need for stability of government policy, and the opportunities to increase illness/injury avoidance practices.

2. Impact of clinical, pharmaceutical and scientific advances

By 2010 there will have been advances in knowledge in many scientific/pharmaceutical/ clinical areas - genetic disorders, the Human Genome Program (and the ethical/moral issues associated with advances in understanding the genetic bases of diseases), and establishment of environmental/disorder links. The way society views and reacts to, or treats, these better-understood diseases/disorders, is an issue.

3. The Aging of the Australian Population

This issue includes the needs of disabled, as they have some symptoms in common with the aged. In 2010, aged persons, who naturally have more ill-health related needs, will be a significantly higher proportion of the total population. They will command an increasing proportion of the health system's resources. Health services are likely to rise as a proportion of GDP. There will also be a shifting of the incidence of medical conditions consequent on the ageing of the population. Maintaining/increasing the mobility and quality of life of the old, frail and disabled is an issue.

4. Increasing/sustained impact of specific diseases/disorders

Diseases/disorders included: mental illness, memory loss in old age, cancer, cardiovascular, AIDS and genetic diseases. Asthma and allergies, products of environmental factors, are also widespread and growing problems.

5. Inequalities in availability of health services

This issue includes the problems associated with access, especially in remote areas and the specific problems of Aboriginal health.

6. Impact of advances in communications, electronic transfer and information technology

This is a suite of technologies which promise to have a major impact on both the conduct and delivery of medical services.

The survey also identified potential contributions of S&T to Key Health Issues in Australia in 2010, including:

- improvement in detection - including screening, earlier diagnosis and diagnostic technologies;
- genetics and molecular biology;
- information technology - telecommunication/computing;
- manufacturing and engineering, commercial product development;
- reduction in cost of services; and
- evaluation of costs and services.

The issue of Australia's ageing population and its health implications was considered to be an ideal candidate. Some have predicted disability-free survival for people based on the successful identification of environmental and other factors which could then be controlled. Prevention based on attention to known environmental and life style risk factors for the systemic diseases – such as salt and other mineral intake, lipids, alcohol, smoking, exercise and activity, accidents and occupational exposures – has been effectively promoted this century and there have been major changes in the attitudes and practices of our society towards these risk factors. Average life expectancy at birth is rising for both men and women in Australia. This expectation for a longer life does not, however, hold for Australian Aboriginals. More older people, in their 80's, are probably experiencing less morbidity from systemic degenerative diseases particularly stroke, cardiovascular disease and chronic lung disease.

However, as we approach the twenty first century an emerging and increasing cause of morbidity and disability in older people are the neurodegenerative disorders – the disorders of brain ageing – which certainly disable and greatly reduce quality of life for older people and their carers. These disorders are the focus of this study viz: motor instability; gait and balance disorder (and falls); cognitive impairment (and ultimately losing the plot); motor instability and balance; motor slowing, immobility (and then isolation); and sensory impairment with loss of vision and/or hearing in old age. Underlying this group of disorders are the great unknowns of Gerontology: the biology of brain ageing, and the neurodegenerative diseases: Alzheimer's disease and the dementias; Parkinson's disease; Motor Neurone Disease; macular degeneration; and, cerebellar atrophy. The neuronal systems involved in these disorders do not appear on current epidemiological and biologic evidence to be susceptible to the same lifestyle risk factors which devastate the other bodily systems - the heart and circulation, lungs, bones and joints.

The ASTEC partnership joined to undertake a study of what contribution S&T could provide to management of neurodegenerative disorders of older people to 2010. The Steering Committee comprised:

- Dr W Jim Peacock (Chair) FRS AO, ASTEC;
- Professor Lyn Beazley, ASTEC;
- Professor GA Broe, Director, Centre for Education and Research on Ageing;
- Professor Jim McLeod, Department of Medicine, University of Sydney;
- Professor John Ross FASSA, Department of Psychology, University of Western Australia and Chairman Strategic Planning and Evaluation Committee, National Health and Medical Research Council; and
- Ms Delys Sargeant, Council On the Ageing Australia.

The partnership deliberately chose to focus on the common disabling multifactorial syndromes of brain ageing rather than on the specific neurodegenerative diseases because of the links created between the three categories of gerontology, namely:

- the biology of senescence or the study of fundamental processes that underlie brain ageing;
- the links between these processes and the disabling syndromes and diseases of old age; and
- the socio-economic outcomes for older people, their carers and the health service systems.

The partners agreed to focus the study on neurodegenerative disorders (NDDs) of older people to 2010 as these disorders were seen to become a priority health issue as Australia's ageing population increases in the first half of the twenty first century. Four neurodegenerative syndrome areas were targeted by the study: motor instability and balance failure, cognitive impairment, motor slowing and sensory impairment. This enabled the study to be completed within the time available. Despite its restricted focus, the findings of the study have considerable generality for health research and policy making, including the applicability of the foresighting methodology.

The partnership had two objectives:

- to test the use of 'foresighting techniques' for long-term planning, and
- to asses what Australia's S&T requirements are to meet the challenges offered by the prevalence of neurodegenerative disorders in our progressively ageing population

The critical foresighting steps included:

1. an analysis of the demographics of Australia's ageing population to 2010 and of Australia's current ageing research profile;
2. expert comment on Australia's ageing research profile;
3. a two-day workshop to develop health scenarios for 2010; and
4. a one-day workshop to identify Australian S&T opportunities, gaps and requirements to 2010.

A summary of the partnership's findings on the foresight process are shown in Box A2.12.

Box A2.12. Health Partnership Findings on the Foresight Process

Finding 1

A national survey is a valuable initial foresighting tool to create awareness and involvement of the sector and to identify key issues.

Finding 2

A comprehensive report, which documents the current situation with respect to research activity and which has been developed through the engagement of experts in the field, is recommended as a background document for an effective scenario-building workshop.

Finding 3

Organisations and sectors should consider the benefits of extensive expert interaction when planning foresighting programs.

Finding 4

A two-day scenario-building workshop followed by a one-day follow-up meeting is a valuable foresight technique for identifying long-term priority actions within a particular sector. The effectiveness of such workshops is dependent on:

- a skilled scenario facilitator
- a reliable and comprehensive background document outlining the current status of the issue/area being explored
- representation by key stakeholders in the sector

Finding 5

Organisations who plan foresighting should ensure that adequate time is provided for consultation before and after the completion of the formal workshop activity, and before the report is concluded.

This foresighting study identified four major S&T developments over the next 15 years which will impact significantly on the delivery of services to older people with NDDs. They are:

- improved biomedical knowledge-base achieved through the Human Genome Project, resulting in improved diagnostics and possible gene-based treatment of NDDs;

- improved understanding of the effects of environment on human health, including its influence on the occurrence and effects of neurodegenerative disorders;
- increased application of information technology developments on health diagnosis, prevention and treatment, resulting in increased availability of information at every level of management; and
- increase in bio materials and bio sensors applications, creating new opportunities for novel treatments and prevention strategies. This will apply to a 'suite of technologies', emanating from diverse scientific fields, including polymer chemistry and micro-electronics.

The Partnership's scenario-building workshop developed four contrasting scenarios describing Australia's health system to 2010. This is the crucial step in foresighting, and building on it depends on the enthusiastic participation of a well-informed group and on the skill of the scenario facilitator in condensing the thoughts of the group.

The scenarios are illustrated diagrammatically in Box 2.7. The figure illustrates the four scenarios developed through the identification of two axes of critical uncertainty about the future of the health system: the relative focus of the health care system on the individual or the community, and on treatment or prevention. A brief description of the four scenarios is given in Box A2.13.

Box A2.13. Health Partnership Scenario Summaries

'Cure Me' – treatment focused on the individual

This is a scenario in which the health care industry in Australia is privatised, and market forces determine the focus and direction of research and service delivery. There is global free trade, and multinational health care companies are more concerned about international export opportunities than national priorities. Funding for health care is provided by private health insurance, and the less well off have limited access to care. For those who can afford it, there tends to be over-treatment and overspending, and specialists proliferate. Technology has advanced significantly, and there are new drugs, and new electronic 'neural interface' prostheses. Much biomedical research is regarded as proprietary commercial information, and is not openly published.

'Cure Us All' – treatment focused on the community

This is a scenario in which there is a strong focus on social equity, and equal access to health care. There has been a resurgence of social priorities in political thinking, after the social failure of the market-led policies of the 1980s and 1990s. There is universal access to health care, and expenditure on health has risen to 15% of GDP. Technology is focused on solutions that improve the environment for elderly people with NDDs. The ergonomic design of products is required to provide ease of use for older people, and many innovations in the domestic environment improve mobility and capability for older people. There are many experiments with information technology to make features of the environment respond differently, according to the capabilities of the user. Personal emergency call systems are provided for everyone over 65. Progressive social thinking has also made euthanasia acceptable in most Australian states.

(cont'd)

Box A2.13. Health Partnership Scenario Summaries, cont'd

'Keep Me Healthy' – prevention focused on the individual

This is a scenario in which there is a global economic upswing, driven by the successful industrialisation of the Third World and the consequent expansion of markets for the already industrialised countries. There is an emphasis on social equity, and a successful balance of public and private interests has been established in Australia. Prevention programs of many kinds are available to the individual. The private insurance companies have been required by regulation to offer care packages that stress prevention, and this has driven the development of an active 'prevention industry'. Products range from personal genome and lifestyle assessment, to diet and exercise programs aimed at specific disease tendencies, to lifetime anti-oxidant supplements. Efforts are made to reduce workplace stress through work redesign, and computer-based personal health management software is in widespread use.

'Keep Us All Healthy' – prevention focused on the community

This is a scenario in which there is a very strong focus on community outcomes. Ecological and spiritual values dominate, in the wake of a rising series of environmental disasters worldwide. Government policies are dominated by a drive to achieve ecologically Sustainable Development (ESD), and economic policy is dominated by the new thinking of ecological economists. Epidemiology is highly developed, and many chemicals are restricted or banned because of their effects on health. Health records are standardised, and everyone is required to have a smart card that holds their medical history. There is general acceptance of legislation that restricts or bans products because of their adverse effects on health. Older people are returning to universities and colleges under a program of universal 'third age' education. The design of organisations is being changed to make them 'family friendly'.

All the scenarios make the assumption that Australian demographics are a smooth projection of the situation today, with no significant changes to immigration or birth rates. Similarly, there are no significant changes in epidemiological patterns from today's world. As a result there is a marked 'greying' of the population, and NDDs of older people are a major health care concern. Other population and epidemiological assumptions could be made for scenario purposes, but the chosen focus of this particular scenario exercise would be undercut if the demographics and epidemiology depicted did not give rise to a dominance of older age cohorts and the prevalence of NDDs. This aspect of the world of 2010 is therefore not specifically referred to in the scenario narratives, but is implied across all the scenarios as a background condition, because it has been arbitrarily defined as a 'predetermined element' in order to focus the scenarios.

For each of these possible futures certain S&T needs and trends are implied, and having completed its scenarios the partnership used them to identify:

- drivers which would influence the health future for older people to 2010;
- the possible contributions of S&T to each scenario; and
- the research priorities for each scenario.

By examining each scenario, the workshop identified the overall impact each 'future' would have on R&D and other health activity between now and 2010 – see Box A.3.14.

Box A2.14. Health Partnership Philosophy of R&D For Older People

INDIVIDUAL

TREATMENT ⟷ PREVENTION

COMMUNITY

Individual / Treatment

R&D
- market driven on cost effectiveness
- non disclosure

Other
- poor co-ordination
- private health care

Individual / Prevention

R&D
- hypothesis based prevention
- normative data

Other
- screening
- consumer engagement

Community / Treatment

R&D
- community drug trials
- cost benefit devices
- balanced medical and social

Other
- information technology interfaces
- basic health care priority

Community / Prevention

R&D
- normative data
- large scale intervention trials
- social and behavioural innovation

Other
- social map of life
- concept of community "wellness"

This general perspective for each scenario was then refined in terms of specific types of R&D that would be directed to neuro-degeneration if the scenario were to be realised in 2010. Box A2.15 identifies the potential priorities for R&D within the scenarios.

Finally, by ranking priorities and gathering them together the workshop developed an overall list of key R&D priorities across all scenarios. These can be grouped into a number of categories:

Data management and access

- Normative data
- Chemical database (to complement pharmacological lists)
- Personal genetic map
- Personal health databases

Education and skills

- Educational and training programs
- Educational experience and cognitive loss
- Activity programs

Research

- Research into social factors
- Basic brain science
- Understanding of cognition
- Motor control and coordination
- Nerve growth factors
- Disease aetiology and pathogenesis

- Tissue maintenance and repair
- Epidemiology
- Molecular markers
- Understanding of micronutrients
- Secure funding for key long term projects

Technology development

- Bioengineering
- Imaging technologies
- Physiological monitoring
- Ergonomics for older people

Delivery

- Best practice private health care delivery

Box A2.15. Health Partnership S&T priorities for each scenario

FOCUS ON THE INDIVIDUAL

FOCUS ON TREATMENT

FOCUS ON PREVENTION

FOCUS ON THE COMMUNITY

'Cure Me' Scenario

- Market-driven R&D
- Non-disclosure of R&D results
- Poor co-ordination of R&D
- Cost effectiveness of treatments
- Best practice private healthcare
- Imaging technology
- Drugs: genetic & proteins
- Customised bioengineering
- Tissue and organ maintenance and repair
- Drug delivery devices
- Implantable devices and materials
- Physiological sensors
- Robotic prostheses and assistants

'Keep Me Healthy' Scenario

- Normative data, all ages
- Screening instruments and training
- Design of educational and activity programs
- Consumer engagement in health planning
- Epidemiology
- Disease aetiology and pathogenesis
- Hypothesis-based R&D in prevention
- Extension of sports science
- Psychological role in health
- Prevention prior to conception and in utero
- Basic brain science
- Longevity research
- Molecular basis of NDD's

'Cure Us All' Scenario

- Community drug trials
- Prosthotic environments
- Personal monitoring devices
- Information technology interfaces
- Bioengineering
- Cost-benefit study of free devices
- Disease data base
- Priorities for basic health provision
- Ethical issues
- International research availability
- Balance medical and social research

'Keep Us All Healthy' Scenario

- Normative data, all ages
- Epidemiology
- Environmental impact on genetic maps
- Large scale intervention trials
- Micronutrient studies
- Functions foods, 'pharmaneutricals'
- Communication of new social 'map of life'
- Subjective aspects of experience & QOL
- Social and behavioural innovation
- Community correlates of 'wellness'
- Implant modulation of brain behaviour

The study then identified a number of actions necessary (Box A2.16).

Box A2.16. Health Partnership Recommendations

Recommendation One

It is recommended that the National Health and Medical Research Council (NHMRC) adopt foresighting techniques to assist in identifying priorities and directing funding within specific health areas and thus contribute to the long-term planning of research.

It is further recommended that the NHMRC's Strategic Planning and Evaluation Committee take responsibility for introducing foresighting to the NHMRC as a tool in undertaking its long-term planning strategies.

Recommendation Two

It is recommended that the NHMRC and other relevant research bodies support active participation of researchers in the Human Genome Project so that Australia can be an innovative contributor to this major area enabling wide access to the data rather than simply a purchaser of products. In particular, this involvement should include:

(i) improved alliances and collaboration with overseas groups, and

(ii) increased emphasis on skilling both researchers and clinicians to understand and apply the new therapies which are expected to emerge from the Human Genome Project.

Recommendation Three

It is recommended that the NHMRC seek research proposals directed to the identification of environmental risk factors which contribute to neurodegenerative disorders in older people. The research should consider:

(i) how these factors should be monitored

(ii) how unfavourable factors can be controlled, and

(iii) how favourable factors can be promoted.

Recommendation Four

It is recommended that the NHMRC and other relevant research funding bodies give priority support to social science research to identify and propose ways in which older people, including those with physical and cognitive impairment associated with NDDs and their family carers, will be able to fully access and use the developments in information technologies to enhance independent living.

Recommendation Five

That the Minister for Employment, Education and Training and the Minister for Health direct research funding bodies to recognise Australia's special skills in the area of biomedical engineering and build on these skills through:

(i) support of innovative biomedical applications for improved management of neurodegenerative disorders of older people in Australia to 2010 and beyond

(ii) identify particular opportunities for commercial development and sale of these products within the Asian-Pacific region.

(cont'd)

Box A2.16. Health Partnership Recommendations, cont'd

Recommendation Six

It is recommended that the relative priority given to gerontology and ageing skills development in medical schools be reviewed. This review should ensure that general practitioners will be skilled to manage neurodegenerative disorders in older people over the next 15 years and beyond.

Recommendation Seven

That the Office for the Aged continue to build on its ageing research database to contribute to improved management of neurodegenerative disorder in Australia.

Recommendation Eight

That the NHMRC and other relevant research and development funding bodies give priority support to inter-disciplinary research proposals which address the complementarity between molecular and genetic research, basic brain function research and social and behavioural research in improved management of neurodegenerative disorders of older people over the next 15 years and beyond.

Recommendation Nine

That networking between research funding bodies and service providers be improved in relation to the health requirements of older people in Australia. Given its role in long-term planning for health research, the NHMRC's Strategic Planning and Evaluation Committee, in conjunction with the Office for the Aged and peak State and private bodies representing older people, should oversee that a cohesive plan to ensure development of this networking.

Recommendation Ten

That the NHMRC, the Office for the Aged and peak bodies representing older people promote active engagement of representatives of older people in policy, planning and participation in research and program development concerning neurodegenerative disorders.

iv) The Youth Partnership

This partnership study explored the views of young Australians on probable and preferred futures for Australia and the role of S&T in shaping these futures.

How young people see Australia's future can have an important bearing on their expectations and outlook on life and their attitudes to matters such as education, vocational training, work and government. These considerations may in turn affect their own personal well-being and Australia's performance in setting and achieving national goals. Positive visions of Australia's future and the role of S&T in creating that future are important if we are to develop a more innovative and enterprising culture, in business and all other areas of national endeavour.

The partnership study had two complementary components:

- *Foresight Workshops* Using scenario foresighting techniques, groups of young people spent 1–2 days exploring the factors shaping Australia's future and how they can be managed. The workshops were held in April, May and June 1995. A cross–section of young people – school and university students, employed and unemployed, from urban and rural areas and from a range of ethnic and socio-economic backgrounds – participated in the foresighting process.
- *A National Youth Opinion Poll* A broad sample of 800 Australians aged 15–24 provided a quantitative measure of the attitudes and views expressed in the workshops. The poll was conducted by telephone.

The Youth partnership Steering Committee, established to oversee the partnership's foresighting activities, consisted of a wide cross-section of government and non-government organisations with an interest in and commitment to young Australians:

- Mr John Vines, Chair, ASTEC
- Ms Fiona Barbagallo, Advisory Group for the Science & Technology Awareness Program
- Ms Christina Bee, The National Science and Technology Centre
- Ms Geraldene Callanan, Australian Business Network
- Mr Chris Coleman, Youth Bureau, Department of Employment, Education and Training
- Mr Richard Eckersley, CSIRO
- Mr Robin Groves, Australian Science Teachers Association
- Dr Richard Haimes, Australian Business Network
- Ms Ann Morrow, Schools Council, National Board of Employment, Education and Training
- Mr Julian Pocock, Australian Youth Policy Action Coalition

i) Foresight Workshops

The project was initiated with a series of eight workshops, involving 150 young people, mostly aged 15–24 and from a variety of backgrounds. The workshops gave young people the chance to think about Australia's future, especially their preferred futures. The outcome of the workshops formed the basis for a national opinion poll of 800 young Australians aged 15-24, which enabled a broader group to give their views on the key issues that emerged from the workshops. An outline of the process used is shown in Box A2.17.

The main hopes and concerns young people raised in the scenario workshops were consistent across the groups. However, there were also differences of opinion on many issues and many individuals saw both good and bad in some important areas of change. It is not possible to say, with the technique used in the workshops, how widely the opinions expressed are shared, especially on the more specific aspects of the issues.

Box A2.17. The Youth Partnership Workshop Process

1. Introductory activity

The facilitators were introduced to the participants and, if necessary, the participants to each other. The facilitators briefly outlined ASTEC's Future Needs 2010 study and explained the purpose, aims and methods of the Youth partnership.

2. Identifying issues

The first task was to identify key issues – techniques for doing this included:

a. 'open space' technique – participants made notes of things they felt passionate, excited, or concerned about and put these up on a wall – the 'market place' – after which participants 'signed up' for issues they wanted to discuss;

b. after the whole group identified issues, prompted by questions from the session leader, participants broke up into groups of 4–5 to discuss these issues – the discussions included interviewing each other; and

c. pairs of participants were asked to produce two key questions about the year 2010 – groups of about four people then asked and answered each other's questions.

3. Identifying key drivers

Except in the case of the 'open space' technique, in which the clustering of issues had already been done, the participants worked as one group to cluster related issues into a manageable number. They then attempted to obtain a clearer and deeper understanding of the issues by identifying the key drivers or variables. This step included determining underlying patterns and structures.

4. Framing scenarios

Working in groups of 4–5, participants used the information from steps 2 and 3 to outline the expected and preferred outcomes for the major variables and issue clusters identified.

This included developing story 'snippets' and timelines to explore possible changes in particular variables or issues. In some cases, where time permitted, small groups reported back to the whole group.

5. Developing scenarios

Participants, again working mainly in small groups, used the outlines, timelines and snippets to flesh out scenarios for their probable and preferred futures. Time did not permit this part of the exercise to be completed, except in a few individual instances.

6. Assessing implications

Participants used the scenarios to consider the implications for Australia today, especially in terms of what was required to achieve the preferred future(s) rather than the expected future. Again, time constraints and the participants' tiredness at this stage of the process, meant that this session tended to be brief and less productive.

The issues emerging from workshops were in two main groups: the *Face of Australian Society* and the *State of the Environment*, an summary of views identified in each of these areas is given below.

- ***The Face of Australian Society:***

  Global context: Australia continues to be perceived as 'the lucky country', which does not face the same problems and pressures as many other parts of the world. However, young

Australians also recognise that their country is increasingly becoming integrated with the rest of the world through the processes of economic and cultural globalisation.

Community and family: A stronger sense of community is a key issue. Young people hope for justice, equality and community spirit. They see this as unlikely due to misplaced values leading to a widening gap as 'the rich get richer and the poor get poorer'. They acknowledge that traditional family structures are changing but are concerned that the changes may not be for the best. Some see a need for harsher penalties, even the re-introduction of capital punishment, to prevent an increase in crime.

Multicultural Australia: True multiculturalism is important to the young people of Australia. They are concerned about racism and that the problem is growing, rather than decreasing. Equal rights on the grounds of race as well as gender and sexual preference are all of concern to young people for the future.

Government and the economy: A major concern of young people today is the lack of a long-term and holistic approach to government policies. In their eyes, the government must consider the future now and listen to the concerns of the public.

Education: Despite differences in education systems and socio-economic experience, young Australians share similar concerns and hopes. They are interested in the direction that the education system is taking and its influence on people. However, personal circumstances also influence the emphasis individuals place on the many educational issues. Those living in remote and rural areas comment on the lack of funds, choice and resources available to them. Others are concerned about the content and cost of tertiary education and the need to make it accessible to all. Some young people believe that foreign students are given priority due to their financial position. There is also an impression that a good education does not necessarily aid in getting a job. Some see educated people as instrumental in changing society.

Health and well-being: Young people's views about the future of health reflect extremes of both optimism and pessimism. There are mixed feelings about how S&T will cope with the evolution of diseases. Drug use and abuse is universally relevant to young Australians. They are aware of the social and economic problems associated with drugs.

The media: The media has a major influence on how young people see the world and their future. Concern was expressed about this influence and the validity of information put out by the media. Although the media can play an important and positive role in educating people about real and valid issues, it was noted that trivial distractions and a focus on discord and conflict have a dangerous and negative effect. Young people are also concerned about media ownership.

- ***The State of the Environment:***

The global context: Young Australians care about the future of the global environment – perhaps more than any other issue. They are articulate and passionate about the likely ecological crises they see emerging between now and the year 2010. One of the perceived results of poor environmental management is climate change, and young people are aware that environmentally irresponsible actions may affect the climate, both locally and globally. They envisage a future in which economics and environment progress 'hand-in-hand'. The practice of S&T is seen as being instrumental in both the destruction and healing of the earth's environment. Many young Australians believe that in order to meet the challenge of thoughtful resource and land management, people will need to change their lifestyle. They consider people need to embrace a sustainable, low-impact existence in which they retain a spiritual link to, and appreciation of, the natural environment and other species. Young people believe that the global nature of environmental problems calls for an appropriate global response. The feeling is that people are 'all in this together'. They think international negotiations need to result in the imposition of strict laws on logging practices, industrial and domestic waste disposal and greenhouse emissions. International aid needs to be provided to those who rely for their livelihood on activities which cause environmental damage.

Population: Population is a global issue frequently mentioned in discussions about the future. Young people appreciate the problems related to the current population increase. Many of the effects of an increasing population are environmental, concerned with resource availability and problems associated with high density living.

Resource use and industry: One of the main environmental concerns apparent to young people, particularly in rural areas, involves resource management. They believe that there is much room for improvement as the availability of resources is a major contributing factor to quality of life. Industrial practices are seen as one of the major causes of environmental problems and an issue that must be addressed urgently. Restrictions and limitations on resource use are seen as important. As individuals and as a society more accountability for excessive resource use and environmental degradation is considered necessary. Current agricultural practices need to be addressed, promoting activities such as Landcare. Recycling needs to be enforced, and the use of alternative resources to reduce the impact on the environment are favoured. Clean technology and sustainable industries need to be developed.

Government policies: While acknowledging that there is great individual responsibility for the environment, young people see governments' roles in policy-making as vital to environmental futures. There is a need to develop vehicles that use alternative fuel resources (for example, electric vehicles). This is linked to the question of future supplies of polluting, non-renewable fuels. Careful urban planning is seen by many as needed to control urban sprawl and its environmental and social impacts. Young people want improvements made to public transport systems, to make them cheaper, more efficient, accessible and secure. Some want cars eliminated from central business districts and replaced by alternatives such as light rail or bicycle transport. Government strategy is of paramount importance to changing attitudes, eg use of the taxation system to reprimand polluters and excessive consumers. Young people believe that, through substantial education about environmental issues, people will develop an increased consciousness, concern and awareness of the global environment. Active attention needs to be paid to issues of biodiversity, conservation, pollution, agricultural practices, animal testing and above all, the preservation and improvement of the planet.

ii) A National Youth Opinion Poll

The second phase of the Youth Partnership study was the conduct of a national opinion poll of young peoples' views on the future and the role of S&T in shaping the future. The Steering Committee commissioned AMR: Quantum Harris to undertake the national opinion poll.

The Poll was based on the topics identified in the workshops, and set out in the previous chapter, as being of concern to young Australians. The poll provides a quantitative measure of opinions, expectations and preferences of a much larger group of young Australians on these matters.

The poll was conducted by telephone with people aged 15–24 years of age and featured:

- a total of 802 interviews;
- equal quotas of male and female;
- a structured sample, so that the number of interviews in each state capital and non metropolitan state area was proportional to the Australian youth population; and
- weighting of the data by gender and age, based on 1991 census figures.

The results of the poll form a representative framework of youth opinions in the areas of:

- world's future in the year 2010;

- expectations regarding Australia's general future state in the year 2010;
- expectations regarding the future of specific aspects of Australian life in the year 2010;
- the role of the media in shaping Australia's future;
- preferred scenarios for Australia's future in the year 2010; and
- the role of science and technology in Australia.

Two different scenarios for Australia in 2010 were presented in the poll to determine the expectations and preferences of young Australians: the scenarios were based on a groupings of factors that emerged from the workshops:

> **'Growth' scenario:** A fast-paced, internationally competitive society, with the emphasis on the individual, wealth generation and 'enjoying the good life'. Power has shifted to international organisations and business corporations. Technologically advanced, with the focus on economic growth and efficiency and the development of new consumer products.
>
> **'Green' scenario:** A 'greener', more stable society, where the emphasis is on cooperation, community and family, more equal distribution of wealth and greater economic self-sufficiency. An international outlook, but strong national and local orientation and control. Technologically advanced, with the focus on building communities living in harmony with the environment, including greater use of alternative and renewable resources.

Young people *expect* that Australia will be closer to the internationally competitive 'growth' scenario (63%) than the 'green' scenario (35%). However, their *preference* is strongly for the 'green' scenario (81%) than the internationally competitive scenario (16%). Therefore the majority of young Australians do not expect to be living in their preferred Australia. Choice of expected or preferred scenarios does not vary with gender, age or region.

The poll showed that most young people are concerned – and care – about the future of the world. It also showed that amongst young people:

- a slight majority (55%) believe the world's future is one of 'more people, environmental destruction, new diseases and ethnic and regional conflicts ... heading for a bad time of crisis and trouble', compared with just below half (41%) who believe the world by 'continuing on its current path of economic and technological development ... (will) enter a new age of peace and prosperity';
- about one-third (35%) believe that the quality of life in Australia will improve, while almost the same number believe it will worsen, and another third believe it will be the same; and
- more than half expect the environment, the gap between rich and poor and crime and violence to be worse in 2010 than it is now; and
- pessimism about the future is more prevalent among females and in most cases increases with age in both females and males.

The use of a structured scenario development process, followed by the national poll, and the focus on identifying preferred futures distinguish this project from other studies. Within the limitations of both workshop and polling techniques, the project produced important data about young Australians' views on S&T. The broad findings from the combination of the workshops and the poll on S&T include the following:

- young people see an important role for S&T in meeting the challenges ahead, but are also concerned about some of the consequences and outcomes of scientific and technological advances;

- young Australians who are optimistic about the quality of life in the year 2010 tend to view S&T more favourably than others; and
- a majority (87%) expect S&T to conquer new diseases and believe S&T offers the best hope for meeting the challenges ahead (69%);

Young people's preferred visions, as identified in the workshops, suggest that they believe there needs to be a fundamental re-appraisal of community values and priorities if their concerns are to be resolved. To the extent that they are optimistic about the future, this optimism rests, at least in part, on the expectation that this shift will occur. This study suggests that science and technology can play a major role in achieving this new vision.

The partnership believes the findings pose a major challenge for the Australian community which needs to be addressed if Australia is to realise its potential, in every sphere, domestically and internationally.

The recommendations of the partnership are shown in Box A2.18.

Box A2.18. Youth Partnership Recommendations

Recommendation 1

Noting the importance to Australia's future of engaging young people in S&T, it is recommended that:

- action be taken by Commonwealth, State and Territory Governments to enhance S&T education (through both the formal education system and more general community programs) to:
  - encourage more young people to be interested in S&T and to pursue studies and careers in S&T;
  - provide all young people with a general understanding of S&T as important skills for living; and
  - ensure that a relevant social context, which reflects national goals and young people's concerns and priorities, is made explicit in schools' S&T curricula.

Recommendation 2

Noting that young Australians see S&T as playing a major role in meeting the challenges ahead but also see serious disadvantages arising from S&T developments, it is recommended that:

- the Commonwealth Government promote a wider awareness of how S&T currently contribute to solving real problems facing Australia in social and environmental areas; and
- research institutions, funding agencies and governments take young people's concerns and preferred outcomes into account in determining research and development priorities.

(cont'd)

Box A2.18. Youth Partnership Recommendations, cont'd

Recommendation 3

Noting the gender differences which emerged in this study which indicate girls and young women are more concerned about the future and the social context of S&T, as well as the low rates of female participation in S&T, and the current work being undertaken by the Office of the Status of Women on the gender-technology relationship, it is recommended that:

- the Commonwealth Government ensure that the social concerns of girls and young women in relation to future S&T are taken into account in decision making in these areas.

Recommendation 4

Noting the need to involve many different parts of the community in developing an holistic approach (across portfolio responsibilities) to programs for young people; and in particular the central role young people themselves must have in this process, it is recommended that:

- the Commonwealth Government, in the context of the next budget, ask the Youth Bureau, assisted by relevant S&T agencies as appropriate, to convene a conference of representatives of young people, government, education, media and the social sciences to establish priorities for a focused Program of Action on 'the Potential Contribution of Science and Technology to the Future of Young Australians'.

Recommendation 5

Noting young people's expressed commitment to achieving an inclusive and ecologically sustainable Australia, and taking note of the severe labour market restrictions in particular communities, it is recommended that:

- the Commonwealth Government expand the opportunities and allowable time people in receipt of income support can spend taking part in 'public good' and other volunteer activities. This could include community service, environmental conservation and rehabilitation work experience, youth leadership programs or personal development activities.

Recommendation 6

Noting the strong views of young people on issues such as environment, crime and the increasing gap between 'haves' and 'have nots', it is recommended that:

- the Commonwealth Government develop a more comprehensive view of young people's preferred futures for Australia; and require government departments and other policy development structures to consider young people's views in the formation of advice to Government in key areas including S&T, education, taxation, health and the environment.

Recommendation 7

Noting young people's high level of interest and concern on environmental issues and the Commonwealth's commitment to ensure intergenerational equity, it is recommended that:

- the Commonwealth Government establish a specific mechanism (eg a Youth Council on the Environment) to provide advice regularly to the Prime Minister and the Minister for the Environment on environmental issues of specific concern to young people.

Recommendation 8

Noting that the findings of this study replicate those of many other surveys in recognising that young Australians are concerned over their lack of input into government decision making, it is recommended that:

- the Commonwealth Government request DEET to consider ways in which Education Network Australia (EdNA) might be utilised to enable young people to provide continuing commentary on government policies and programs; and
- the Commonwealth Government investigate ways in which it might utilise newly developed channels, such as the Internet, to broaden input to its policy development process.

Box A2.18. Youth Partnership Recommendations, cont'd

Recommendation 9

Noting the central role of the media in conveying views and information on S&T to young people, their need to access this information and the changing role of the media in Australia, it is recommended that:

- the Commonwealth Government encourage State governments to ensure that the education system specifically addresses the need for young people to develop the social-critical facilities necessary for making sound judgments about information obtained from the media; and
- the Commonwealth Government investigate ways to encourage the media to adopt more positive and responsible roles in addressing concerns about the future and the roles of S&T in helping Australians achieve the society they want.

Recommendation 10

Noting the consistent reports of pessimism about world futures found in this and other studies of youth, it is recommended that:

- the Commonwealth Government fund a research project aimed at developing a better understanding of the world view of young people, any implications for them personally and for Australian society.

Recommendation 11

Noting the success of the foresight workshops in building more positive visions of the future amongst mid secondary school students, it is recommended that:

- Australian Governments provide opportunities for students in mid secondary school to experience the ways in which the technique of foresight can encourage the development of more positive and engaging visions of the future as well as an attitude which enables young people to manage their role in the future; and
- Australian governments consider the merits of developing this methodology for use in consultations with special groups, in particular, younger age groups and different cultural backgrounds and those who are in positions of social or economic disadvantage.

v) *The Shipping Partnership*

The Shipping Partnership was the last of the partnerships to be started and had the longest planned program of activities, including a two stage Delphi survey. Once it became clear that the program would not be completed within the same time-frame as the rest of the study, the Council decided to treat it as a separate study.

The Shipping Partnership was formed in May 1995. Its members are drawn from a cross section of government departments, industry and research organisations. The partnership comprises twelve financial members and three learned societies:

- Australian Defence Industries (ADI) Marine
- Australian Maritime Engineering Cooperative Research Centre (AMECRC)
- Australian Shipowners' Association
- ASTEC
- BHP Transport
- Blohm & Voss (Australia)
- Caterpillar of Australia
- Cooperative Research Centre for Materials, Welding and Joining (CRCMWJ)
- Department of Defence (DOD)
- Department of Industry, Science and Technology (DIST)
- Department of Transport (DOT)
- Lloyds Register of Shipping
- Institution of Engineers, Australia
- Institute of Marine Engineers
- Royal Institution of Naval Architecture

The Shipping Partnership's Report examines the S&T and skills required for an innovative and sustainable shipping and shipbuilding industry in Australia to the year 2010.

The ASTEC Shipping Partnership methodology was in three phases:

Pre-foresight

- Preparation of background paper outlining key issues confronting nine sub-sectors of the maritime industry. The sub-sectors: ship design; ship manufacture; ship ownership and operation; research and development, transport; warship design and production, industry suppliers; Exclusive Economic Zone and cargo handling provided the fields in which topics were surveyed and where possible developments in science and technology would occur.
- Major roundtable in August 1995 with experts from a cross section of the maritime community to design a set of topic statements for each subsection to incorporate into the Delphi survey. The roundtable resulted in the some 80 topic statements being developed, with 74 questions being included in the final survey. Partners and attendees at the roundtable were asked to nominate between 8 and 10 people to complete the survey. Nominations were placed in a database and the names formed the basis of the survey respondent list.

Main foresight

- Round one of the Delphi survey was sent to 560 people. Following receipt of surveys from round one, the ABS processed the results and prepared preliminary findings on the outcome. A second round of 200 survey forms was then despatched to respondents returning round one forms.

Post foresight

- The final stage of the process involved the analysis of data from round one and round two and the production of a report containing the results of the Delphi survey. Following the launch of the report, the results will be disseminated to stakeholders throughout the maritime industry.

i) Delphi survey

The Partnership used the Delphi survey as its foresight tool. The Shipping Partnership Delphi Survey on *S&T Directions in the Maritime Industries to 2010* was conducted in two rounds, in September 1995 and January/February 1996. An Australian Bureau of Statistics Consultancy Group compiled and analysed the survey results for the Partnership.

The survey's questionnaire sought views from people with knowledge and experience in the maritime industries on 74 topic statements, which postulated developments in the areas of: ship design; ship manufacture; ship ownership and operation; research and development; transport; warship design and production; industry suppliers; the EEZ and cargo handling.

A total of 550 survey forms were dispatched to nominated persons. 135 people completed both round one and round two of the survey, representing a final response of 24.5 per cent. This response is low when compared with ABS national surveys but not unreasonable for a survey of this kind, which was voluntary, difficult and time-consuming to complete and the first of its kind conducted in the maritime industry in Australia.

Australia's S&T Priorities and Opportunities

The survey results steps by which the partnership selected priorities are outlined in Box A2.19. This process resulted in 36 topic statements being identified for consideration as S&T priorities.

Box A2.19. Five Steps for establishing S&T priorities in the maritime industry

Step 1. Assessment of wealth and quality of life impacts.

Rationale: Foresight is ultimately concerned with how S&T contribute to wealth creation for Australian industry, Australian economic well-being and quality of life.

Method: Topic statements were examined for their assessed ability to contribute jointly to wealth creation and quality of life, ie a sustainable industry.

Step 2. Identification of Australian capabilities.

Rationale: S&T and innovation can only contribute to wealth creation and quality of life if they are embodied in commercial products, processes, services or regulatory activities.

Method: The Partnership used a weighted formula to arrive at a composite rating for Australia's capabilities (ie S&T capability, innovation capability, production capability or service delivery and exploitation and commercial potential) for each topic statement.

(cont'd)

Box A2.19. Five Steps for establishing S&T priorities in the maritime industry, cont'd

Step 3: Identification of topic statements rated highly on both wealth creation/quality of life grounds and for positive overall/ above average overall Australian capabilities.

Rationale: Topic statements rated high on both grounds have the greatest claims for consideration as priorities.

Method: A comparison was made between topic statements with high capability ratings and those with high wealth creation/quality of life impacts ratings.

Step 4: Exclusion of non-starters

Rationale: The Partnership considered there was no point in pursuing topic statements which respondents rated low on wealth creation/quality of life impact and on Australian capabilities.

Method: The lowest rating topic statements identified in Steps 1–3 above were excluded from further consideration as S&T priorities at this stage.

Step 5: Identification of S&T priority clusters

Rationale: The sub-sector categories in the Delphi survey, eg ship design, industry suppliers, included topic statements which were related to one another or to topic statements in other categories. In assessing overall priorities it is logical to treat these inter-related topic statements as groups or clusters.

Method: By examining the topic statements identified in Step 3 above, it was possible to identify clusters of topic statements with linkages and logical connections between individual items.

The principal priority areas identified by this process were:

- **Fast ship transportation for passengers and cargo;**
- **Maritime defence opportunities; and**
- **Exclusive Economic Zone (EEZ) resources and management.**

Priority Area: Fast Ship Transportation for Passengers & Cargo

The export of Australian designed and built fast ferries for passengers and vehicles has been an Australian shipbuilding industry economic success story in the 1990s. In the future, the development of an Australian high-speed vessel regional cargo service appears to be a viable option. Australia's leading position, however, is under increasing threat as overseas suppliers recognise the commercial opportunities and endeavour to exploit them. This priority area is structured as a core cluster containing two key topic statements relating to the production of specialised ships and shipping and storage technology for fast cargo transportation and five sub-clusters of 3–6 topic statements each relating to design initiative, design technology, construction efficiency, maritime safety and environmental impact, port infrastructure and export opportunities. The topic statements for this priority area are shown in Box A2.20.

Box A2.20. Fast Ship Transportation for Passengers & Cargo

Topic statements	Timeframe for realisation	Main constraint/s
1. Environmental regulations have a significant impact on ship design.	1995–2000	Economic. viability
2. Nearly all ships will be designed for whole-life, with particular stress on economic repair and maintenance.	1995–2000	Industry/ commercial
4. A wide range of ship designs can be selected and customised interactively and detailed design for production information can be accessed by using commercially available software.	1995–2000	Funding
5. Ship performance can be accurately predicted by computational methods rather than physical model tests.	2001–2005	Industry/ commercial
9. New materials, ie other than conventional steels and aluminium, are in widespread use.	1995–2000	Technological feasibility, Funding
10. Ship manufacture has become a priority component in the ship design process.	1995–2000	Industry/ commercial
11. Mechanisation, automation and advanced robotics are in widespread use in ship manufacture.	2001–2005	Industry/ commercial Skills
12. A systems integration approach to ship manufacture, using modular assembly, is in widespread use.	1995–2000	Industry/ commercial
14. Australian shipbuilders with certification to ISO 9000 series are able to deliver vessels with certification of compliance with regulations.	1995–2000	Industry/ commercial
16. Benchmarking and comparative productivity assessments are widespread.	1995–2000	Industry/ commercial
17. New joining technologies are in widespread use.	1995–2000	Industry/ commercial, Skills
20. Transport infrastructure which permits maximum efficiency in door to door delivery of cargo, both nationally and internationally, has been developed.	1995–2000	Industry/ commercial
22. An increased supply of special purpose shipping and facilities, which meets changing client needs, is available worldwide.	1995–2000	Economic viability
23. Shipping and storage technology, which provides a competitive advantage in the transport of quality perishable food products, is in widespread use.	1995–2000	Industry/ commercial
27. Surveillance systems, which enable avoidance of floating and submerged obstacles by vessels moving at up to 100 knots, are in practical use.	2001–2005	Technological feasibility
29. Technologies which substantially reduce water and air resistance of vessels have been developed.	1995–2000	Funding
31. Substantially improved condition and stress monitoring technologies for ships have been developed.	1995–2000	Funding
32. Advances in ride control and reduction in ship motion permit higher speeds in all weather conditions.	1995–2000	Technological feasibility.

Topic statements	Timeframe for realisation	Main constraint/s
34. Computer integrated manufacturing (CIM) is in widespread use in ship manufacture.	1995–2000	Funding
38. Intelligent marine traffic management for navigation in congested and environmentally sensitive waters is widespread.	1995–2000	Regulation/ policy
39. Government has an expanded role in the development and enforcement of technical standards for safety and environment protection.	1995–2000	Regulation/ policy
40. Automated port infrastructure including cargo handling equipment is in practical use.	2001–2005	Industry/ commercial
43. Advanced information technology which facilitates cargo movement is in widespread use (eg EDI, chartering via Internet, paperless trading).	1995–2000	Industry/ commercial
65. Joint ventures between customers, builders and suppliers for local and regional ship manufacture are widespread.	1995–2000	Industry/ commercial
66. Australian services related to ship support have gained a substantial share of the regional market (eg design, project management and training).	2001–2005	Industry/ commercial
67. Australia has gained a substantial share of the regional market for specialised ships.	1995–2000	Industry/ commercial
67. Australia has gained a substantial share of the regional market for specialised ships.	1995–2000	Industry/ commercial

Priority Area: Maritime Defence Opportunities

The last decade has seen a resurgence in Australia's naval shipbuilding capability and capacity and the Royal Australian Navy (RAN) is still the major customer for the Australian shipbuilding industry. The development of Australia's self-reliant maritime defence capability is focused on three areas: presence and surveillance, defence of territories and contiguous zones and trade protection. Coupled with the defence requirement for ships are the likely needs of a national authority tasked with enforcement of regulations which apply to Australia's marine zones. The surveillance and enforcement role has yet to be determined.

As regional defence forces seek to replace ageing units or make improvements to existing capability, Australia's industry needs to be alert to the opportunities for involvement, since there is insufficient new build, repair and modification work programmed for the RAN to support the current number of indigenous warship design, construction and repair facilities in the period to 2010.

To become involved in meeting these requirements, to retain existing expertise and to remain financially viable, Australian industry, and shipbuilders in particular, must tender a product which offers 'value for money' when compared with competing offers. This can be interpreted in minimal terms as an offer meeting, if not exceeding, all capability requirements, being priced very competitively and, providing cost-effective through-life support.

Table A2.21. Maritime Defence Cluster

Topic statements	Timeframe for realisation	Main constraint/s
2. Nearly all ships will be designed for whole-life, with particular stress on economic repair and maintenance.	1995–2000	Industry/ commercial
10. Ship manufacture has become a priority component in the ship design process.	1995–2000	Industry/ commercial
12. A systems integration approach to ship manufacture, using modular assembly, is in widespread use.	1995–2000	Industry/ commercial
16. Benchmarking and comparative productivity assessments are widespread.	1995–2000	Industry/ commercial
16. Benchmarking and comparative productivity assessments are widespread.	1995–2000	Industry/ commercial
34. Computer integrated manufacturing (CIM) is in widespread use in ship manufacture.	1995–2000	Funding
45. Commercially available technology is in widespread use in warships.	1995–2000	Industry/ commercial
48. A sustainable Australian industry base is capable of the design and development of all types of warships.	1995–2000	Economic viability
48. A sustainable Australian industry base is capable of the design and development of all types of warships.	1995–2000	Economic viability
52. Surface combatants capable of hybrid amphibious operation, with speeds in excess of 50 knots have been developed.	2001–2005	Technical. feasibility
53. Light weight vessels with speeds in excess of 50 knots are in widespread use in military operations.	2001–2005	Funding
63. The generation and retention of intellectual property rights for suppliers of equipment used in ship manufacture are widespread.	1995–2000	Industry/ commercial
65. Joint ventures between customers, builders and suppliers for local and regional ship manufacture are widespread.	1995–2000	Industry/ commercial
66. Australian services related to ship support have gained a substantial share of the regional market (eg design, project management and training).	2001–2005	Industry/ commercial
67. Australia has gained a substantial share of the regional market for specialised ships.	1995–2000	Industry/ commercial
67. Australia has gained a substantial share of the regional market for specialised ships.	1995–2000	Industry/ commercial

Priority Area: EEZ Resources and Management

There are very considerable opportunities for Australian industry arising from the creation of Australia's EEZ but the scale of the opportunities must be quantified. Natural fish stocks are in decline and opportunities exist in mariculture beyond the 12 nautical mile limit. Offshore oil, gas and engineering currently contribute over $8 billion per annum to the economy and 90 per cent of untapped resources are thought to be offshore. Leisure pursuits are a growing and important revenue earner. The extraction of deep sea bed minerals (eg cobalt) could become important for Australia after the year 2010, if technological and economic viability hurdles can be overcome.

Table A2.22. EEZ Resources and Management Sub-cluster

Topic statements	Timeframe for realisation	Main constraint/s
54. Management systems, which provide an integrated and coordinated approach to the marine environment are in widespread use.	2001–2005	Common-wealth/State
55. Recovery of oil and gas at depths 50% greater than at present is widespread.	2001–2005	Economic viability/ technical feasibility.
57. A national authority has been established to regulate Australia's marine zones.	2001–2005	Common-wealth/State
58. A national authority has been established to enforce the regulations which apply to Australia's marine zones.	2001–2005	Common-wealth/State
59. A national marine database for the EEZ is in widespread use including physical, resource and biological data.	2001–2005	Common-wealth/State
60. The extraction of deep sea bed mineral resources is widespread.	2010+	Technical feasibility.
61. Marine farming has substantially replaced the fishing of wild stocks.	2001–2005	Technical feasibility
62. Multi-lateral cooperation in the management of oceans and seas in Australia's proximity is widespread.	2001–2005	Common-wealth/State

This priority area received the highest combined mean score for Australian opportunities and capabilities. This reflects respondents' positive views about the opportunities for Australia arising from the EEZ, Australia's capabilities to take advantage of these opportunities and their view that the creation of a national authority or central coordinating agency is critically important to exploit the opportunities and to fulfil Australia's obligations arising from proclamation of Australia's marine zones.

Other important issues included: managing ballast water; export of marine equipment and marine management expertise; cargo handling and measurement technologies; and marine pollution monitoring systems.

ii) Recommendations

The Partnership made 18 recommendations:

Recommendations relating to the development of an Australian shipbuilding industry development program:

Recommendation 1: That the Australian Maritime Engineering Cooperative Research Centre's (AMECRC) participants lay the foundation for an Australian shipbuilding industry development program fostering innovation in shipbuilding and covering such elements as strategic marketing, design and production process improvement, collaboration and technology transfer.

Recommendation 2: That the Departments of Defence and Industry, Science and Tourism, in conjunction with Australian shipbuilders, develop and implement such a program.

Recommendations relating to the three Priority Areas identified in the study:

i) Fast ship transportation for passengers and cargo

Design initiative

Recommendation 3: That the Australian Maritime Engineering Cooperative Research Centre (AMECRC) and the Cooperative Research Centre for Materials, Welding and Joining (CRCMWJ) continue to give priority in their research programs to supporting imaginative and technology intensive concepts to improve ship performance.

Design technology

Recommendation 4: That industry foster the creation of design and professional engineering expertise to avoid possible future increasing reliance on overseas design capability and minimal indigenous intellectual property ownership.

Construction efficiency

Recommendation 5: That the AMECRC and CRCMWJ continue to expand their collaboration on the integration of design and construction technology. As this cannot be fully effective without active shipbuilder input, the Partnership should work through the Australian Shipbuilders Association to bring about such participation.

Port infrastructure

Recommendation 6: That the Government, through the AMECRC, support R&D on technologies associated with port interface in terms of both the physical aspects and the information interface.

Recommendation 7: That the Government continue to give priority to implementing policies aimed at improving waterfront performance to enable industry to take full advantage of new technologies which would improve port efficiencies.

Export opportunities

Recommendation 8: That the Government support industry access to regional market opportunities, for example through continued support for Government market intelligence and strategic market research activities, through strategic alliances and joint ventures.

Recommendation 9: That, consistent with Australia's international obligations, the Government implement policies that encourage Australian shipowners to buy Australian fast ships for operation under the Australian flag.

ii) Maritime defence opportunities

Design initiative

Recommendation 10: That the Government requirement for open and effective competition in all shipbuilding and repair contracting arrangements be balanced by having longer term contracts which not only cover the build but the necessary through-life support requirements.

Recommendation 11: That the Shipping Partnership investigate ways of fostering an adequate Australian design and professional capability with government, learned societies and industry.

Recommendation 12: That the Department of Defence consider the use of ship design consultancies when developing conceptual designs for tendering purposes.

Recommendation 13: That Defence shipbuilding, maintenance and repair requirements be programmed with high priority consideration being given to the needs for industry in terms of skills retention and development.

Recommendation 14: The Partnership considers the capability to design and build warships to be of such strategic importance to the development of the industry and to the defence of Australia that it recommends the Government add this to the list of industry capabilities considered as most important for Australia's self-reliance in defence.

Construction efficiency

Recommendation 15: That the partners identify a suitable set of benchmarking measures so that a basis for comparisons of international competitiveness and continual improvement can be established for the Australian shipbuilding industry.

Export opportunities

Recommendation 16: That the Government, where appropriate, support industry bids in off-shore markets, through such mechanisms as access to financing, increased training and R&D programs.

iii) EEZ management

Recommendation 17: That the Federal Government, working with State/Territory governments, consider the establishment of a central agency or authority to fulfil Australia's obligations, arising from proclamation of Australia's marine zones. The agency's functions would include regulation, surveillance and enforcement of Australia's marine zones, integration and coordination of Australia's approach to the marine environment, the further development of a national EEZ marine data base and regional cooperation.

Recommendation 18: That the Government give consideration, as a matter of priority, to the development of suitable ships and technologies which will enable the EEZ to be effectively managed, regulated and monitored.

The Partnership believes that the steps proposed in its list of recommendations will lay the foundation for an innovative Australian shipping and shipbuilding industry for the future. It envisages a 'partnership approach' to implementation which will require, inter alia, that:

Industry

- foster the creation of design and professional engineering expertise to avoid possible future increasing reliance on overseas design capability;
- support CRC collaboration on the integration of design and construction technology; and
- develop and implement a national shipbuilding industry development program.

The Cooperative Research Centres

- lay the foundation for a national shipbuilding industry development program;
- give priority in their research programs to supporting imaginative and technologically intensive concepts to improve ship performance; and
- support research into technologies associated with port interface efficiencies in terms of both the physical aspects and the information interface.

The Department of Defence

- consider longer term contracts covering both the acquisition phase and through life support requirements;
- consider the use of ship design consultancies when developing conceptual designs for tendering processes;
- give consideration to industry needs in terms of skills retention and development when programming ship construction, maintenance and repair requirements; and
- investigate the feasibility for military operations of high-speed light-weight vessels.

The Federal Government

- support R&D and the maintenance of workforce skills;
- implement policies that encourage Australian shipowners to buy Australian-built fast ships for operation under the Australian flag;
- implement policies aimed at improving waterfront performance;
- promote a self reliant Australian warship design and construction capability within Australian industry;
- consider the establishment of a national authority for EEZ resource assessment, exploitation and management; and
- support industry penetration of market opportunities in the region, for example through continued support for Austrade's market intelligence and strategic market research activities, through strategic alliances and joint ventures.

The Shipping Partnership

For its part, the Partnership intends to disseminate information and encourage implementation of recommendations. It will consult and work with other bodies (eg. AMISC, Government Oceans Policy, AMSA) to investigate ways of fostering an adequate Australian design and professional capability; and will identify a suitable set of benchmarking measures for the Australian shipbuilding industry.