Research and Technology: Future Directions

1991
My dear Prime Minister

We have the honour of submitting to you a report entitled Research and Technology: Future Directions. It has been prepared in response to your request of 30 July 1990 that ASTEC initiate the process leading to a White Paper on science and technology as we recommended in our earlier report Setting Directions for Australian Research.

Research and Technology: Future Directions deals with the major issues which Australia must face if it is to maximise the contribution of research and technology to economic development and to social well-being.

The scope of the report is broader than either science and technology or research and development. At the outset of the study, ASTEC decided that the widest possible range of research and technology issues should be eligible for discussion. Research has been defined in the report as the pursuit of new knowledge. It embraces the humanities and social sciences as well as the natural sciences and engineering. Technology has been defined as the application of knowledge. It embraces experimental development arising from indigenous research, technology transfer from overseas and its diffusion, and the overall environment for innovation in Australia.

ASTEC has adopted this approach because it is convinced that research and technology, defined in this broader way, are of crucial significance to Australia. Further, research and technology require strategic planning and management to ensure that our limited resources are committed to areas of highest national priority.
A healthy and innovative research system contributes to the generation of wealth and the creation of more secure, stable and robust economic conditions. It is also important in achieving steady improvements in the community's quality of life. The structural changes to the research and technology system over the last five years have greatly improved the capacity of the system to provide real returns to the Australian community. In ASTEC's view, further major structural changes are not warranted at this stage. However, improvements can be made and the report draws attention to these in its discussion of issues and options.

Consultation with the industry, government and higher education sectors has been an integral part of the development of Research and Technology: Future Directions. ASTEC received nearly two hundred submissions, held a similar number of consultations in the capital cities, and undertook a special program of interviews with nearly one hundred industry leaders. The consultative process has contributed many valuable insights to the report, and will help to provide a constructive climate for the future directions of Australian research and technology.

Yours sincerely

Ray Martin
Chairman

For and on behalf of

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A W Goldsworthy
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Executive summary

This issues and options report is framed around the conviction that research and technology are matters of strategic importance to all Australians. They require a long-term perspective and the adoption of a planned approach which extends well beyond the annual budgetary cycle. The notion of direction setting is not new. It has long been part of the basic philosophy of the business community and, more recently, of public sector research organisations such as CSIRO and the universities. Internationally, direction setting is practised extensively by the governments of many of the advanced industrialised nations with which we trade, most notably, Japan.

ASTEC’s views on the need to identify directions for Australia’s research effort were presented in its earlier report Setting Directions for Australian Research (1990). That report recommended that the Prime Minister establish a means by which broad national directions for Australian research are set every four years. Subsequently, the Prime Minister asked ASTEC to prepare an issues and options report which would prepare the way for a Government White Paper on Science and Technology to be tabled in May 1992.

Research and Technology—Future Directions is ASTEC’s response to this commission. It follows logically from the Council’s 1990 report and from the Government’s 1989 Science and Technology Statement. It represents the next step in the development of a strategic approach to managing Australia’s research and technology system. The report does not attempt to embrace all aspects of that system. Rather, it focuses on how research and technology can be applied more creatively and purposefully to solving significant national problems and to capitalising on opportunities.

Research and technology are areas where governments have been very active in the last ten years. In Australia, there have been significant changes in the character and structure of our research and technology system—it is now much more outward looking and nationally relevant than was the case in the early 1980s. These changes have focused on the need to direct expenditure towards significant problems and to ensure that Australia’s limited resources are used more effectively to improve the international competitiveness of its industries.

ASTEC endorses this more strategic approach to managing the nation’s research and technology resources and believes it signals the broad direction which Australia must follow in the future. It considers that no major changes should be made to the basic structure of the system at this time. What is required is stronger national resolve, improved coordination and continuing action to ensure that desired national outcomes are achieved.

While the report has been written as the precursor and background to the 1992 White Paper, its contents range widely across the whole of the nation’s political agenda where research and technology can be brought to bear. For this reason, the issues it discusses are not all economic and the options for
dealing with them do not all relate to science or technology. Because of its breadth, the report will be of interest to Ministers, governments and to all parties with an interest in funding, performing or using Australia's research and technology system in one way or another.

Chapters 4 to 8 present the principal issues and options which have been identified from the consultations as having an important research or technology dimension. They fall under five main headings.

**Research, technology and international competitiveness**

The need for Australia to generate new wealth and create more secure, long-term job opportunities is the central theme of this report.

There are no easy solutions to our economic problems. The capacity of Australian industry to find opportunities which can provide a basis for new wealth and employment will depend in part on the quality and competitiveness of our research and technology system. Developing these attributes during the next decade will require:

- greater collaboration between industry, higher education institutions and government research organisations;
- sustained increases in business expenditure on research and technology activities;
- more effective arrangements for the transfer and commercialisation of research originating in public sector organisations; and
- greater awareness by Australian industry of the contribution made by technological innovation, including scientific and technical information, to improving international competitiveness.

**Energy and the environment**

The world’s population is now straining the entire ecosystem of the planet. The rate of population growth, especially in third world countries, is not sustainable. Australia’s population density is among the world’s lowest but the environment of this continent is somewhat fragile and is easily stressed.

There is widespread community concern at the prospect of climate change due to the greenhouse effect. As a major energy exporter, the nation will be affected by targets and strategies to reduce emissions of greenhouse gases, set by other nations as well as Australia. Longer term research is needed on reducing greenhouse gas emissions, including the development of a strategy for renewable energy.

Better management of the Australian environment will be a dominant issue for the 21st century. It will require:

- improved collection and coordination of data;
policy research in fields such as resource pricing and valuation, and social aspects of environmental assessment;

- development of a comprehensive National Climate Program, closely linked to the World Climate Program;

- national coordination of environmental research priorities to achieve ecologically sustainable development and a more uniform approach to environmental decision making;

- coordination of, and support for, long-term research and baseline monitoring; and

- multidisciplinary research to support Australia’s comparative advantage in tropical agriculture, medicine and technology.

The quality of Australian life

A prosperous Australia will have more options for dealing with quality of life issues. However, the options open to us are not a function solely of prosperity. Quality of life can sometimes have little to do with a society’s wealth, and deserves consideration in its own right.

For research to contribute to a better quality of life, there must be:

- more effective links between social policies and research, and between the natural sciences, the social sciences and the humanities;

- improved understanding by governments and the community that the social sciences and the humanities have an important part to play in dealing with specific Australian problems; and

- funding allocated to research into social problems, industrial relations, Aboriginal disadvantage and the nature of the Australian identity.

Medical research in the biological sciences is one of Australia’s international strengths. Research aimed at making health care a matter for personal responsibility should be encouraged. The overall funding of health research should be examined to ensure that critical areas of need are not neglected and that an appropriate balance is maintained between public health and medical research. Better coordination is needed for research into the health of Aborigines, other disadvantaged people and the aged.

Research into the problems of Australian cities and rural areas is poorly coordinated at present. Research strategies, programs and centres should be developed to enable research to contribute more effectively to improving the nation’s quality of life in harmony with industrial and economic growth.

Managing Australia’s research resources

It takes a long time to train people and to get results: there is therefore a need for long-term planning in research and technology. Moreover, the gains that
come from a greater understanding of problems can be difficult to measure, both in the short and longer term.

ASTEC emphasises that developing an internationally competitive infrastructure is vital if the nation is to make the best use of its research and technology resources. The temptation to cut resources for research infrastructure in periods of economic downturn must be resisted.

If the nation's research and technology resources are to contribute as fully as possible to national goals, more attention needs to be given to:

- collaboration between industry and public sector research institutions;
- strengthening research and technology networks within Australia and internationally;
- focusing on problems and opportunities rather than on specific disciplines;
- ensuring an adequate supply of researchers, technologists, teachers and managers to meet national needs;
- the availability of high-quality research equipment and facilities to support the best research endeavours and those projects which contribute most to national socioeconomic goals; and
- the collection, analysis and dissemination of internationally available scientific and technical information.

Commonwealth and States: a national approach

ASTEC's report is focused on the Commonwealth Government's role since it provides a large part of the nation's research funding.

However, the States have a vital interest in research and technology. Most of Australia's public sector research is conducted in the States; most of the funds from all sectors for research, technology and industry development programs are spent in the States. Moreover, many problems and opportunities relevant to research and technology bear no relation to State or local government boundaries. In Commonwealth-State relations, the principal task is to develop a national approach to research and technology policy and program administration, supported by an agreed allocation of responsibilities.

The future

This report has identified important contemporary issues which emerged from extensive consultations. Because the Council has focused on issues of perennial importance to the nation, many may still be on the political agenda in 1996. Inevitably, however, the profile of the issues will be different in five years time and new issues will be added as circumstances change.

All this supports the case made in ASTEC's 1990 report that the process of setting directions is dynamic—there should be another issues and options
report in 1995, with a White Paper to follow. This should ensure that the policy directions set by Government not only achieve a desirable coherence and continuity but also reflect the perceptions of the performers, users and funders of research and technology.
1 Research and technology: a key to the future

Science and technology, including engineering, have changed the quality, length and direction of life far more in the past century than politics, education, ideology or religion. Edison and Ford shaped human experience more broadly and enduringly than Lenin and Hitler. Because they are central to our culture and to the success of our economy, governments must be concerned about science and technology and how they benefit us...Society looks increasingly to science and technology to provide knowledge and understanding, to support economic development, to contribute solutions to new and pressing concerns and to help maintain the high standards of living we now enjoy.1

1.1 Introduction

In the second half of the 1980s, questions about the nature and management of research and technology moved to the top of the Australian political agenda. The reasons were interrelated and important. The Australian economy was declining in potency and research and technology were increasingly seen as essential constituents of economic recovery. Moreover, research was a matter in which the Commonwealth Government had a considerable financial interest, since much of the funding, and the activity itself, was of Commonwealth origin.2 Finally, research and technology are characterised by creativity and a sense of individual endeavour. Providing a supportive environment for the best research, in the context of an increasing interest in national purposes and outcomes, is neither an easy nor a straightforward task.

Since its creation in 1978, the Australian Science and Technology Council (ASTEC) has played a continuing role in helping to shape national decision making on research and technology and their application to the national well-being. Many of the structural changes that have occurred in the organisation of research and technology in Australia since 1985 have flowed from the score of reports which ASTEC has made to the Prime Minister on important research or technology issues. The process and nature of these changes are outlined in Chapter 2. This report arises directly from the Prime Minister’s response to ASTEC’s earlier report Setting Directions for Australian Research3 and its major themes emerged through an extensive submission and consultation process which is described in Chapter 3.

This report sets out the major issues which face the nation and its government in the research and technology fields, and the options available for addressing them. It is the precursor of the White Paper on Science and Technology to be delivered by the Prime Minister in May 1992. That White Paper will examine progress since the Science and Technology Statement of May 1989 and will set out a program for the next three- or four-year period.
1.2 What is the rationale for national direction setting?

The rationale for a long-term national planning approach for research and technology was outlined in *Setting Directions for Australian Research* (see Chapter 3). Briefly, direction setting is not new. In industry, business plans based on an assessment of short and longer term competitive positions and commercial opportunities are used to determine corporate research and technology priorities. In the public sector, strategic priorities are set by departments or agencies themselves, by bodies such as the Commonwealth Scientific and Industrial Research Organization (CSIRO) Board, the Australian Research Council (ARC), or by university vice-chancellors. These higher level decisions are complemented by operational priorities set by committees of the ARC, by the heads of university departments and by chiefs of CSIRO divisions, for example.

However, the setting of directions has not been explicit at the national level. Cabinet has set directions, in effect, through broad national priorities, guidelines and policy. This report makes more explicit the issues that face Australia in linking aspects of its endeavours in research and technology to current and prospective national needs. It also aims to make those involved in making decisions more aware of the choices facing them. Apart from providing broad guidelines for formulating a clearer vision and better policies for the nation, a national direction-setting process offers a means of anticipating emerging trends, improving linkages and generating consensus.

1.3 What is meant by research, development, technology, and science?

ASTEC decided at the outset of this study that a broad range of issues should be eligible for discussion in its report. ‘Research’ and ‘technology’ are used throughout this report to identify the two key elements of the innovation process. Research widens and deepens our understanding of a given issue by increasing our knowledge of its components and their relationship to each other. Research, as used here, embraces all human knowledge and the application of knowledge and inquiry to the problems and opportunities which confront the community. Development is the bridge between research and commercial or other application. When used in a general sense in this report, ‘research’ includes developmental research. Technology, which refers to the application of knowledge to industrial and other practical uses, can offer more efficient or effective ways of doing things. It has been interpreted as covering the development, transfer and diffusion of technology, and the overall environment for innovation in Australia. The research and technology system in Australia comprises not only research and technology as intellectual processes, but the commercialisation and use of their outcomes. Science is employed in this report to refer to an ordered body of knowledge and includes the natural sciences, engineering, the social sciences and the humanities. ASTEC includes membership from each of these disciplinary areas.
1.4 The strategic importance and cost of research and technology

It is now widely accepted within Australia that research and technology are of immense strategic importance to the future of our nation. This is so in part because research (particularly developmental research) and technology seem to underpin the dynamism of the economically successful societies of the world; Australia cannot afford to set itself apart from the countries with which it trades and associates. Any examination of Australia’s contemporary situation reveals the importance of research and technology in achieving national aspirations. Australia’s historic dependence on unprocessed or relatively lightly processed raw materials has been the cause of our economic advance in the late 19th century and, in the view of some, of our economic decline in the late 20th century. In part, this decline is related to technological change which has resulted in a world oversupply of some commodities through greater efficiency and substitution. Australia must learn to add further value to what it produces by applying the fruits of new knowledge and new technology, and to produce new products and processes that spring more from the mind than from the ground.

This report emphasises the problems and potential of the natural sciences and engineering. The contribution of these disciplines to improving efficiency and competitiveness of Australia’s agricultural industries, to the successful exploitation of our mineral wealth, to increasing our understanding of Australia’s unique ecosystem and to advancement of knowledge—to name only four important fields of endeavour—has been crucial, and will remain so. Yet the cost of research in the natural sciences and engineering is growing rapidly. Major installations and facilities deemed essential to advanced research, such as oceanographic research vessels, modern purpose-built laboratories, particle accelerators, nuclear reactors and large telescopes, require capital expenditures of several millions to hundreds of millions of dollars. Commitments of this scale, in turn, require the dedication of many highly trained people, the clear definition of career paths and a long-term commitment of recurrent funds to staff and infrastructure.

As the last few years have shown, the process of economic transformation has been difficult for Australia. For a range of structural and cultural reasons, the orientation of much of Australian business is far more short term than many of our trading partners. Traditionally, Australia has been hesitant in identifying and pursuing promising or strategically significant investment opportunities in its region. As a community, Australians have long preferred consumption to saving and investing, and have been preoccupied with wealth distribution rather than wealth creation. The tendency to borrow internationally on a large scale is handing on a heavy burden of debt to future generations. Australia has a powerful industrial relations culture which has its own momentum—one not always geared to economic change. The country’s social welfare system has been based to a large degree on a high minimum wage, low levels of skill and relatively full employment.

In the last decade of the 20th century, the challenges facing Australia are by no means confined to its economic difficulties. The Australian continent is deficient in water and is somewhat fragile ecologically; its 17 million people...
are making significant demands on the natural environment. The development of an essentially European multicultural society in an island continent south of Asia presents a number of geopolitical and domestic challenges which may not assist Australia’s speedy integration with the Asia-Pacific region.

The problems currently experienced are sufficiently serious as to require the kind of research that produces new knowledge and understanding.

1.5 **Who and what are needed to tackle the nation’s problems and opportunities?**

All these matters are important to the nation in their own right. All of them require sustained inquiry (that is to say, research) and, where appropriate, the use of up-to-date technology. It is ASTEC’s firm view that, in addition to harnessing the research talents of the natural sciences and engineering, Australia needs to make full use of the social sciences and the humanities in tackling the problems and opportunities on the national agenda. The applications of new technology and research discoveries involve people and their social settings and many of the important questions facing contemporary Australia fall squarely within the research responsibilities of the social sciences and humanities.

Government, the social sciences, and the humanities together need to recognise the contribution that these broad disciplinary areas can make. This is a matter to which ASTEC will give greater attention in the coming year.

Australia cannot do all the research it would like to do, nor everything that it might be prudent to do. In the natural sciences and engineering—as in the social sciences and humanities—it needs a portfolio of long-term, medium-term and short-term research endeavours. Some of these will be prompted by the researcher’s own sense of where the challenging intellectual problems lie. The advancement of knowledge is an international endeavour, in which Australia is acknowledged to be among the world’s leaders in a number of fields. It is characterised by creativity of the human mind and its quality is ultimately determined by the judgment of international peers. For Australia to be competitive, its basic research must be world class and well supported either on the basis of excellence alone or because of its contribution to the attainment of national goals.

To make an effective contribution to solving national social and economic problems and to realise opportunities, research and technology have to be employed in a long-term context. Research programs and the introduction of new technologies typically have long lead times and the training of researchers is a ten-year process which starts with entry to university. In other words, those who will qualify as researchers in the year 2000 have only just entered university. It may be five years before research programs which, for example, aim to increase understanding of soil degradation or the distribution of wealth and income in Australia and its relationship over time to social harmony,
produce significant results, and eight or nine years before they display their full potential.

Good research in any field is often expensive, requiring the right level and mix of human and other resources. It tends to require extensive libraries, easy access to international databanks, up-to-date equipment and travel to conferences and institutions in other countries. Research benefits from good leaders with a capacity to make quick decisions and to redirect resources as the progress of the research program produces unexpected opportunities. Comparable observations can be made about the adoption and adaptation of new technologies by firms and industries.

All this makes the management of Australia’s research and technology resources a major task. On the one hand, the community is entitled to expect a high level of accountability for the several billion dollars spent annually on research and development in Australia. On the other hand, researchers are more likely to do their best work in an environment which they see as supportive. Managing a research enterprise so that creativity is enhanced but without the organisation becoming inward-looking, is a continuing challenge.

1.6 What should the Government do?

The role of the Commonwealth Government in the furthering of research and technology is subtle and many-sided. The solution of national problems, and the realisation of opportunities, requires full and effective contributions from all four elements of the research and technology system—business, higher education, government laboratories and the private non-profit sector (see Chapter 2). For these contributions to occur, each of the sectors must be active and healthy, and possess a capacity to adapt successfully to changing national and international conditions.

It is an Australian tendency to see ‘government’ as in some sense responsible for the activity and health of aspects of social life outside government itself. The private sector must continue to be encouraged to fund and perform more of the nation’s research and technology effort if we are to derive maximum economic and social benefits from our resources in these areas. At present, higher levels of investment by the business sector in research in Australia are being inhibited by the financial environment within which firms operate. Long-term, higher risk investments are discouraged by the structure of the tax system, high interest rates and a poorly developed venture capital market. Removing these and other impediments to achieving a better integrated and more effective research and technology system should be a priority for governments in the 1990s.

This report advocates certain government initiatives and policies to achieve results which ASTEC sees as important for the future of Australia’s research and technology system and, through it, for the well-being of Australian society generally. However, the Council recognises that there is considerable variation in the extent to which governments can or wish to direct the different elements of the system. Moreover, the development of the research
and technology system is not a matter which can or should be left solely to
government. Government has an important role to play, but so have others
in society. The enhancement which ASTEC seeks requires an understanding
on the part of government, industry and the research community of the
changes which are taking place in Australian society, and of the new ways in
which research and technology can assist in solving problems and realising
opportunities.

As outlined in Chapter 3, extensive consultation has been a central feature of
this study. ASTEC has no doubt that the will to improve the research and
technology system is widespread, and that the national consciousness of the
contribution that an enhanced research and technology system can make to
Australia’s future is higher than in the past.

As ASTEC sees it, the role of government in the next decade is to ensure that
the research and technology system does in fact make that contribution. It
should do so in three principal ways. First, it should ensure that there is an
appropriate balance between research endeavours that are prompted by
researchers themselves (‘science push’) and those which are prompted by
external needs (‘market pull’). Second, government needs to guide the
system so that important national problems and opportunities receive
appropriate attention from the research community. Third, government has
responsibility to provide an environment which encourages longer term
investment in research and innovation by business enterprises. In ASTEC’s
view, there has been a tendency in the past for many such issues to be
neglected.

It is important to recognise that what is proposed is not a bureaucratic process
of ‘picking winners’. Rather, it is an essential process of ‘identifying issues’,
and of giving these problems and opportunities relative priority and an
appropriate injection of scarce resources in the context of national research
directions.

The process embodied by this report represents a fresh approach to the
management and funding of the Australian research and technology system.
The options for action are significant but not central to the report: ASTEC
recognises that there are many ways of enhancing the various endeavours
which make up the research and technology system. What is central is the
strategic purpose which underlies all the issues and options and, of course,
the whole direction-setting process itself. The elements of that strategic
purpose have guided ASTEC’s thinking in this policy area for several years
and are now demonstrably widespread in government and industry.

1.7 Structure of this report

The structure of this report is simple. After an essentially historical second
chapter which sets the scene, Chapter 3 deals with the background to, and the
methodology for, the study. Chapter 3 also introduces the main themes and
general issues which emerged in the course of the study. Further information
on the methodology is given in Appendix A.
In the remaining chapters, ASTEC discusses a series of major issues, explains their importance and offers some options for action. This report is therefore both a discussion paper and a prospectus for the decade ahead.

Chapter 1: Notes and references


3. ASTEC, Setting Directions for Australian Research, AGPS, Canberra, 1990.


2 Australia’s research and technology system

Science, technology and industry should be regarded as three points on a triangle—with direct linkages between each point. It is essential for our future economic growth that all these linkages should remain in good repair and constant use.¹

2.1 Introduction

This chapter reviews the essential features of Australia’s research and technology system and assesses its abilities to cope with the likely challenges of the next decade. First, it provides an overview of current investment in research and development in Australia and of recent trends. Second, it examines recent themes in the development of the research and technology system in the context of overseas developments. Third, it briefly summarises ASTEC’s perceptions on the present strengths and shortcomings of Australia’s research and technology system as a prelude to discussion of detailed issues in subsequent chapters.

2.2 The pattern of research and technology investment

Australia spent $4.2 billion, or 1.23% of GDP, on R&D in 1988–89.² This represents a consistent and significant increase on the 1.00% of gross domestic product (GDP) committed to R&D in 1981–82.³

Four broad sectors carry out R&D in Australia: business enterprises, government research organisations, higher education institutions and private non-profit (PNP) organisations (eg independent medical research institutions). Figure 2.1 shows the index of change in expenditure (calculated on the basis of proportion of GDP) for each sector over the period 1981–82 to 1988–89. R&D undertaken by government bodies declined overall, a greater disaggregation showing that spending by Commonwealth agencies declined by more than 20% over the period while State government expenditure was constant. R&D in the higher education sector and private non-profit sector increased slightly over the period, but has declined as a proportion of GDP since 1986. The greatest change took place in R&D performed in the business enterprise sector which more than doubled (as a proportion of GDP) over the period, overtaking the government organisations to become, from 1986, the largest R&D performer. Over 40% of Australian R&D is now carried out by business, compared with 23% in 1981–82.

Figure 2.2 indicates the socioeconomic objective of Australian R&D expenditure in 1988–89. Economic development attracts over 70% of expenditure with contributions from all sectors. A significant proportion of government and higher education R&D has national welfare as its purpose. The Commonwealth Government conducts virtually all defence research in Australia while advancement of knowledge (less than 12% of national R&D expenditure) is largely undertaken within the higher education sector.
Figure 2.1  Index of change in R&D performed by the business enterprise, government, and higher education and private non-profit sectors, Australia, 1981-82 to 1988-89

The index is calculated as expenditure on R&D carried out by each sector (expressed as a proportion of GDP) relative to expenditure for each sector in 1981-82. Expenditure in 1988-89 was: business enterprises, 0.51% of GDP; government research organisations, 0.39%; higher education and private non-profit institutions, 0.36%.

Figure 2.2  Australian R&D expenditure by socioeconomic objective, 1988-89

Source: CSIRO Data Office.
Figure 2.3 shows the type of research or development (pure basic, strategic basic, applied, or experimental development) carried out in each sector in 1988-89. Most business enterprise R&D is categorised as 'development', although where technology is a major source of a firm's competitive advantage it will invest in longer term basic research. Growth in business R&D can be expected to lead to an increase in the proportion of applied research and experimental development carried out in Australia.

As Figure 2.3 indicates, most basic research and a substantial portion of applied research is carried out by government agencies and the higher education sector. Figure 2.4 shows the breakdown of this public sector (and private non-profit sector) R&D expenditure by field of research in 1988-89.

2.3 Recent trends in the research and technology system

Current common trends in research and technology policy within member countries of the Organisation for Economic Cooperation and Development (OECD) are:

- increased government spending on the 'knowledge base' (particularly on strategic research in universities);
- focus on research priorities, in particular on new technologies and the environment;
Figure 2.4  Australian R&D expenditure by field of research, 1988-89: government, higher education and private non-profit sectors

- Physical & Chemical Sciences
- Biological Sciences
- Earth Sciences
- Applied Sciences & Engineering
- Agricultural Sciences
- Medical Sciences
- Social Sciences
- Humanities

Total Expenditure: $2445 Million

$ Million

Source: CSIRO Data Office. ‘Applied Sciences and Engineering’ includes computer and communications technologies, aerospace technologies, manufacturing and process technologies, materials science, industrial biotechnology and food sciences.

- increased networking and other linkages between industry and academia through, for example special centres;
- internationalisation and decentralisation of research; and
- policy initiatives arising from concern about shortages of science and engineering personnel.

Several of these themes are evident in recent Australian developments while other initiatives have been taken in response to particular Australian problems.

2.3.1 Expansion of business enterprise research and development

As demonstrated in Figure 2.1 the most notable aspect of Australia’s research and technology system in recent years has been the rapid expansion of R&D undertaken by business enterprises (reaching $1.74 billion in 1988-89). The increase from 0.24% of GDP in 1981-82 to 0.52% in 1989-90 results from a real average annual growth rate of 14%, the highest for any OECD country. Yet, because of Australia’s very low starting point, the increase in business enterprise R&D in Australia, as a percentage of GDP, has done little more than match the average increase in OECD countries so that Australia’s ranking has improved only marginally. Ireland, Spain and New Zealand are among
the countries spending proportionally less on R&D in business enterprises than does Australia, while the most highly industrialised nations (e.g., Japan and Switzerland) spend over 2.0% of GDP, or nearly four times as much.

The historically low level of business R&D is partly a reflection of Australia's industrial structure and output which is substantially lower in most of the R&D-intensive high- and medium-technology manufacturing sectors than the 'typical' OECD economy. However, even on an industry-by-industry comparison, the proportion of turnover spent on R&D by Australian companies is often substantially less than their foreign counterparts. Australian R&D intensity for medium and low technology industries is only slightly lower than other OECD countries; it is in the high technology industries, which are dominated in Australia by transnational companies, where the gap is largest. This gap is narrowing, with average R&D intensities in Australian manufacturing increasing more rapidly than in almost every other OECD country.

Associated with the high growth in Australian business R&D over the 1980s has been an even stronger growth in patent applications lodged by Australians in foreign countries. Applications grew at an annual rate of more than 17%, by far the highest in the OECD.

Most business R&D (87% in 1988-89) is directed towards manufacturing. Manufacturing R&D has continued to expand in real terms (Figure 2.5) over the last decade. Figure 2.6 shows changes in selected areas of industry R&D between 1984-85 and 1988-89: the increasing significance of R&D on computer software is particularly evident. Four manufacturing areas (electronics, computing and electrical appliances; transport equipment; chemical, petroleum and coal products; basic metal products) accounted for 65% of business enterprise R&D in 1988-89. This concentration underlines the importance of industry structure. The appliances and electrical equipment industry, for example, performed about one-quarter of manufacturing industry R&D in 1986-87 and accounted for about 0.3% of GDP. Any increase in this industry's contribution to GDP, assuming R&D effort increased commensurately, would have a proportionally greater impact on the level of business R&D in Australia.

The level of R&D carried out is but one factor in improving the international competitiveness of Australian industry. Other factors, including structural change, profitability, quality of management and marketing skills also affect the export performance of firms. Despite the increase in manufacturing R&D, Australia's imbalance of trade in high- and many medium-technology manufacturing groups has worsened over the 1980s (Figure 2.7). More knowledge is also being imported: payments for overseas technical knowledge substantially outstrip receipts and have increased at a greater rate than receipts. However, this pattern largely reflects funds flowing between foreign-controlled companies in Australia and their overseas affiliates.
Government actions to stimulate industry research, development and innovation

Programs to encourage research and development and technological innovation by industry have been a central element of government policy since the mid 1980s. A 150% tax concession for business R&D was introduced in 1985 and is to be retained as a permanent concession at the rate of 125% from 1993. About 1600 companies are registered to claim the concession and the annual total company tax revenue (gross) forgone for eligible R&D activities stands at around $230 million. Companies may also form syndicates to undertake significant R&D projects. Discretionary Grants are available (on a competitive basis) under the Grants for Industry Research and Development (GIRD) scheme for companies unable to take advantage of the R&D tax concession.

Targeted R&D grants are also available to industry, for example for motor vehicle and component development (started in 1985–86), for research into advanced ‘generic’ technologies of importance to the international competitiveness of Australian industry (from 1986–87) and for energy research.
Government policies on industry regulation, the development or restructuring of specific sectors and on government procurement all affect local industry. At various times the Commonwealth Government has used these policies to influence the level of industry R&D; for example the Pharmaceutical Industry
Development Program provides higher prices for some drugs where a firm makes a significant commitment to Australian manufacturing, product development (including R&D) and export activity.

Nearly one-third of business R&D in Australia is carried out by foreign-controlled companies. Government policies recognise this by, for example, including R&D as an eligible offset activity under the Australian Civil Offsets Program. The Partnerships for Development Program (PDP) for the information industries (introduced in 1986-87) is an extension of the offsets policy and a central element of the Commonwealth Government’s Information Industries Strategy. Partner companies agree to meet specified levels of performance in exports and R&D in Australia in return for exemption from other offsets requirements.

The National Procurement Development Program (NPDP) supports research, trial and demonstration projects which are directed towards meeting government purchasing requirements and aimed at producing internationally traded goods and services. An Advanced Manufacturing Technology Development Program is also being introduced to assist leading-edge customers to work more closely with local suppliers and relevant research organisations to develop products and services to meet their needs.
Government business enterprises (GBEs) account for about 8% of business enterprise expenditure on R&D in Australia, concentrated in telecommunications. However, GBEs were unable to sustain high growth in R&D expenditure over the period 1981-82 to 1988-89 and did not keep pace with the private sector. Despite a peak in 1986-87, annual R&D expenditure by GBEs (as a proportion of GDP) had increased by less than 15% in total by the end of the decade. The adoption of a more commercial approach to GBEs (including privatisation and the introduction of competitors) may well have a significant effect on the level and nature of their R&D over the next few years.

Broad economic factors are very important to any decision by companies to invest in R&D: a case can be put, for example, for an association between R&D expenditure and profitability. There has certainly been some faltering in business R&D growth rates since the October 1987 stock market collapse. Section 1.6 has also noted the importance of factors such as high interest rates and a poorly developed venture capital market in discouraging long-term industry investment such as in R&D. While governments have tried in various ways to promote an investment climate more amenable to research and innovation, the management record of some of those entrusted with this task has been poor. The Management and Investment Companies tax deduction provisions (in place from 1984-85 to 1990-91), which were seen as an important initiative, became a victim of the 1987 stock market collapse.

While it is impossible to measure the impact of specific government actions in improving research and innovation in the business sector, the mix of government policies appears to be on the right track. The broad tax incentive has contributed to increased R&D activity throughout industry and particularly in small and medium-sized Australian owned companies. Other initiatives support collaborative technological R&D and target significant R&D-based industries such as pharmaceuticals and the information industries. The level of direct government support for business R&D is however relatively modest compared to levels of government support provided in many OECD nations. It appears that increased expenditure on R&D has prompted companies to improve the planning and evaluation of their innovation and technology strategies. With continued growth, business R&D can be expected to have a positive effect on research in the public sector—indeed, this is already taking place.

2.3.2 Focusing on the application of research

An important theme of government policy, particularly in the second half of the 1980s, has been to ensure that a higher proportion of Australia’s substantial public investment in research and technology is directed towards the needs of identified users, whether government, industry or the community. This objective has been met in two main ways:

- by increasing the ‘mission orientation’ of government funding, for example by providing research grants for defined purposes, such as research into human immunodeficiency virus (HIV) infection under the Commonwealth AIDS Research Grants program; and
• by encouraging linkages between researchers and potential users of R&D, for example by involving users in the funding and planning of public sector research programs.

Some initiatives, such as the Generic Technology Grants (part of the GIRD scheme), aim to serve both purposes.

The publicly funded research sector in Australia is comparatively large by international standards because of our major Commonwealth research institutions, the Commonwealth Scientific and Industrial Research Organization (CSIRO), the Defence Science and Technology Organisation (DSTO) and the Australian Nuclear Science and Technology Organisation (ANSTO), and State government research arms, especially in agriculture. Expenditure on research and development conducted in government research institutions and the higher education sector accounted for 0.72% of GDP in 1988-89 (a slight fall over the decade). This level of funding is at the higher end of the range in the OECD, although it is on a par with a number of countries (Germany and Italy, for example). However, the balance between the government and university sectors varies widely.15

The bulk of research (rather than development) in Australia is carried out in the publicly funded sector. Government research organisations in particular are important centres for strategic and applied research and experimental development (Figure 2.3).

Around 30 Commonwealth Government agencies offer grant funds for R&D. The number, scope and expenditure of the ‘mission oriented’ grant schemes have grown significantly over the last decade or more with the establishment of marine science and energy research schemes in the late 1970s, biotechnology in 1983-84, followed by other industrial technologies in 1986-87. Grants for R&D into AIDS began in 1985-86 and expenditure has increased significantly in each subsequent year. R&D into aspects of global climatic change has been targeted since 1988-89.

Expenditure through rural industry and fisheries research funding bodies has doubled in real terms since the early 1980s. The management of these funds (which in most cases comprise government and industry levy monies), and of energy research funds, has been significantly reoriented in recent years with the adoption of the Research and Development Corporation (RDC) model. RDCs are commercially oriented statutory organisations accountable to the Minister for Primary Industries and Energy but which have considerable independence in day-to-day funding of, and strategic planning for, R&D. Several RDCs, eg those for Meat and Grains, have produced detailed strategic plans identifying priorities for R&D in their areas of responsibility. The rationale for the RDCs is to encourage greater end-user participation in the research and to ensure that industry research organisations are more active in commercialising research and transferring technology.

The Industry Research and Development Board’s Generic Technology Grants support collaborative research between public sector researchers and industry in nominated areas having wide application for Australian industry:
Despite the increase in targeted funding, competitive research grants remain a small proportion of total public spending on R&D. In addition, government research organisations in particular have been strongly encouraged to develop funding and other linkages with users.

Following a review by ASTEC in 1985, CSIRO’s mandate was revised to focus more explicitly on research in support of existing and emerging industries. The Government also set a target for external funds for CSIRO, ANSTO and the Australian Institute of Marine Science (AIMS) at 30%, with a view to improving these organisations’ links with industry and other users. CSIRO expects to reach this target in 1991–92, with estimated external earnings of $194 million representing 30.6% of the its total budget of $634 million.

Figure 2.8 shows the growth of external research funding in CSIRO from 1979–80 to 1990–91. The industry component of CSIRO’s external research funding has increased to about one-third, the remainder being provided by competitive grants and contracts from, for example, the rural industry and energy R&Ds and other government departments and agencies. During 1990, CSIRO undertook a major program to assess research priorities at a national level. The process involved:
the establishment of a comprehensive, manageable classification scheme for research, using the Australian Bureau of Statistics interim Australian Standard Research Classification socioeconomic objectives (CSIRO is largely concerned with the economic development and national welfare categories);

- assembling the best available key research and national account data and information for each research purpose; and

- developing a framework of assessment criteria that could be used across the whole system.

Executives and experts (in particular, Institute Directors) within the CSIRO assessed each research purpose on the basis of: potential benefits, Australia's ability to capture benefits, research potential and research capacity. These assessments were combined into an overall assessment for each research purpose. The results (presented graphically in Figure 2.9) represent CSIRO's assessment of national research priorities and are being used as a basis for

Figure 2.9  CSIRO national research priorities

Areas of high attractiveness and feasibility warrant strong emphasis while areas of low attractiveness and feasibility warrant only limited support. Other research areas may gain selective emphasis. CSIRO notes that further decision making must necessarily have regard to the full range of conclusions arising from the priority assessment.
determining its own priorities and resource allocations. Because of CSIRO's emphasis on primary, manufacturing and information industries and on environmental research they do not necessarily accord with ASTEC's assessment of national research priorities in this report.

The Cooperative Research Centres (CRC) program, established in 1990, is a major initiative designed to promote long-term, high-quality collaborative scientific and technological research. The objectives set for the CRCs include strengthening links between research and its commercial and other applications, concentrating national research resources more efficiently and involving researchers outside the higher education system (eg from CSIRO) in training researchers. At least one higher education institution is required to be involved in each CRC. The Commonwealth Government is providing funds (reaching an annual level of $100 million by 1994–95) to enable outstanding research groups jointly to build up to 50 world-class research centres. The first centres announced suggest the new direction: pre-competitive research in areas of which many can underpin national industrial development (see box).

2.3.3 Support for the 'knowledge base'

Australia's universities and colleges have undergone unprecedented student expansion and structural change in recent years. These changes have had far-reaching consequences for the organisation of academic research and research training and will continue to do so well into the 1990s. As in most countries, by far the majority of basic research in Australia is carried out in the higher education sector (see Figure 2.4). It employs half of

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<tr>
<th>Cooperative Research Centre</th>
<th>Major University</th>
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<td>Aerospace Structures</td>
<td>RMIT/Monash/Sydney</td>
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<td>Antarctic and Southern Ocean Research</td>
<td>Tasmania</td>
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<td>Australia's Petroleum Industry</td>
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<td>Cellular Growth Factors</td>
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<td>Eye Technology and Research</td>
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<td>G K Williams CRC for Extractive Metallurgy</td>
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<td>Mining Technology and Equipment</td>
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<td>Robust and Adaptive Systems</td>
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<td>Soil and Land Management</td>
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Australia’s researchers and is responsible for training Australia’s future professional researchers and technologists. Higher education institutions are the principal custodians of the nation’s intellectual and physical ‘knowledge base’.

As the Government has acknowledged:

The pursuit of curiosity-driven, basic research is essential to the survival of a rich and lively science and technology in Australia. It provides the best training ground to stimulate and enthuse young scientists. However, the relationship between science and technology is very complex. Science provides the foundation of knowledge and skill formation which makes technology possible—it provides a context of continuity with past experience and future capability. Investment in science helps to provide the core capacity which is an essential precondition to the next stage of development in technology.

The Government’s 1988 White Paper on higher education set a new course for higher education in Australia. Institutional amalgamations abolished the former distinction between universities and other colleges and institutes and reduced the number of higher education institutions within the new Unified National System (UNS) to thirty-six.

The number of students undertaking higher education increased by 59% from 336,702 in 1981 to 534,593 in 1991. The number of students enrolled in science increased from about 42,000 in 1980 to approximately 61,000 in 1989, in line with the general increase in student numbers. While the total number of postgraduates has more than kept pace with the general increase, those engaged in research (doctoral and masters research candidates) increased by only 35% between 1981 and 1990, less than the percentage growth in total student numbers over that period. In science subjects, the proportion of students enrolled for higher degrees fell from 10.3% in 1981 to 8.5% in 1989. Most of the general expansion in student numbers has occurred since the mid 1980s and growth seems likely to continue—increase is currently running at over 10% annually. The demand for higher education places has been fuelled by an increase in the proportion of students completing a full twelve years of schooling from 34.6% in 1981 to 64.0% in 1990.

One effect of the expansion of student numbers has been to increase teaching loads and reduce disposable time available for research or supervision of research students. The amalgamation of the university and college sectors also has implications for the allocation of research resources. R&D expenditure as a proportion of GDP in the (relatively small) college sector grew threefold between 1981 and 1987, much more rapidly than in the established universities. In addition, there have been significant changes to the funding of research in the higher education sector in recent years.

In 1990 a ‘relative funding model’ for university operating grants was introduced which allocated greater weight to research teaching and recognised a specific ‘research related’ component of operating funds. The Australian
Research Council (ARC), established in 1988, funds a major part of higher education research by way of project, program and infrastructure grants, research scholarships and fellowships.26 ARC competitive funding increased from $102 million in 1989 to $208 million in 1991. Part of this increase has been financed by a reallocation of operating funds from the pre-1987 universities, amounting to $65 million in 1991. As well as expanding project and program grants, the ARC has instigated a substantial increase in the number and value of postgraduate research awards and established a career fellowship scheme from postdoctoral to professorial level. The ARC (and NHMRC in relation to the John Curtin School of Medical Research) are to be given a role in determining the allocation of resources to the Australian National University’s Institute of Advanced Studies (IAS).

Increased competitive R&D funding such as that for the Special Research Centres (from 1982) and Key Centres of Teaching and Research (from 1985)—both now the responsibility of ARC—and from other ‘mission-oriented’ agencies for energy, rural and industry research has also been a feature of the last decade.27 The Cooperative Research Centres program will add significantly to this trend.

Common to many competitive research grants, programs and other awards is the emphasis on collaborative linkages between disciplines, universities and sectors. For example, ARC introduced the Australian Postgraduate Awards (Industry) in 1989. Collaboration is also a requirement of Generic Technology Grants, the National Teaching Company Scheme (which supports graduates working on industry-based projects) and the CRCs.

ASTEC has shown that the ‘academic and academically related research’ component of public R&D expenditure was in 1987 significantly less than that of several leading industrial countries regardless of the way in which allowance was made for country size.28 While overall research funding in the higher education system has risen following the introduction of the UNS, a significant outcome has been that the system is now under much greater stress because more academics have an expectation of access to research funds.

Submissions to ASTEC expressed particular concern about provision for capital facilities (both buildings and equipment). Figure 2.10 shows the level of capital expenditure per researcher in the higher education sector from 1978 to 1988. While expenditure on capital facilities has increased in recent years it has yet to regain the level of funding per researcher in the late 1970s and there was a noticeable ‘trough’ in the early 1980s. This pattern of funding is the product, in part, of a decline in the real level of funding for each additional student in the first half of the 1980s, coupled with increasing numbers of researchers. The number of full-time equivalent researchers (including postgraduate research students who make up more than half of higher education sector researchers) has grown by 60% over the period 1978 to 1988, mirroring the increase in overall student numbers. Management and funding of research infrastructure is discussed further in Section 7.5.
The clear intention behind current Government policy for research in the higher education sector is to increase competition for funding while pressing ahead with a greater concentration of resources for the best performers. This will require far greater emphasis on the management of research resources by universities in coming years, an issue discussed further in Chapter 7. It has been strongly argued in submissions to ASTEC that the research effort in the university sector would also now benefit from a period of consolidation and stability in Government policy.

2.3.4 Coordination of the national research effort

At the Commonwealth level, Australia's research and technology endeavour is the responsibility of a number of departments and specialist agencies within several ministerial portfolios (Figure 2.11). Ensuring effective coordination has become an important focus of government activity in the late 1980s, with the formation of new high-level consultative and coordination mechanisms.

Until 1987 the importance of research, science and technology was recognised by the existence of a separate ministry. With the establishment of 'mega-departments' in mid 1987, CSIRO and other former functions of the science ministry became the responsibility of the Minister for Industry, Technology and Commerce (who had assumed responsibility for technology development in 1985). Academic research granting functions were transferred to the Minister for Employment, Education and Training. What was lacking,

Figure 2.10  Capital expenditure on R&D in the higher education sector, 1978 to 1988

Source: ABS.
however, was a forum (other than Cabinet or ad hoc meetings of officials) for the powerful new departments to discuss and coordinate policies and programs in support of research and technology.

There was renewed interest in the late 1980s in the relationship of science and technology to economic development. This was prompted in part by the failure of many of Australia’s small, emerging high technology companies following the stock market collapse of October 1987. Also, in 1988, concern in the research community about funding built up to unprecedented levels. Late in 1988 the Government convened a group of officials to advise on actions which could be taken to strengthen research and development in science and technology.29

The findings of that group, as well as information from ASTEC reviews and other sources, formed the basis of the statement *Science and Technology for Australia* in May 1989—the first consolidation of government policy in this area.30 The themes of this statement were: promoting greater innovative effort in Australian industry and closer links between performers and users of research; rewarding excellence through competitive research funding; and expanding the capacity of the research and technology training system. The Statement announced the current structure for the Commonwealth organisation of science and technology (Figure 2.11) which included four important changes:

- the formation of the Prime Minister’s Science Council (PMSC) to consider matters of national significance. It is chaired by the Prime Minister and comprises senior ministers, heads of government bodies with strong science and technology responsibilities, and leading scientists and industrialists. The PMSC meets twice yearly and its agenda has included discussion of global climatic change, scientific and medical instrumentation, engineering in Australia, and science and mathematics in schools.

- the appointment of the Minister for Science, Customs and Small Business as the Minister Assisting the Prime Minister for Science and Technology and Deputy Chair of the PMSC.31

- the appointment of a Chief Scientist, within the Prime Minister’s portfolio, to provide advice to the Prime Minister, and to serve on the PMSC as its Executive Officer.

- the establishment of the Coordination Committee on Science and Technology (CCST), chaired by the Chief Scientist, to bring together senior officers from relevant departments and the heads of major research agencies to share information and assist in the coordination of scientific and technological programs and policies. The CCST has tackled issues such as the costing and pricing of public sector research, Australian activity in genome sequencing, and coordination of resource and environmental databases.

Advisory mechanisms within portfolios have been strengthened by the appointment of Chief Science Advisers in the Department of Industry, Technology and Commerce and the Department of Arts, Sports, the Environment, Tourism and Territories, along with the establishment of a
Figure 2.11  Government coordination and advisory arrangements for research and technology

Notes to Figure 2.11  This diagram was simplified from Figure 1 R. Free Science and Technology Budget Statement 1991-92, Budget Related Paper No. 6, p 18. It shows only the major flows of advice and does not include all consultation mechanisms.
Senate and House of Representative Standing committees tend to mirror portfolio structures, eg Industry Science and Technology, and the Environment, Recreation and the Arts.
Ministers with a responsibility for research and technology include the Ministers for Industry, Technology and Commerce; Science and Technology; Employment, Education, and Training; Health, Housing and Community Services; Primary Industries and Energy; Arts, Sport, the Environment, Tourism and Territories.
Research funding agencies include the Primary Industries and Energy Research Corporations; the National Health and Medical Research Council; the Australian Research Council; the Industry Research and Development Board.
Research performing agencies include CSIRO, the Australian Nuclear Science and Technology Organisation, the Defence Science and Technology Organisation, the Australian Institute for Marine Science.
Policy advice is also provided by other organisations such as the Australian Manufacturing Council and Industry Advisory Councils.
Primary Industries and Energy Research Council to assist in the coordination of research policies and funding within that portfolio.

Since 1989 the coordination of Commonwealth funding has been assisted by the annual tabling, by the responsible Minister, of a Science and Technology Budget Statement as a Budget Related Paper.

With these changes, and the better coordination they have engendered, the Commonwealth now has mechanisms to integrate government action on national research and technology issues more effectively. The role of the States in these issues is discussed in Chapter 8.

2.3.5 Internationalisation of research and technology

In recent years most industrial countries have begun systematically to encourage international collaboration in science and technology. It is not so much that science has become internationalised (this has always been so), but rather that the planning and funding of research and technology endeavours have become international collaborative activities.

Australia conducts only about 2% of the world’s research and has always recognised the need for effective international linkages to gain access to the latest international developments in research. On the technology side, international ‘strategic partnering’ has become important, particularly for small, high-technology-based enterprises. High-technology industries are dominated by transnational companies having access to development and commercialisation capabilities and which are already market players. Gaining access to international R&D consortia or markets through transnational companies in Australia can considerably enhance the likelihood of commercial success for Australian businesses. There are some signs of a stronger emphasis on international linkages emerging in relation to innovation in the business sector. The increase noted in overseas patent applications by Australians can be regarded as a positive indication of increased innovation and internationalisation.32

In recognition of the need to integrate Australian research into the international environment, the Government provides support for various categories of collaboration through the International Science and Technology Program (ISTP). This program supports exchanges between Australian and overseas scientists, larger scale cooperation involving institutions and academic and industry research consortia, access to major research facilities not available in Australia, international conferences in Australia, and scientific exchange programs of the learned academies. The 1991–92 budget allocated $5.2 million for this program, some 0.2% of total Commonwealth Government support for major science and innovation programs.33 There is, in addition, expenditure on travel related to international research and technology activities from the funds allocated to the universities, government research laboratories and several government departments—but these are difficult to quantify. Although the total Australian commitment to this area is increasing,
it is still a very small proportion of national research and technology expenditure.

The Multifunction Polis (MFP) project, a joint initiative of the governments of Australia and Japan, aims to put Australia in a position to take better advantage of opportunities in the financial, business, research and technology sectors of the global economy. Over the next decade the MFP, to be situated in Adelaide, has the potential to become home to advanced education and research programs, new industries and modern urban villages linked to research and technology activities across Australia.

While significant government and private sector initiatives to strengthen bilateral and multilateral international research and technology cooperation have taken place in recent years, the public funding involved is very small compared with Australia's overall R&D expenditure and the budgets of other countries. Germany spends almost 10% of its science and technology budget on international cooperation and Spain more than 12%. Australia will need to examine critically the level and focus of its commitment to international research collaboration and industrial R&D cooperation in this context.

2.4 Perceptions and shortcomings

National policy on matters as dynamic as research and technology rarely reaches a plateau. The submissions and consultations, together with the data assembled for this chapter, make it clear that while much has been accomplished in recent years, many problems remain for Australia's research and technology system. For example:

- Australia's focus on increasing our international competitiveness by boosting business enterprise R&D is vital given our poor international standing in business R&D and our economic situation. However, the recent significant growth rates in business enterprise R&D need to be at least maintained if we are to approach the R&D investment of competitor nations.

- In common with other OECD countries Australia is targeting research in specific priority areas, notably the development of new technologies, and environmentally related research. However, we need also to ensure that many other research areas of particular importance to Australia are not neglected.

- Increased interaction between the public and private research and technology sectors is in line with policy trends in other countries. Australia's industrial structure makes the development of collaborative networks linking industry and the public research system both imperative and difficult. But overseas models for promoting interaction with industry are not necessarily appropriate for Australia.

- While Australia has provided increased funding for the higher education system in recent years a number of other OECD countries are also substantially expanding public investment in the 'knowledge base' of research and technology, perhaps at a greater rate. The effect of
recent restructuring and initiatives such as the Cooperative Research Centres on the level and focus of research in the universities remains to be assessed but is likely to be substantial.

- Australia is following other countries in assessing critically the likely future labour market requirement for researchers, scientists and engineers.
- Despite recent government initiatives and encouraging signs in the business sector, Australia appears to be lagging behind many countries in the internationalisation of research and technology. How best to optimise its ability to make use of global research and technology is an important question facing Australia.
- Measures in Australia to improve high-level coordination of the national scientific and technological research effort mirror actions taken in other countries in the mid 1980s or earlier (eg in Sweden and the United Kingdom). However, Australia's funding and performance of R&D is less devolved to the States or regions than in some federal systems.

Resolution of these issues requires a greater focus on longer-term guidelines within which the Australian research and technology system can develop strategic priorities. The subsequent chapters of this report make a first contribution to this goal.

Chapter 2: Notes and references


2. The term 'R&D' in this chapter is used synonymously with the Australian Bureau of Statistics' (ABS) definition of research and experimental development activities.


5. DITAC, Australian S&T Data Brief, 1989–90, op cit, Table 1.2; R Free, op cit, Tables 6 and 7. Only in the last few years has the ratio of BERD/GDP eclipsed that prevailing in the late 1960s in Australia (eg, private sector BERD stood at 0.41% of GDP in 1968–69).

6. DITAC, Australian S&T Data Brief, 1989–90, op cit, Figure 1.13. High technology, R&D-intensive manufacturing includes electronics and computing, electrical machinery, scientific instruments and pharmaceuticals. Medium-technology manufacturing includes motor vehicles, chemicals, rubber and plastics and non-ferrous metals. Clothing, food, ferrous metals, wood, and
paper and printing are among the industries categorised internationally as low technology.


12. DITAC, Australian S&T Data Brief, 1989–90, op cit, Figure 1.10 (data for 1986–87).


14. DITAC, Australian S&T Data Brief, 1989–90, op cit, Figure 2.3.

15. R Free, op cit, Table 6.


19. ABS, op cit, Table 6.


22. DEET, Selected Higher Education Statistics, 1991 (Preliminary), DEET, Canberra, 1991, Table 2. Females comprised 53.2% of the student population in 1990 compared with 45.5% in 1981.

23. DEET, 'Postgraduate students', Higher Education Series, Report No. 5, DEET, Canberra, June 1990, Table 1; and unpublished figures supplied by DEET.

25. DEET, ‘Retention and participation in Australian schools’, *DEET Monograph Series No. 6*, AGPS, Canberra, April 1991, Table A9.

26. On its formation the Australian Research Council subsumed the granting programs of several research grant and fellowship schemes, notably those of the former Australian Research Grants Scheme (ARGS) as well as Commonwealth research scholarship funding.


31. The current Minister, the Honourable Ross Free, MP, is designated Minister for Science and Technology and Minister Assisting the Prime Minister for Science.

32. R Free, op cit.

33. R Free, op. cit, p 47.

34. OECD, op cit, p 45.
3 How should directions be set?

Scientists alone can establish the objectives of their research, but society, in extending support to science, must take account of its own needs.¹

3.1 Introduction

In its earlier report to the Prime Minister, Setting Directions for Australian Research,² ASTEC recommended that a White Paper set national directions for research every four years.

The first section of this chapter reviews relevant points made in that report. Later sections outline the information gathering and evaluation processes followed by ASTEC in preparing this report, and describe the themes and issues which emerged from the Council’s consultation program. The chapter concludes with an explanation of how these have been handled in Chapters 4 to 8.

3.2 ASTEC’s 1990 report: Setting Directions for Australian Research

Setting Directions for Australian Research argued that the Commonwealth Government should set broad and coordinated guidelines for research and development in Australia. The benefits of a major commitment to setting directions were seen to include:

- a clearer sense of national vision in terms of how we can use research and technology to meet important, long-term, economic and social objectives;
- the development of a national agenda for ensuring action in key socio-economic areas;
- a greater capacity to anticipate or identify emerging trends and to use foresight in making longer term policy decisions;
- achievement of consensus on issues through a combination of consultation and analytical procedures; and
- improved communication and education within the research and technology community, and between that community and the users of research and technology in the wider community.

The 1990 report looked at formal studies for setting priorities which have been undertaken in Australia at the strategic and operational levels. It reviewed some previous attempts at national direction setting and examined mechanisms for setting priorities in countries such as Japan, France, Norway, Canada and Sweden, which have organisational structures for decision making in research policy similar to those of Australia. The more successful mechanisms were found to have a number of similar features:
the task of setting national directions is generally overseen by a high-
level committee with the authority or influence to implement its
recommendations or findings;

- responsibility for managing the task is often entrusted to a small group
  of people with acknowledged expertise;

- broad consultation is an integral part of the process to encourage input
  from a wide range of organisations and people, and to ensure
  commitment to implementation;

- appropriate support is provided by a suitably qualified and technically
  competent unit; and

- the philosophy of the group’s approach to setting directions is
  compatible with the structure and culture of the national research
  environment.

Setting Directions for Australian Research contained only one recommendation,
namely ‘ASTEC recommends that the Prime Minister establish a means by
which a White Paper sets national directions in Australian research and
development every four years’.

The mechanism for implementation was
constructed around existing arrangements for decision making in research and
technology, such as the annual budget process, and the new structures
established by the Government following the 1989 Science and Technology
Statement (Figure 2.11). It embodied ASTEC’s assessment that, to be
effective, setting directions at the national level needed to be based on the
following principles:

- national direction setting should aim to set broad and coordinated
government guidelines within which research and technology policies
can be developed;

- development and reassessment of national directions for research and
technology should take place in cycles of four years and include a
longer term perspective; they should relate to annual reviews of
research priorities at the strategic and operational level within agencies
as part of their continuing budget processes;

- each direction-setting cycle should culminate in a White Paper which
should be endorsed by the Prime Minister’s Science Council (PMSC)
and be tabled in Parliament by the Prime Minister;

- the White Paper should be drafted by the Coordination Committee on
Science and Technology (CCST) and be based on an issues and options
report produced by ASTEC; and

- ASTEC’s issues and options report should follow wide consultations
with the research community, industry and other users of research, and
government; it should lead to the development of a national
perspective.

The four-year cycle proposed by ASTEC for the White Paper is summarised in
Figure 3.1. A shorter cycle would mean that new initiatives would have to be
assessed too soon after their implementation.
ASTEC reiterates its previous recommendation that the White Paper's proposed four-year cycle, integrating the implementation of annual budget decisions and the results of evaluation of programs, be adopted by the Government as the ongoing basis for setting national directions for research and technology.\(^4\)

Figure 3.1 The four-year White Paper cycle

Source: ASTEC, Setting Directions for Australian Research, AGPS, Canberra, 1990, Figure A3.1.

3.3 The nature of this report

This section outlines the scope of the study on which the report is based and describes the processes employed for gathering and analysing information. It also summarises the general themes and issues which emerged from ASTEC's consultation program.

3.3.1 Scope

Fundamental to this report is ASTEC's belief that Australia needs a broad and authoritative set of national guidelines within which government, business and universities can develop their own strategic and operational research priorities.

ASTEC has not sought to develop a prescriptive list of national priorities. Rather it has sought to identify key structural weaknesses in the research and technology system, and areas of significant national need. Interpretation of
these needs and the implementation of priorities are best done, in ASTEC's view, at the organisational level.

This report is based on extensive research and consultation in the four broad socioeconomic areas of economic development, national welfare, advancement of knowledge and national security. However, issues of defence science and technology are not discussed beyond this section. This is not because ASTEC regards defence research as unimportant or in any way subordinate to matters of civil research and technology. Consultations with the Defence Science and Technology Organisation (DSTO) and with industry confirmed the view expressed by ASTEC in its 1986 report, *The Defence Science and Technology Organisation and National Objectives*, that 'strengthening...Australian industry's technological capabilities is vital for a number of major social and economic goals, and that DSTO has a part in achieving this'.

The Council notes that there have been some major changes in the structure and management of defence industry research in recent years. DSTO was reorganised radically to align its objectives and activities with the defence priorities enunciated in the 1987 White Paper *The Defence of Australia*. These priorities involved improvement of efficiency and effectiveness, focusing on core research, devolving advanced engineering to industry and responding to Ministerial objectives on commercialisation. Further major changes have been announced following the recent review of the Australian Defence Force structure, which will involve shedding a substantial number of staff. ASTEC understands that there is already interaction between CSIRO and DSTO, and urges both organisations to use these interactions to promote an optimal level of coordination and collaboration between defence and civil research.

### 3.3.2 Methodology

The work program for this study began with a review of all recent ASTEC reports and relevant major studies commissioned by business groups, other government bodies and selected overseas organisations such as the Organisation for Economic Co-operation and Development (OECD). This step was undertaken to identify issues arising in broad industry sectors, in government and in higher education, and was followed by an assessment of current statistical trends relating to Australian research and technology.

An extensive consultation program, involving written submissions, discussions held in each of the major capital cities, and structured interviews, was a central feature of the study. This enabled ASTEC to solicit the views of a wide range of people and organisations—nearly 600 in all—involved with research or technology in Australia and overseas. Another important contribution to the report was made by consultations undertaken in connection with ASTEC’s forthcoming study on the provision of major national research facilities in Australia. This involved contact with a further 93 organisations, principally in the government and higher education sectors.

By the end of this program, ASTEC was presented with a large amount of wide-ranging and mostly qualitative information. A management group was
established to guide the study as a whole and Council members were divided into working groups to consider issues relating to specific socioeconomic objectives. The issues raised, far too numerous to deal with individually in this report, ranged from the specific to the general. The following criteria, adapted from those employed by the Australian Research Council, were used to identify the principal and subsidiary issues:

- is the issue long term or short term in nature?
- is it essentially Australian (rather than international) in character?
- is it significant in financial terms?
- is it an opportunity or problem in itself, or merely a symptom? and
- is research an important aspect of dealing with the opportunity or problem?

The ranking of issues was based on judgment rather than a quantitative weighting of the different criteria.

Further information on the methodology used by ASTEC is at Appendix A. A list of organisations and individuals who participated in ASTEC's consultation program is at Appendix B.

3.3.3 Some general themes

ASTEC's consultation program indicated that there is strong private and public sector support for developing more formal procedures for setting directions and priorities at the national level. However, those involved with setting strategic and operational priorities at the institutional level believe they must be able to do so in an environment characterised by consistency and stability in government policy.

Consultations identified two categories of opinion concerning relations between research and technology policy, and industry policy. The majority view, put most strongly by industry, is that research and technology policy is dependent to a large extent on the direction and content of industry policy. In this view, the Government should set out either a comprehensive industry policy, or a series of sectoral policies, which would enable business to establish compatible research and technology policies, and so improve its international competitiveness. Another view is that research and technology policy is also linked to other important policy areas (eg health, the environment and transport) and therefore should be developed and implemented independently of industry policy. Industry and state advisory bodies stressed that the states and territories should have a more significant role in national research and technology policy development and in program administration. ASTEC believes that, to work effectively, research and technology policy must be highly interactive and be well coordinated across all major portfolios, and between Commonwealth and state governments.

ASTEC's consultation program revealed that there is broad acceptance of many of the research and technology policy initiatives taken since the mid 1980s. These include the reorientation of CSIRO, greater emphasis on
commercial outcomes and socioeconomic benefits, the need to identify and support excellence, concentration of research resources for maximum effectiveness and introduction of more competitiveness into funding programs. Furthermore, there is widespread acknowledgment of the need for more effective linkages between the research and technology system and its potential users, for more effective interaction between people and organisations throughout the system, and for Australian researchers to develop more extensive and continuing contacts with their counterparts overseas. There is also increasing acceptance of the need for greater emphasis on multi-disciplinary and cross-disciplinary research to solve problems.

At the same time, universities and public sector research organisations are particularly critical of the low level of action in updating and improving research equipment and facilities, and of the general absence of funds for buildings for research. Other matters of major concern to the universities include the considerable time which has to be spent in seeking and justifying research funds, and the effects of overcrowding.

Another important theme to emerge was the need to achieve and maintain an appropriately balanced research and technology system in terms of government and industry funding, support for advancement of knowledge, applied and developmental research, and for both short and longer term research. Achieving a more effective and efficient system was also seen as dependent on the development of a greater appreciation of research and technology by business management, and on more effort in selecting and training managers in public sector research organisations.

Some submissions indicated that ASTEC’s study should be concerned with the identification of strategic research priorities which should be supported by government in the national interest. CSIRO, which has successfully implemented a process for identifying priorities for its own research using a structured methodology (see Section 2.3.2), suggested that its approach might be adapted by ASTEC for purposes of preparing this report. The Council strongly supports the need to define clear, strategic priorities in an organisation of the size and complexity of CSIRO. It commends that body for its initiative and suggests other organisations carrying out research should closely examine the relevance of CSIRO’s approach to their own activities. However, ASTEC believes the establishment of thematic priorities is not a necessary component of direction setting for research and technology at the national level (see Section 3.3.1). It is more appropriately performed by those with responsibility for the management of research organisations.

ASTEC’s evaluation of the information from its consultation program leads it to support the conclusion reached in a recent OECD report that:

...the setting of science and technology priorities is essentially a complex political process involving many people who interact with one another. It is not a case of science-push or demand-pull, but a changing combination of the two...All countries can of course benefit from the experience of others, but there is no single universal model and the most successful experiences
cannot be transposed without adjustment to local circumstances.\textsuperscript{6}

The same OECD report, supported by information received from Australia’s Industry, Science and Technology Counsellor Network, indicates that the Commonwealth Government’s policies are consistent with the broad orientation of overseas policy developments and trends in program implementation. There is increasing acceptance of the importance for direction-setting exercises based on the predominantly qualitative information derived from consultative processes like those conducted by ASTEC. However, such qualitative information has to be supported by sound quantitative information on the national research and technology effort and on economic and social activity.

3.3.4 Presentation of issues and suggested actions

The broad issues identified in ASTEC’s analysis represent challenges, problems and opportunities which should be of future concern to the Commonwealth and state governments, and to the broader community. The principal and subsidiary issues are:

- **Research, technology and international competitiveness:**
  better links between research and technology organisations; industry research and development; information arising from research and technology activities; awareness and understanding of the role of technology in industry.

- **Energy and the environment:**
  energy research and technology; environmental management; climate change; national coordination of environmental matters; long-term research and baseline monitoring; development of tropical Australia.

- **Quality of Australian life:**
  role of social sciences and humanities; research and society; a healthier Australia; urban and rural settlement.

- **Management of Australia’s research resources:**
  managing the system as a whole; managing research organisations and programs; the supply of skilled people; the provision of infrastructure; the provision of information for research, technology and policy development.

- **Commonwealth–State issues:**
  cooperation and better policy coordination.

Chapters 4 to 8 of this report discuss, in order, these principal and subsidiary issues; later Occasional Papers will explore some of these issues further. The importance of maintaining a strong base in advancement of knowledge, or pure basic research, is emphasised in Chapters 1, 2 and 7.

Options to deal with these issues are proposed. The responsibility for their implementation rests primarily with government, but there is a broader responsibility throughout industry and the community for lifting the
contribution which research and technology can make to achieving national socioeconomic goals.

Chapter 9 reviews the major findings of the study and draws the report together.

Chapter 3: Notes and references


2. ASTEC, Setting Directions for Australian Research, AGPS, Canberra, 1990.

3. ibid, p 71.

4. ibid.


4 Research, technology and international competitiveness

Any company that is not either developing new technology or adapting advanced technology to their present business has made a decision to be out of business in five to ten years.¹

4.1 Introduction

In the 1980s there was a growing realisation that action was needed to resolve the significant problems confronting the Australian economy. These problems were most evident in the continuing high rates of inflation, first experienced in the early 1970s, in the continuation of unemployment levels which were high by earlier postwar standards and in an absence of growth in real wages. The need to generate wealth, create secure, long-term job opportunities and to stabilise prices and costs was widely recognised by government, business and the trade union movement.

There can be no doubt of the need to turn around Australia’s economic performance. In the past three decades, Australia’s exports of visible items have not increased as a share of gross domestic product (GDP) and its share of world trade has steadily declined. Significantly, trade statistics show that Australia’s share of trade in the fast-emerging Asian region actually fell during the 1980s from 6.2% in 1980 to 3.5% in 1987. Further, from the mid 1980s, the nation’s international debt rose disturbingly, suggesting that the achievement of stability would be unlikely until well into the present decade.

Despite this gloomy picture, ASTEC’s consultative process revealed that there is optimism for the future, provided Australia takes greater advantage of its very favourable location in relation to markets in the Asia-Pacific region and its substantial resource base. In the 1990s, identifying and developing new markets either internationally or in Australia represents a major challenge to business. Many skills are required and there are new and compelling constraints to be observed. A balance must be struck between unfettered economic development and the need for ecological sustainability to slow down consumption of finite natural resources and to protect the environment.

Meeting these challenges requires action on a number of fronts. There must be a resolute commitment to developing an economic environment which promotes business prosperity and growth. Micro-economic reform must continue to occur in fields such as industrial relations to ensure that the performance of Australia’s export and import-competing industries is not impaired by outdated work practices. Further, the nation needs a research and technology system which contributes fully to economic development by assisting the creation of new and more innovative products, processes and services.
Some of the more important initiatives taken during the 1980s for making more effective use of the nation's research and technology system are described in Chapter 2. They include the restructuring and reorientation of much of Australia's public research sector, greater emphasis on excellence and applications as a criterion in programs for research funding and the establishment of new consultative and coordination arrangements within government.

Private sector involvement in research and technology was given impetus through the introduction of the 150% research and development tax concession in 1985, and establishment of the Grants for Industry Research and Development (GIRD) scheme and the National Industry Extension Service (NIES) the following year. More attention was given to better coordination and coherence between the Government's research and technology programs. Other initiatives were taken to improve the environment for innovation in Australian industry. The Management and Investment Companies (MIC) Program, introduced in 1984, aimed to increase the supply of venture capital available to small, innovative companies. Wider exposure of Australia's capital markets to the international environment, a process greatly accelerated by deregulation of the nation's financial sector, was an important step in broadening the outlook and modifying the traditional, inward-looking culture of many Australian firms.

At the same time, the 1980s revealed some significant deficiencies in the culture and attitudes of Australia's business community. Before the 1987 stock market collapse, opportunities for sound, productive investment were often perceived as less attractive than those which offered short-term or speculative profits. A legacy of the mistakes made during that period is that much of our wealth has been squandered and some harm has been done to Australia's reputation as a stable, secure destination for international investment. Re-establishing our image as a desirable commercial location will require considerable effort by business and governments alike.

Many of the economic measures implemented by the Government will lead to progressive enhancement of the innovative potential of Australia's manufacturing and service industries and to the adding of greater value to traditional agricultural and natural resource exports. The broad policy settings established over the last five to seven years need to be maintained and core programs must be adequately funded. At the same time, continuing attention needs to be given to their coordination and management to ensure their full potential is realised.

This chapter focuses on four issues which ASTEC sees as central to making the most effective use of Australia's research and technology resources for economic development and to improve the overall quality of the outcomes of research. They are:

- the development of better links between organisations which comprise the nation's research and technology system;
the achievement of sustained increases in industry’s research and development effort and the need for greater effectiveness of its use of technology;

- the better use by industry of information gained from Australia’s investment in research and technology; and

- greater understanding by management and employees of the role of research and technology in developing internationally competitive business activities.

4.2 Better links between research and technology organisations

In recent years, Australia’s economic problems have drawn greater attention to the contribution which public sector research institutions might make to improving economic prosperity and to industry competitiveness.

ASTEC’s consultations confirmed that significant progress has been made in this direction during the last decade. Research agencies such as CSIRO and the universities are now working more closely with a range of industries and have a clearer understanding of the role of research and technology in business than they did ten years ago. At the same time, industry is commissioning more research from public sector research organisations (see Figure 2.8) and larger companies such as BHP and MIM Holdings are continuing to develop long-term relationships with CSIRO divisions or with specific universities. As well, there is now a wider appreciation among the principal users of research that more knowledge and better information are needed to solve many of the nation’s economic, environmental and social problems.

Initiatives by the Commonwealth Government have assisted these developments. The research and development tax concession and the GIRD scheme have provided incentives for companies to commission their research and technology requirements from organisations such as CSIRO. The Cooperative Research Centres (CRC) Program is encouraging more collaborative research ventures between the private and public sectors in a range of strategic research fields. Interaction between the sectors is also being fostered by the requirement for CSIRO, the Australian Institute of Marine Science (AIMS) and the Australian Nuclear Science and Technology Organisation (ANSTO) to raise 30% of their total funds from external sources such as contract research or competitive research funding programs (see Section 2.3.2).

A strong message which emerged from ASTEC’s discussions with industry is that, to produce results, the basic elements of a nation’s research and technology system must be linked more effectively.

Although good progress has been made in recent years, much more needs to be done to stimulate further cooperative research and technology ventures between industry, CSIRO and the universities. All organisations cooperating in research or technology must give more attention to the formation of
collaborative research teams whose activities can give a stronger sense of strategic purpose to joint research ventures.

As well as being a useful stimulus to cooperative action, collaboration can stimulate mutual learning and lead to the development of a better appreciation of the benefits of interdisciplinary projects.

In the longer term, collaborative teams can assist the formation of national and international networks in fields of research which are important to raising the competitiveness of Australian industry. Ultimately, these can play a valuable role in building a better understanding between organisations and individuals of the contribution which they can make to better use of the nation's research and technology resources.

Collaboration occurs more naturally in some fields of research than it does in others. For example, research which is strongly oriented to solving problems experienced by large, technically oriented companies can provide a ready basis for cooperative links. In other circumstances, such as in more labour-intensive industries, developing a cooperative approach to research or technology projects may be more difficult to achieve.

The following sections discuss the adequacy of some existing mechanisms for improving interaction between public sector institutions, higher education and industry. They also present views on how a more cooperative research environment could be established in Australia.

4.2.1 Linking public sector institutions and industry

The way in which the research and technology system is funded can assist the creation of strong links between publicly funded research and industry. As noted earlier, the Government now requires agencies such as CSIRO to raise 30% of their overall funding from external sources.

Discussions with public sector researchers and with industry revealed conflicting views on the advantages and disadvantages of this measure.

It was strongly believed in some quarters that the 30% target has led to greater involvement by industry in public sector research and to a more desirable commercial orientation. Those who hold this view believe that increases in the external funding target would see industry becoming even more influential in the determination of short and longer term research priorities in Australia. Under this approach, many CSIRO groups working with industry could ultimately become research units managed by their principal client industries.

On the other hand, criticism was expressed by several organisations, including some from the private sector, that external funding at levels approaching or in excess of 30% implies a shift towards tactical research which may not be in the nation's long-term interest. Those holding this view believe that the level of targets for external funding should not only be researched thoroughly but, if implemented, should be set conservatively and with considerable care.
In presenting these views, ASTEC concludes that the management of public sector research agencies must be vigilant to ensure that the balance between strategic and tactical research is optimal. At the same time, it endorses the underlying principle that substantial national benefits can accrue from industry being more influential in guiding the research directions of government research organisations.

4.2.2 Links between higher education and industry

Universities play a key role in economic development by training people for careers in research and technology, and in other occupations such as financial management and marketing. However, as noted in Chapter 7, they are also important as performers of research in their own right. This applies especially to research relating to the advancement of knowledge (see Figure 2.2).

ASTEC heard a wide range of views on the contribution which higher education institutions make to Australia's research and technology effort. Although it is important that this contribution is most significant in the field of basic research, there is considerable potential for the universities to be more active partners in assisting industry's research needs.

As noted in the previous section, numerous government initiatives have been taken in the last ten years to increase the contribution made by public sector institutions to national research and technology goals. In relation to the higher education sector, these have included the introduction of the Teaching Company Scheme in 1984 and the Australian Postgraduate Research Awards (Industry) program launched by the Australian Research Council in 1989. These have been paralleled by action within higher education institutions to create university consulting companies and to engage industry more actively in the design of courses for teaching and research programs.

While these initiatives are working constructively to improve the level of understanding among these sectors, additional action is warranted to promote collaborative industrial research and technology ventures.

Government, industry and higher education institutions should keep government programs relevant to research collaboration under regular review to ensure they are effective in fostering cooperation among Australia's research and technology sectors. Moreover, greater publicity should be given to the benefits which can accrue to university departments and individuals from interaction with industry. The elements of such a program should be based on the following factors:

- Australia needs to gain more economic benefit from all forms of university research, including the social sciences and the humanities;
- industry research projects can provide valuable experience which is relevant to research undertaken in the higher education sector;
- training in industrial research can open up rewarding career opportunities for undergraduates and postgraduates; and
mobility of researchers between the public and private sectors can be important in terms of personal development and subsequent career advancement.

ASTEC sees considerable scope for industry to stimulate the extent to which universities undertake research projects which are relevant to industry. While some university research teams or individuals may not be able to work as closely with companies as, say, a CSIRO division, others have significant expertise in various fields of industrial research and technology. Their skills should therefore be used to best advantage in furthering Australia's economic development.

4.2.3 Research and technology links within industry

Investment in research and technology is costly and risky for all companies. This is especially so in Australia where the small size of many firms militates against the pursuit of ambitious internal research programs involving, say, multidisciplinary teams, the employment of international experts or the establishment of large laboratories.

Contracting of research to specialised research bodies is one way in which companies can overcome some of the problems of performing research on a small scale. Another approach involves greater emphasis on cooperative research through research associations or similar groups where there is agreement across a broad industry sector that future competitiveness depends on achieving improvements in product quality, service standards or efficiency in one or more fields.

Previous ASTEC studies and consultations undertaken during the preparation of this report identify four ways by which cooperative industrial research could be stimulated in Australian industry. Each embodies a practical approach to meeting industry's research and technology needs; each can be pursued independently of the other options. They are:

- the development of cooperative arrangements based on the excellent model of the Australian Mineral Industries Research Association (AMIRA): member companies jointly sponsor pre-competitive research projects which AMIRA contracts to specialised research organisations;
- the formation of research groups similar to the Australian Membrane and Biosensor Research Institute (AMBRI): a public sector research agency such as CSIRO forms the nucleus of the research group; resources are contributed by industry and by the agency with all members of the group having access to research results;
- the formation of cooperative industrial research and development centres: the pre-competitive research requirements of smaller, innovative firms are met in part by encouraging greater networking and clustering with larger, successful companies; and
- the formation of traditional research associations: firms in a specific industry sector sponsor pre-competitive research relevant to that sector, eg the Australian Wine Research Institute.
ASTEC considers that the small size of many Australian firms and the geographic dispersion of similar manufacturing or service activities makes cooperative research an attractive option for the conduct of research and technology development activities. Cooperative groups also represent an important way of accelerating the diffusion of new or best practice technologies within specific industry sectors.

With this in mind, ASTEC believes the Government should closely examine how it can best stimulate more cooperative research in industry. The effectiveness of provisions of the 150% R&D tax concession which relate to cooperative research activities should be kept under review as should other programs which could, with modification, be used to promote inter-firm collaboration. ASTEC also sees a role for NIES in advising government on how best to design incentives or other measures to promote more cooperative research in industry.

ISSUE:
Better links need to be developed between the research and technology system and industry. The research and technology system needs to contribute more effectively to the international competitiveness of Australian industries.

OPTIONS:
(A) Industry associations, government research organisations and universities could identify and remove impediments for closer collaboration among public sector researchers and industry.
(B) Industry associations and universities could give greater publicity to the career opportunities and other benefits which can result from greater involvement by university departments and students in industry research projects.
(C) Industry associations and university departments could cooperate more closely in designing courses and developing projects of strategic importance for Australian industry.
(D) The Government could stimulate more cooperative research by:
• ensuring the R&D tax concession and other government programs provide a strong incentive for companies to undertake inter-firm research and technology programs;
• providing assistance to government research organisations to form more collaborative ventures with industry;
• encouraging NIES to promote alternative approaches to cooperative research using successful models such as AMIRA.
4.3 Industry research and development

A prime aim of the Government's research and technology policies is to foster an environment conducive to sustained increases in research and development activity, and a greater commitment to technological innovation in industry.

Consultations established that the Government's initiatives have been generally well received by industry, although it was considered that, to be effective, the GIRD scheme should provide support over a longer term, say, up to five years. However, action could be taken in a number of areas to enhance further the contribution which research and technology could make to the development of Australian industry. These are discussed below.

4.3.1 Business sector expenditure on research and development

Despite the significant growth which has occurred since the mid 1980s, expenditure by Australian business enterprises on research and development is still low by international standards (see Section 2.3.1). Comparisons with other developed nations indicate that, notwithstanding the atypical structure of Australian industry and the high proportion of publicly funded research, Australian business will need to increase substantially its expenditure on research and technology during the 1990s if technological innovation is to become a hallmark of Australian products and services.

To achieve this objective, business expenditure on research and development (BERD) should be increased to an amount equivalent to at least 1% of GDP within ten years. This will require an average annual increase in BERD of around 7%. In addition, Australia should examine how more foreign investment could be attracted into significant, technology-based industries. However, any strategy for doing so must recognise that research and technology, like other activities, will be undertaken usually in locations where the greatest rewards are forthcoming for minimal outlay and risk. In an economy the size of Australia's, only limited opportunities exist to influence the rewards available to overseas companies without introducing serious distortions to the taxation system or establishing costly assistance programs. Given this, alternative approaches, such as the development of 'good corporate citizenship' programs, should be explored. An examination could be made of how stronger and more extensive strategic relationships could be developed between the longer term research programs of government-funded bodies in Australia and compatible research or technology activities of major overseas companies operating in Australia.

4.3.2 The role of research and technology programs

There was considerable discussion during consultations about the contribution which the 150% R&D tax concession has made to raising industry's research and development expenditure since the mid 1980s. Comments were made on the likely impact of the Government's decision to reduce the level of the concession to 125% from 1993 and to the eligibility of particular activities or forms of expenditure under the concession.
In the first of these, support was indicated for the Government’s decision to make the R&D tax concession a permanent feature of the support arrangements for research and technology in Australia. However, some industry groups were concerned that the less generous rate may fail to provide a strong incentive to small-to-medium-sized companies to expand their research and development expenditure substantially throughout the 1990s. If the aim is to raise business spending on research and development to a target figure of at least 1% of GDP within ten years, a substantial contribution will need to come from smaller firms. ASTEC therefore believes that the R&D tax concession should remain permanently at 150% after 1993.

A number of industry groups said that the existing structure of the 150% tax concession for research and development should include more support for large capital items such as the cost of constructing laboratories and pilot plant. If this were to be provided, some adjustment to the tax concession or to other provisions of the Income Tax Assessment Act, such as its depreciation provisions, would be necessary.

Other industry groups expressed the view that while the tax concession has provided a stimulus to research and development projects, more generous support must be provided by government for other forms of expenditure on technological innovation. Those expressing this view pointed to the need to provide more assistance for product development, prototype testing, industrial design and market research; in other words, all stages of the innovation process.

A second view, less widely expressed, is that governments need to be cautious in including clauses in incentives legislation which require research and development supported by the tax concession or the GIRD scheme ‘to be exploited for the benefit of the Australian economy’. ASTEC notes that provisions of this type have long been included in industry assistance programs in Australia and overseas. However, it draws attention to the need to keep these and other provisions in the national interest under review so that they do not deter the subsidiaries of foreign companies in undertaking research and development activities in Australia.

Another program which attracted discussion during consultations was the Government’s Partnerships for Development Program. A number of organisations support this as an important initiative in terms of encouraging the subsidiaries of overseas companies to undertake more research and technology activities in Australia.

ASTEC sees the Partnerships for Development Program as an important step in helping Australia to capture more of the benefits arising from the increasingly integrated nature of international research and technology activities. It therefore proposes to review the Program at some stage to assess its effectiveness.
ISSUE:
Expenditure on research and technology by Australian business remains low compared to countries with economies of similar size.

OPTIONS:
(A) Business expenditure on R&D could be increased to at least 1% of GDP within ten years.
(B) The R&D tax concession could be maintained at 150% after 1993.
(C) The Department of Industry, Technology and Commerce (DITAC) could monitor the effectiveness of the research and development tax concession and other government programs in raising the level of business expenditure on R&D towards the target level of 1% of GDP within ten years. DITAC could also monitor the contribution of small-to-medium-sized companies and the subsidiaries of overseas companies to meeting this target.
(D) DITAC could fund a program enabling groups from public sector research organisations to visit targeted companies to assess their technology needs and to propose projects which could be funded on commercially attractive terms.
(E) The Partnerships for Development Program could be extended, wherever practicable, to other substantially foreign-controlled industries in recognition of its role in attracting more research and technology activities to Australia.

4.4 Information arising from research and technology activities
ASTEC considers that Australian companies must make the best possible use of worldwide information sources if they are to undertake their research and technology activities effectively and efficiently.

4.4.1 Better access by industry to information generated by research
The volume of research and technology information available internationally is expanding rapidly. In countries such as Japan, Korea, the USA, Taiwan and in the European Community, the value of information about research and technology is widely recognised. In Japan, for example, the Ministry of Education, Science and Culture has established an extensive data communication network which is complemented by other information-gathering and interpreting services provided through the Ministry of International Trade and Industry, and the Japan Centre for Information on Science and Technology.

While Australia’s larger, research-oriented companies are likely to be well acquainted with worldwide information sources, small-to-medium-sized firms often encounter considerable difficulties in identifying and meeting their information needs.
Improvements in collaboration and communication between research groups and between researchers and end-users will do much to improve the flow of information about research and technology. However, to be effective, formal coordination of information-gathering arrangements need to be well publicised, and information made easily accessible and affordable to encourage extensive use.

An important element in the successful dissemination of information is that those involved should demonstrate an understanding of the circumstances in which the information is to be used. Brokerage services and extension and advisory services which disseminate information and provide authoritative interpretation of international data are operated overseas in cooperation with the private sector, especially in Germany. Traditionally, a similar service has been provided in Australia by the agricultural extension services of state governments.

ASTEC suggests that NIES, working in conjunction with industry associations, should aim to improve the range of information brokerage services available to Australia's manufacturing and service industries. Improved information gathering and dissemination could also be facilitated by making more effective use of Australia's Industry, Science and Technology Counsellors and AUSTRADE offices in overseas countries (see Section 7.6.1).

Australia could do well to adopt a scheme along the lines of Sweden's Technical Attache System. Sweden, which conducts about 1% of global research, has made a significant investment in following and reporting on scientific and technical developments internationally. The Technical Attache System is a service agency with broad contact with science and industry in the countries where it operates, and with Swedish industry. It is designed to complement the work done by industry and government authorities in Sweden. It posts a total of some 60-70 people, mostly from industry, for one-to-four year assignments in the ten leading industrialised countries which together account for almost 95% of the world's research. The System is financed in part by grants from the Ministry for Industry and also earns income from contract work.

ISSUE:
Internationally available research and technical information which is important to competitiveness is not readily available throughout Australian industry.

OPTIONS:
(A) An information brokerage service could be established to promote the dissemination and interpretation of information generated by research.
(B) A scheme similar to Sweden's Technical Attache System could be established by Australia.
4.4.2 Commercialisation of research

In recent decades, the low level of interaction between industry and public sector research organisations has manifested itself through the low take-up rate by manufacturing and service industries of apparently useful ideas originating in institutions such as CSIRO or the universities.

Concerned by this problem, public sector organisations and the universities responded in the 1970s and 1980s by establishing consulting companies to promote and market their research results more effectively. More recently, with the extensive restructuring of much of Australia's public sector research system, more fundamental steps have been taken to develop robust links between the private and public sectors. Specifically, there is now a growing recognition that industry involvement must occur at the earliest possible time in the development of public sector research projects if the prospects for commercialisation are to be maximised.

The more outward-looking culture which is now developing throughout much of Australia's public research sector will contribute significantly to industry becoming more technologically aware in the years ahead. However, the increasingly complex environment for research and business in the 1990s is likely to require the formation of new types of organisations specifically equipped to interact with a broad range of interest groups both nationally and internationally. The kind of services these organisations will need to provide include analysis of complex and diverse end-user requirements and a capacity to identify advanced, interdisciplinary research capabilities in Australia and overseas. They will also need a high level of competence in international business law and in commercial negotiation.

Establishment of an Australian Technology Group (ATG), as discussed by the Coordination Committee on Science and Technology (CCST) and by CSIRO, would be one way in which Australia could provide its business community with better access to the resources represented by Australia's research and technology system. An ATG, if modelled on the British Technology Group, could also assist the flow to industry of information generated by public as well as private sector research organisations.

The formation of an ATG, however, represents only one approach to developing more effective arrangements for the commercialisation of research originating in the public or private sectors. Other suggestions discussed during the consultation program included the establishment of a series of product engineering centres in major commercial locations which would be owned or managed by industry. The function of these centres would involve working collaboratively with one or more firms to develop innovative products or processes from promising research ideas. If established, the product engineering centres could complement the Advanced Engineering Centres, three of which are to be established with funding to be provided in 1992-93. The Fraunhofer Institutes in Germany provide an excellent model for advanced engineering centres in which the partners are government, industry and universities.
A third initiative suggested in ASTEC's discussions would be to encourage the development of one or more technology development companies which could assist the development of products based on the research outputs of internationally competitive Australian firms. Companies of this type could also play a role in assisting the development of research-based products or processes needed by these firms. A possible model for their establishment would be the industry-specific companies formed in recent years by AUSTRADE such as AGRITEC Australia, AUSTMINE and AUSTENERGY. The private sector should also be encouraged to undertake more activities of this type.

ISSUE:
The transfer of the results of public sector research and development into commercial products and processes needs to be improved.

OPTIONS:
(A) An Australian Technology Group could be formed.
(B) Product engineering centres could be established to complement the Advanced Engineering Centres to be funded in 1992-93.
(C) Technology development companies could be encouraged, possibly based on the industry-specific organisations established in recent years by AUSTRADE, or through an extension of existing private sector activities in this field.

4.4.3 International business links

Australia's success as an exporter of manufactured products and services often suffers because of a generally poor understanding of other cultures, languages other than English, and failure to appreciate the concepts essential for successful international business dealings—for example, the importance of quality, reliability, packaging and the development of a sound reputation for Australian products.5

Australian industry has often been poor at marketing itself and its products internationally. Frequently, little interest is shown in identifying ways in which our products and services compare with those produced in other countries or to the operations of successful international companies. Moreover, international business alliances have not been used extensively by Australian firms to gain access to markets of strategic importance to our country.

As noted in Section 4.3.1, ASTEC believes that a practical contribution to overcoming these weaknesses is for the subsidiaries of overseas companies to locate more of their strategically important functions, such as their research and technology activities, in Australia.
However, Australian industry, particularly small-to-medium-sized firms, must also accept more responsibility for improving its skills in many areas of management, including those of research, technology assessment and evaluation, financial management and marketing.

ISSUE:
Australian industry needs to improve its image and become more effective at marketing its products and services internationally.

OPTION:
Industry associations could be encouraged to be more active in alerting firms to strategically important developments in key overseas markets especially in the Asia-Pacific region.

4.5 Awareness and understanding of the role of technology in industry
Historically, Australian industry has lagged behind other industrialised economies in its awareness of how to develop and apply new technology to economic advantage. Often this is attributed to shortcomings in management which, in turn, are a reflection of how the community generally perceives the importance of research and technology. As the Institution of Engineers, Australia, said in its submission:

The general public has little appreciation of the relevance of science and technology to wealth creation and Australia’s future living standards. Before Australia can become a ‘clever country’, these attitudes will have to be changed...

ASTEC received a number of suggestions for improving business and community awareness of technology issues. These ranged from initiating an inquiry into innovation in Australia to a more comprehensive program to raise awareness and increase understanding of the processes of technological innovation. While government can assist the development of more positive attitudes to research and technology, industry must accept a significant share of the responsibility for fostering an environment which is receptive to desirable technological change.

At present, responsibility for functions embracing research and technology is seldom represented at senior levels in Australian companies. Career paths for industrial researchers or technologists are not well delineated. In addition to removing any career impediments experienced by these people, it is important, in the longer term, to increase the proportion of industry managers with both technological and business skills. ASTEC sees this as an important step in raising management’s awareness of the significance of technological innovation as a key requirement for international competitiveness. One argument contained in the submission by the Institution of Engineers,
Australia, is that technological innovation is sufficiently important for every company to have a well-defined technology and productivity strategy covering, for example:

- best practice productivity levels associated with the use of specific labour and capital inputs;
- the identification of any work practices and technological factors which may impair productivity growth; and
- the nomination of explicit targets for productivity growth.  

It is important for management and business generally to become more aware of the contribution which technological innovation can make to enterprise growth and competitiveness. To this end, industry itself must do more to train researchers and technologists. It should also be more involved in the development and implementation of university teaching and research programs (see Chapter 7). Management awareness of the role of technology would be raised if Australia followed the United Kingdom initiative by requiring companies to publish annually their expenditure on research and development.

At the same time, the higher education system should monitor existing research training arrangements and should be encouraged to evaluate whether they are appropriate for people in industry. Specifically, existing PhD programs might be examined to determine how this form of academic qualification could be made more relevant to research programs conducted in industry: for example, by a scheme similar to the UK Cooperative Awards for Science and Engineering (CASE).

As well as improving management’s familiarity with research and technology issues, it is also important for the work force to be more aware of how new technologies can be applied to best advantage within various industries.

The attention given by governments to improving performance and developing the national knowledge base in these and related fields is reflected in initiatives such as the Australian Best Practice Program of NIES. However, more needs to be done to upgrade the technical knowledge and skills of individual managers and their employees. Government and industry must therefore continue their support for these activities and should monitor the contribution made by existing programs to ensure that the research and technology capabilities of the Australian work force are steadily improved in the present decade.

ISSUE:

Management, researchers and the work force need to become more aware of the role of research, development and technology.
OPTIONS:

(A) Research scholarships could be established as an incentive for students to undertake training in research fields of strategic importance to Australian industry.

(B) More research relating to technological innovation could be undertaken by institutions teaching postgraduate management courses.

(C) A prestigious national fellowship scheme could be established to enable managers, researchers and other employees in technology-intensive industries to spend time in relevant overseas companies.

(D) Programs such as the NIES National Best Practice Program could be expanded.

(E) The number of PhD awards for research undertaken in industry could be increased.

(F) All companies taking advantage of the 150% R&D tax concession could be required to publish annually their expenditure on research and development.

Chapter 4: Notes and references

1. Recent remark by the Secretary for Productivity, Technology and Innovation in the US Department of Commerce, Dr Bruce Merrifield.

2. The risk of CSIRO losing control of its own R&D programs due to the leverage exerted by industry through external funding has been emphasised in the recent report of the Australian National Audit Office (Report No 8, 1991-92).

3. See, for example, Prime Minister's Science Council, Engineering in Australia, a paper prepared by a working group for the May 1991 Council meeting, AGPS, Canberra, 1991, p 14 and Recommendation 4.


6. This is a main theme of both the Australian Manufacturing Council (AMC), The Global Challenge—Australian Manufacturing in the 1990s, a report to the AMC by Pappas Carter Evans and Koop/Telesis, Melbourne, 1990; and BCA, ibid.


8. A summary report Innovation in Australia has just been prepared for the Industry Research and Development Board by Pappas Carter Evans and Koop. This reinforces many of the opinions expressed to and by ASTEC.

5 Energy and the environment

The complexity of the links between energy efficiency, environmental protection and economic growth is becoming increasingly clear.¹

5.1 Introduction

Energy underlies the economy totally. Without the cost-effective supply of energy, the Australian economy would be in severe difficulty. The pervasive role of energy is illustrated in Figure 5.1: the transport and manufacturing sectors constitute about two-thirds of the total energy use. Because of this widespread dependence, energy and energy-related products represent a significant part of the Gross Domestic Product (GDP) of Australia. One estimate puts this figure at 7% of GDP or about $30 billion per annum. Further, Australia's role as an exporter of coal provides about $6 billion per annum which is the largest single export item.

Australia's energy needs are met by a variety of fuels as shown in Figure 5.2. As would be expected from the importance of the transport sector, petroleum is the major fuel type, although black coal and brown coal, which are the major fuel types for electricity generation, are a similar fraction of energy use.

Recently emerging concerns about sustainable development, including the greenhouse effect, have major implications for the future of energy policy. These concerns are discussed in the recent paper Issues in Energy Policy,² which outlines the need for a national approach to energy policy and effective mechanisms to incorporate the costs of environmental impacts into energy costs and prices. Other priorities are improvements in efficiency of energy

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conversion and usage, reform of the electricity supply industry, natural gas development, a secure energy future in relation to liquid fuel supplies, and expansion of Australia's role as a major and efficient supplier of traditional fossil fuels. The Government made a decision at the end of 1990 to adopt an interim planning target to stabilise emissions of greenhouse gases (other than those ozone-depleting substances already dealt with by legislation) at the 1988 levels by the year 2000 and subsequently reduce these emissions by 20 per cent by the year 2005. The Government is encouraging the adoption of immediate options to reduce such emissions.

ASTEC has identified the reduction of emissions of greenhouse gases from the energy sector as the major challenge for research and technology—in the short term by using fossil fuels more efficiently and in the long term by developing viable alternatives.

However, it will never be possible to have an energy sector that has no environmental impacts and the challenge is to manage the environmental consequences of the energy sector in a manner acceptable to the community. The Government is committed to the concept of Ecologically Sustainable Development (ESD) which is essentially about changing the way human progress is approached and managed to ensure the prosperity of future generations. The concept of ESD emphasises the preservation of resources that cannot be replaced including ecosystems and species, the careful and more caring development and use of remaining resources, the rejuvenation of resources, and the control of harmful side-effects of resource production and use which in some cases are irreversible.

The interactions between energy production and use and the environment are at the very core of the ESD issue. Concern for long-term ecological and social sustainability must increasingly guide decisions that were formerly directed only to short-term economic goals. The concept of ESD encompasses social
The greenhouse effect

The greenhouse effect is the name given to the trapping by the atmosphere of some of the sun’s energy when it is re-radiated from the Earth’s surface. As a result the surface and the atmosphere are significantly warmer than they would be without this effect. The atmosphere contains gases that absorb heat radiated from the earth’s surface. These natural ‘greenhouse gases’ are water vapour, carbon dioxide, methane, nitrous oxide and tropospheric ozone. The other greenhouse gases are chlorofluorocarbons which are human made. Human activities have resulted in increased rates of emission of many of these gases over the past 200 years. These increases are enhancing the natural greenhouse effect and leading to increased warming of the earth’s surface and the lower atmosphere with potentially significant changes in climate, both on a global and regional scale. Recent predictions by the Intergovernmental Panel on Climate Change suggest that if present emissions continue at the same rate, the enhanced greenhouse effect will result in an increase of global mean temperature above present-day values by about one degree centigrade by 2025 and three degrees centigrade before the end of the twenty-first century. Changes to the hydrological cycle and increases in sea level are also predicted.

equity, efficiency and sustainability, both within the present generation and through future generations.

The Government’s environment statement, Our Country Our Future, pointed out that:

We cannot continue to squander the Earth’s assets. If we are to leave a viable future for our children we must better understand the planet, and make a conscious decision to protect and live in harmony with it.3

To meet the needs of the present without compromising the ability of future generations to meet their needs, Australia has a responsibility to preserve its unique ecosystems, to maintain biological diversity, and to manage renewable resources so that they are not permanently depleted. ASTEC’s broad consultative process has reinforced issues in the environmental area identified in its earlier detailed study of environmental research in Australia4 and raised new ones. Current issues include:

- environmental management;
- climate change;
- national coordination of environmental research;
- long-term baseline monitoring; and
- the development of tropical Australia.

These issues are particularly responsive to research. Changes in organisation and funding will enable research to contribute more effectively to the common
good. Other important issues, identified by ASTEC in *Environmental Research in Australia—The Issues*, but not specific to environmental research, are discussed in Chapter 7. They include the provision of an adequate supply of researchers, the need for interdisciplinary skills and access to research information.

### 5.2 Energy research and technology

The agenda set out in *Issues in Energy Policy* is to be commended, but an increased emphasis is needed on research and technology to reduce emissions of greenhouse gases from the energy sector which is the most important source of such emissions. Within the sector the major sources are electric power generation from fossil fuels, and transport, particularly road vehicles (see Figures 5.1 and 5.2).

Strategies and targets to reduce emissions of greenhouse gases, set by other nations as well as Australia, will put the coal industry under considerable pressure. Both black and brown coal will continue to be the major energy source for electricity production in Australia in the foreseeable future and realistic predictions are that global consumption of coal will increase substantially. Increased tensions are likely between growing demand for coal on the one hand, and for reduced emissions on the other, and thus:

Considerable effort will be required to ensure that Australia's share in world coal trade is maintained or increased. This will require effort in...enhanced efficiency of power generation...new approaches to specific environmental problems...fundamentally new or improved processes in the long term...(and) new efficient low environmental impact conjoint coal/mineral processes to add value in Australia to our mineral exports.

Until recently, the coal industry has regarded environmental expertise as marginal or irrelevant to its commercial success. There is some substance to that view, but a sustainable future for coal is dependent on increased research on energy production and on improved energy management.

By far the greatest potential for reducing emissions in the short to medium term lies in energy conservation through improved energy production and end-use efficiencies and through application of economically viable energy management techniques. A prime target for Australia is the use of clean coal technologies with higher thermal efficiencies for electricity generation.

While nuclear power is currently not an option for Australia, the nation's abundant reserves of uranium constitute a valuable energy resource for the world and a source of income for Australia. ASTEC notes that the Synroc Study Group is continuing a study of commercialisation of the advanced ceramic waste form Synroc ('synthetic rock') which offers an opportunity for safe disposal of high-level waste from nuclear power reactors together with
considerable potential economic returns to Australia. This continuing activity follows up an earlier recommendation in an ASTEC study of the nuclear fuel cycle.\textsuperscript{11}

As shown in Figure 5.2, renewable sources of energy made up only an estimated 6\% of total energy use in Australia in 1989-90 and the major sources, wood and hydro-electricity, are unlikely to grow substantially. Although solar energy constituted only about 0.1\% of total energy consumption in 1988-89, it is growing rapidly (at about 20\% per annum over the past decade). It is particularly relevant to Australia because sunshine and land for deployment of arrays of solar cells are abundant, and there is scope to provide electricity in remote areas.

Australia is already a world leader in photovoltaics, which produce electricity directly and reliably from sunlight using solar cells. The nation is a major manufacturer of solar cells, exporting half its production. It pioneered the widespread use of cells in telecommunications. Photovoltaic manufacturing has considerable potential as an intermediate level technology with export opportunities in Asia and neighbouring countries of the Pacific.

Over the next 15 years, a major change is expected with mainstream cell applications changing from small ‘stand-alone’ systems to much larger ‘grid-connected’ use. Many observers believe that photovoltaics hold the key to large-scale, sustainable energy generation in the longer term.\textsuperscript{12}

Australia has the knowledge and people required to develop such technologies, but also requires a long-term strategy for research.

**ISSUE:**

Environmental constraints on energy production and use can be expected to increase, particularly in regard to emission of greenhouse gases.

**OPTIONS:**

(A) Australia could aim to become an acknowledged leader in energy conservation and energy management in the public and private sectors.

(B) Priority could be given to strategic research on reducing greenhouse gas emissions, particularly within the manufacturing, energy production and transport sectors.

(C) A long-term strategy for renewable energy could be developed, with attention to environmental costs and benefits and emphasis on technologies where Australia has geographic and technical advantages.
5.3 Environmental management

In a recent ASTEC study, environmental management was identified as a major area of concern where research could play an important role. This perception has been strengthened by the fact that environmental management was the third highest research area (some 15% of expressions of interest) in ASTEC's study of major national research facility needs in Australia. Further, the draft ESD reports on agriculture, mining, forestry, energy and intersectoral issues have already provided recommendations for research action to tackle management issues in several of these priority areas.

It is not possible to judge the effectiveness of any management action or policy without information about the state of the system at the time of management action, and some means of assessing changes in that state.

Environmental management depends on up-to-date information on research funding, research gaps and future priority areas. ASTEC found that such decision-making information for environmental management was poor. Clearly, more emphasis must be placed on ensuring maintenance, access and management of such critical data. Chapter 6 examines in more detail this issue of information for management.

To ensure high quality environmental management in Australia, future environmental research must develop a range of environment policy instruments including resource pricing, infrastructure investment, resource valuation, and the social dimension of environment assessment. Such instruments will contribute significantly to future environmental management in Australia in all sectors, particularly in resource development.

Important tasks for environmental research in the future include the development of:

- economic policy principles which take greater account of the need for long-term environmental sustainability;
- a concept of GDP which includes the use of natural resources and the costs of environmental degradation; and
- mechanisms that lead to market decisions being more compatible with environmental sustainability.

Future environmental management will require a better understanding of the interactions between ecological and economic systems. This includes valuing ecological services such as water supply at local, regional and global levels in order to determine the best combination of natural and developed land areas to serve regional economies and their long-term productivity.

The importance of values in environmental issues is being recognised. For example, the concept of intergenerational equity is emerging clearly in international economics. The increasing complexity of sustainability enhances the idea that the protection of nature cannot be seen in isolation from long-term human survival. Future environmental research will need to tackle
complex socioeconomic systems and relationships (quality of life and economic development) involving interdisciplinary research.

ISSUE:

Management of the environment and valuation of our resources are suffering from a lack of sustainable policy instruments.

OPTIONS:

(A) Alternative policy instruments for environmental management (pricing policy, resource taxation) could be developed¹⁹ by appropriate interdisciplinary research agencies.

(B) Research in universities, government departments and agencies which is related to environmental management could recognise the social sciences and economics perspectives within the planning and implementation phases.

(C) High priority could be given by the Commonwealth Government to research strategies for environmental management identified through the ESD process.

5.4 Climate change

There is widespread community concern at the prospect of climate change due to the enhanced greenhouse effect but little confident knowledge of the likely future climate over Australia or what its impacts will be. It is important to realise that the effects of the build-up of greenhouse gases in the atmosphere will impose only a slow, long-term trend on a naturally highly variable climate which already impacts substantially on almost every aspect of the Australian environment and way of life. Other environmental and social trends (eg population increase in areas subject to floods, droughts, bushfires and cyclones) will accentuate such changes, quite apart from any long-term trends in the climate itself.

There is a compelling need for establishment of a comprehensive National Climate Program as foreshadowed by the Prime Minister in April 1989. It should be closely linked into the World Climate Program (especially the World Climate Research Program) and associated international initiatives such as the Global Climate Observing System, and the International Geosphere Biosphere Program (concerned with multi-disciplinary research involving atmospheric, oceanographic, biological, chemical and earth sciences). The National Climate Program should encompass integrated monitoring and research into both the natural climate system and human influences on climate. It should involve interdisciplinary study of climate science, impacts of climate change and response measures to minimise adverse effects of climate change. It should be based on the existing national climate infrastructure and should draw on other climate-related national programs and strategies (eg the National Greenhouse Strategy and the National Drought Strategy).
Because of the pervasive influence of climate considerations on virtually all areas of government and sectors of society, an essential element of an Australian National Climate Program should be an inter-agency coordination mechanism such as exists within the national climate programs of Canada, the US, the UK and elsewhere. This should involve all key government agencies, the Bureau of Meteorology's National Climate Centre and the non-government climate research community represented by the Academy of Science’s National Committees for Climate and Atmospheric Sciences and for the International Geosphere Biosphere Program.

ISSUE:
Research in Australia into climate sciences, impacts of climate and related environmental change, and response measures to minimise adverse effects of change is both fragmented and uncoordinated.

OPTIONS:
(A) A comprehensive National Climate Program could be set up to encompass integrated monitoring and research into both the natural climate system and human influences on climate.

(B) A National Climate Program Inter-Agency Committee could be established by the Commonwealth Department of the Arts, Sport, the Environment, Tourism and Territories (DASETT) to facilitate communication and cooperation between participating agencies and ensure coordinated Australian involvement in the World Climate Program and other international climate initiatives.

(C) A National Climate and Environmental Change Coordination Committee could be established by DASETT to ensure necessary inter-agency communication and coordination of monitoring, research, impact assessment and response studies in respect of climate and related environmental change.

5.5 National coordination of environmental matters
Under the Australian Constitution, the States have primary responsibility for environmental matters, from land-use planning and resource management to waste disposal. Environmental matters of broad national significance are the responsibility of the Commonwealth Government.

National statements on environment policy have called for land-use options to be kept open to optimise the quality of life for all Australians. Environmental management should provide:

- an increase in the store of knowledge on which environmental management decisions can be made;
- a focus on the causes as well as the symptoms of environmental problems; and

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an emphasis on the common ground between conservation and development.\textsuperscript{21}

In response, government departments and agencies have adopted new approaches and have reoriented their research efforts. However, a result has been the emergence of a plethora of programs to deal with environmental problems, such as Greening Australia, Landcare and Save the Bush.\textsuperscript{22}

State governments have established bodies and agencies which deal with similar environment issues. Australian industry is developing its own environment strategies.\textsuperscript{23} The research programs of Commonwealth and State agencies are determined by their primary responsibility.\textsuperscript{24} As a result, priorities in environment programs frequently reflect competing portfolio interests rather than the national interest, and conflicts between public agencies may end in environmental damage and degradation of natural resources.\textsuperscript{25}

The spread of environmental issues across portfolios and the diffusion of environment responsibilities and programs in all levels of government and industry have increased the need for effective national coordination. A new direction is required which recognises that the major environmental issues confronting Australia are national in nature and should be dealt with through a national approach (Section 8.2.5). Identification of national environmental priorities and responsibilities, and coordination of environmental research would enable Australia to better manage its environment and to achieve sustainability for this decade and beyond.

Australia is ready for a more unified and equitable approach to solving environment problems. This is clearly signalled by the Commonwealth’s involvement in the World Climate Program and the International Geosphere Biosphere Program, by development of an Intergovernmental Statement on the Environment through the Special Premiers’ Conferences, and by the establishment of national ESD Working Groups and of the Resource Assessment Commission (RAC). The newly announced Commonwealth Environment Protection Agency (EPA) provides an excellent vehicle for achieving better coordination by the Commonwealth and States working cooperatively to develop national guidelines for environment protection.\textsuperscript{26}

A national environment strategy incorporating an ecologically sustainable development strategy would provide an integral component of coordinated environment decision making. National coordination could also assist individual research agencies and institutions to develop their own internal priorities and programs.

Submissions, and consultations including the Environmental Research seminar\textsuperscript{27} confirmed ASTEC’s previous recommendations on national coordination and these are repeated here in an amended form.
ISSUE:

There is a need for national coordination of environmental priorities and research to achieve ecologically sustainable development and a uniform approach to environmental decision making throughout the nation.

OPTIONS:

(A) A National Environment Strategy could be established to identify environmental priorities and corresponding research for Australia's future. Appropriate machinery involving research councils, industry and community associations could be developed to facilitate the implementation of research according to identified priority areas.

(B) A Commonwealth Environment Strategy, to provide an agreed Commonwealth focus for environment policy and research across Commonwealth departments and agencies, could be initiated immediately by the DASETT in consultation with other relevant Commonwealth departments and agencies.

(C) Commonwealth environmental research coordination could be tackled immediately through the establishment of a Commonwealth Government Inter-Agency Committee on Environmental Research as a first step to the development of an Environmental Research Strategy to support a Commonwealth Environment Strategy.

5.6 Long-term research and baseline monitoring

Environmental information is a crucial tool for decision making in the use of resources, but it is not restricted to lists of threatened species and nature reserves. It includes compilation of information which enables researchers to understand the functioning of ecosystems and their relation to sustainable development. In the case of the Wesley Vale pulp mill proposal, for example, there was very little scientific knowledge on which to base opinions and what little was available was based on overseas research.

Unique land and water systems make it essential that long-term environmental research is conducted in Australia. Inquiries by the RAC have highlighted the lack of adequate information on environmental change in Australia, and of definitive information on the causes of such change. Long-term monitoring data are essential in order to analyse trends and patterns of change.

Continuing research is needed into appropriate equitable and uniform environment standards and guidelines. The development of national environment quality standards must take into account the variation in environmental conditions in different regions of Australia. The Commonwealth EPA will contribute significantly to agreement on national standards.
Long-term environmental research is directed towards intergenerational equity and is thus funded mainly by government. There is little short-term output or economic return to encourage industry to fund such research.

Existing policy must provide incentives for the gathering and maintenance of comprehensive environment information critical for effective resource use decision making. The existing annual budgetary cycle, competitive granting schemes, cost recovery demands, and political pressure for quick solutions are impediments to long-term environmental monitoring and research.33

ISSUE:
There is no coordinated long-term research and baseline monitoring of the environment to provide the necessary data for informed decision making by government.

OPTIONS:
(A) The Commonwealth Government could fund a system of national long-term monitoring and research sites to assess environmental changes34 and a mechanism to review national needs.

(B) The Commonwealth Government could establish uniform Australian environmental data standards by 1994 to ensure that data collected by different agencies are high quality, continuous and uniform.

(C) The Commonwealth Government could ensure that long-term environmental research conducted by AIMS, ANSTO and CSIRO be exempt from the external funding requirement.

5.7 The development of tropical Australia

Australia has potential commercial opportunities in a number of areas, including environmental management of land resources, development in climatically extreme environments, marine environmental management, air quality, waste management, geographic information systems, and the development of environmentally benign industries. There are opportunities (especially in environmental services) within the Asia-Pacific region and eastern Europe, based on high quality Australian research35 in regions such as northern Australia. Rapid growth is expected in demand for environmental and waste management technology and services both here and in Asia.37

Australia is the only large economically developed nation in the tropics and has the potential to be a world and regional leader in tropical zone products and processes. Australia possesses expertise38 in areas such as biotechnology (especially in agricultural and forestry applications), medicine (including pharmaceutical products), food processing, sustainable development, and environmental management. The challenge is to apply this expertise more effectively in tropical areas, and to realise the potential for significant commercial returns.
A regional assessment of tropical Australia will contribute to an understanding of the total environmental system, and its effect on, for example, genetic diversity, alternative food sources, sustainable water resources, aquaculture, human health, land use, recreation, development of a space port, mining, tourism, and fisheries.

ISSUE:
The unique opportunity for Australia to exploit its natural competitive advantage in tropical agriculture, medicine and technology is being neglected.

OPTIONS:
(A) Australia could aim to become the world leader in tropical research and technology, with emphasis on its potential contribution to environmental, economic and social development of Northern Australia.

(B) ASTEC, in conjunction with relevant State governments, industry and tropical research institutions, could assess tropical Australian research and technology as a critical area of economic and social benefit to Australia.

Chapter 5: Notes and references


5. ASTEC, ibid.


12. University of New South Wales, School of Electrical Engineering and Computer Science, submission, p 2. As an example, Germany allocated DM 318 million to its renewable energy program in 1991—30 per cent more than in 1990—and is planning to build a 4 megawatt solar power plant.

13. ASTEC has been commissioned by the Prime Minister to report on major national research facilities by the end of 1991.

14. The Commonwealth Government established nine ESD Working Groups to consider the implementation of ESD principles in the main industry sectors that use or have impact on natural resources. The Groups are to report to the Prime Minister by the end of 1991.


17. A Jernelov, Experiences of 20 years of environmental research—which were the questions, what are they and which will they be?, quoted in Swedish Council for Planning and Coordination of Research, Towards an Ecologically Sustainable Economy, Report from a policy seminar, Stockholm, 1989, p 55.

18. Australian Bureau of Agricultural and Resource Economics, submission, and NSW Department of Agriculture and Fisheries, submission.


22. There are moves to amalgamate some of these bodies; see ‘Big spending green agencies face shake-up’, The Australian, September 5, 1991, p 5.


29. ibid, Figure 2, p 56.


32. DASET, op cit.


34. ibid, Recommendation 4, p 41.


36. AIMS, ibid.


38. ASTEC, *Profile of Australian Science*, AGPS, Canberra, 1989, Ch 7, and Northern Territory Department of Primary Industry and Fisheries, submission, p 2.
6 The quality of Australian life

If we are going to stop being a lucky country and start becoming a clever
country, we must recognise our own particular problems and
opportunities. We must be prepared to understand the distinctiveness of
our own society.¹

6.1 Introduction

In this report, ASTEC has placed its primary emphasis on measures which
aim to improve the strength and resilience of the Australian economy.
Without a strong economy many of the other things that Australians desire for
themselves cannot easily be achieved. Yet the quality of life of any society is
not a simple function of its wealth. Whether or not people will move to help
a stranger in difficulties, have a more or less equal chance to succeed in life,
walk the streets at night without fear, enjoy good health over a long life,
benefit from an intellectually stimulating environment—all these variables, and
many others, can have little to do with a society’s wealth, and deserve
consideration in their own right.

It would be tragic if Australia were to grow wealthier in absolute terms but, at
the same time, the quality of life for most of its citizens were to decline. In a
report which has as its rationale the need for Australia to make conscious
choices about the direction of its research endeavours, ASTEC points to the
great need not to assume that these endeavours are confined either to the
physical and biological sciences or to attempts to make Australia a wealthier
country.

ASTEC believes that if research is to contribute to a better quality of life, more
effective links must exist between social policies and research, and between
the natural sciences, the social sciences and the humanities. It agrees that:

The primary problem that needs to be addressed is that research
knowledge has not been adequately recognised as a fundamental
economic and social resource...much scientific and technical
research (is insulated) from associated economic and social
research to the detriment of both.²

A major problem is that research programs and funding tend to be aligned
with disciplines rather than problems and opportunities:

...many issues of national concern are far more likely to cross the
boundaries between disciplines than to be delineated by them.³

In ASTEC’s consultations, many people emphasised that the direction-setting
process should focus on all determinants of national welfare, not just those
factors which relate to economic prosperity. ASTEC’s consultation program
drew attention to the fact that governments, universities and industry have all
been active in recent years in identifying the dynamics at work in Australian society. One commendable example is the Ideas for Australia program, a Commonwealth Government initiative which poses questions about Australia’s economic, social and cultural life and the place of research and technology in national aspirations.4

6.2 The role of the social sciences and the humanities

Research directed to quality-of-life issues essentially involves the social sciences and the humanities, and in these fields Australia is both a relatively large spender and, though this is harder to assess, relatively strong.5 What seems less conjectural is that much (but not, of course, all) of the research conducted by the social sciences and the humanities in Australia seems unrelated to contemporary national concerns. Social scientists in particular tend to study their own contemporary society and its antecedents, and Australia appears as well served by its historians and political scientists, for example, as it is by its geologists and biologists. Yet during its submissions and consultations process, ASTEC encountered the view that the social sciences and the humanities should in some ways be involved more self-consciously in tackling important social problems that lie in their domain. In the 1960s the Academy of the Social Sciences in Australia organised a major study of Aborigines in Australia which underpins both contemporary attitudes and much government policy,6 while in 1991 the Academy of the Humanities published a volume on the humanities perspective on environmental questions.7 ASTEC believes that such initiatives have immense value and need to be encouraged.

Why such initiatives are so few in number deserves a brief, and somewhat tentative, comment. First, studies of contemporary society inevitably arouse political concerns. The Norwegian Prime Minister’s Department has commissioned a study of the distribution of wealth and income in Norway, but such initiatives are rare, since the distribution of wealth and income in all democracies is a central element in party politics. Proposals to change the way things are done always produce resistance from interests whose members like things the way they are. In short, the big questions that the social sciences and the humanities should tackle are usually difficult ones, where passions can be aroused and data may be hard to obtain. It is not surprising that many researchers in these fields choose areas which are rather less controversial and where data are more easily available. The notion that the best research is pure research is as characteristic of these fields as it is, say, of physics.

Second, there is a corresponding tendency to think that some of the important questions are not really for research at all—that they are properly the preserve of government ministers, trade union officials, business leaders or pressure groups. As an example, ASTEC points to the central importance of industrial relations in any analysis of the strengths and weaknesses of the Australian economy, and contrasts it with the small scale and low visibility of academic research in this area. Allied to what ASTEC sees as almost an antipathy to the conduct of research in certain areas is the widespread though mistaken
belief that there is nothing really to know. This belief that comes from the fact that the social sciences and humanities commonly use English rather than mathematics or other symbolic languages as their medium of expression and argument, and that they deal with aspects of human experience that most citizens share. It follows that there has been little explicit encouragement of the social sciences and humanities to engage in major collaborative research endeavours that bear on important aspects of Australia's future.

Third, the social sciences and the humanities are, like the physical and biological sciences, international in their scope and organisation. In most fields Australia is neither a major research performer nor a special place for the conduct of research. The trends and central questions which generally dominate these disciplines are set by the international research community, and those Australian researchers who want to distinguish themselves internationally tend to work on those questions. Research conceived and carried out by individuals remains the central organising principle of research in the social sciences and humanities. The combined effect, therefore, can seem to be of a loose confederation of individuals and disciplines pursuing a series of research agendas that are usually set elsewhere and only occasionally bear on problems important to Australia.

ASTEC believes that there should be a more self-conscious understanding on the part both of the research community and of government that the social sciences and the humanities have an important part to play in dealing with specific Australian problems and taking advantage of Australian opportunities. In the development of that understanding the learned Academies of the social sciences and the humanities have a crucial role to play. ASTEC notes that the Australian Research Council (ARC) has urged on the Academies a more important function as brokers or coordinators of research, and believes that its initiative should be followed by other research funders.

It is rare that the social sciences and the humanities provide determinate solutions to any specific problem. Just as in the physical and biological sciences, the purpose of most research in these disciplines is the advancement of understanding. Rather, ASTEC is suggesting that great social and economic benefits are likely to follow from a sustained research endeavour that seeks to lift our understanding of the components of major social and economic problems. It proposes research programs and projects which have a powerful collaborative character, are pursued for at least a decade, and are funded from a variety of sources. Some thought will need to be given to an appropriate management structure for such endeavours; the CRC program provides one kind of model, while the ARC provides another through its initiatives with the Academies.

ISSUE:
Research in the social sciences and humanities seems unrelated to contemporary national concerns, and needs to be aligned more closely with economic and social imperatives.
OPTIONS:
(A) The ARC could allocate part of its funding for social science and humanities research to projects that address specific national needs.
(B) A small number of social policy research centres could be funded through a competitive program analogous to that for the Cooperative Research Centres (CRCs).

6.3 Research and social issues

The remainder of this chapter deals with several important research questions which seem basic to quality-of-life issues. In some, what is done is hardly more than to point to an issue and to suggest some elements which lend themselves to a sustained research endeavour, and satisfy the criteria (discussed in Chapter 3) that ASTEC has employed throughout this exercise. In others, such as health and the research questions that arise from the kinds of settlements in which Australians have chosen to live, the discussion is more detailed.

These are problem areas which are important now and are likely to remain important well into the new century. ASTEC raises them to provoke discussion within the appropriate research communities and outside them, especially where these issues are the concern of governments or public agencies. ASTEC emphasises again that research seems to be an important element in increasing understanding of the processes involved. ASTEC is not saying what research should be done or who should do it, only that a major collaborative research effort seems likely to pay dividends.

One important issue concerns income, wealth and social malaise. Although Australian gross domestic product (GDP) per capita has increased about two-and-a-half times since the end of the Second World War, it is also true that the incidence of crime has climbed as well. In a society where the social welfare system has traditionally been based on high levels of employment and a relatively even distribution of income, a shift to high unemployment, a widening gap between rich and poor and a growth in the prison population clearly have implications for the quality of Australian life.

Another issue is industrial relations. Analysis after analysis has pointed to the nature of Australian industrial relations as a key element both in Australia’s competitiveness in international trade and in the pace and extent to which Australia restructures its economy. It is arguable that no technological or scientific advance that could bear on Australian industry would have a fraction of the effect that would follow from a major decline in working days lost through strikes or in other indices of industrial unrest. The character of Australian industrial relations is of course deeply embedded in Australian history, and in the ideological struggles which took place in Australia’s first two centuries.

The future for Aboriginal Australians remains a central question for social policy. Despite the money that has been expended, the Aboriginal population
remains especially disadvantaged in matters of health, education, opportunities and longevity. A sustained research endeavour, increasingly in the hands of Aborigines themselves, needs to be mounted into the underlying causes of Aboriginal disadvantage.

In the wider population, national identity has changed. Today’s Australians are very different persons to their counterparts even forty years ago. Contemporary Australian society is arguably more diverse, more effervescent and more creative, but also less cohesive, less open and less caring than in the early 1950s. These cultural characteristics have great impact on the efficacy of the delivery of government programs of all kinds. A greater understanding is needed of the changes which have produced the present multicultural Australia, and also a feeling for the changes which may be expected in the future.

6.4 A healthier Australia

Medical research in the biological sciences has been one of Australia’s international strengths and is likely to remain so, given current levels of funding and the structures in place to manage that funding. ASTEC believes that there may be a case for devoting more attention to the preventative, rather than the curative, aspects of health research. Changes in public behaviour in the areas of smoking, diet and exercise suggest that an increasing proportion of the population is able to take responsibility for at least some aspects of personal health. Given rising educational levels and increased attention to the needs of people, research aimed at making health care a matter for personal responsibility could clearly be effective as well as cost-efficient.

The economic burden created by diseases in Australia is indeed a heavy one. For heart disease, stroke and peripheral vascular disease, this amounted to $1500 to $2000 million in 1984 including $600 million for hospital, medical and pharmaceutical services, and $900 to $1400 million for productivity losses.

A particularly Australian problem is the high incidence of sun-related skin cancers. Australia has the highest incidence of cutaneous malignant melanoma in the world and the incidence of non-melanoma skin cancer (NMSC) is the highest recorded for any cancer in any population. An estimated 140 000 Australians are treated for NMSC every year. Increased exposure to ultraviolet radiation, resulting from depletion of the ozone layer, will probably result in an increased incidence of both skin cancers, but this can be reduced if education programs are effective in changing behaviour and reducing exposure.

The National Health and Medical Research Council (NHMRC) research system, based on competitive funding of investigator-initiated projects, supports a strong clinical and biomedical research effort and provides an essential link to international research information and understanding.
The strength and breadth of Australian expertise...have enabled rapid and informed application of the findings of national and international research...The AIDS epidemic gives one illustration...Without a strong research base extending from virology and immunology through epidemiology and biostatistics to community health, the outstanding national response to this major and suddenly emerging threat could not have been mounted and continued.18

The importance of medical research and the level of expenditure devoted to it focus attention on the NHMRC and its procedures. In response, that Council reviews its activities every three years. For the most recent review, in 1990, the NHMRC invited submissions from a wide range of organisations and individuals and addressed a number of issues which included:

- the appropriate mix of funding resources between public health and medical research; and
- more explicit priority setting in health and medical research.11

These related issues are discussed separately below.

6.4.1 Funding mix

Two important issues emerged about funding for health and medical research in ASTEC's consultations.

The first issue is whether medical research is adequately funded. Australian medical research expenditure accounts for only 1.5% of the $14 billion that government spends on health each year. In the USA, for example, the figure is 3%. Despite this apparent discrepancy in funding, Australia has demonstrated a high standard of performance in medical research. Compared with other disciplines, medical research accounts for only 13% of Australian research expenditure,12 but produces a high proportion of the scientific publications.13

ASTEC noted that areas of relative weakness, indicated by a small research presence in the area, were epidemiology, dermatology, mental health research, public health research and preventative medicine.14 Clearly a strengthening of these areas would lead to improved quality of life in Australia.

The second issue is whether funds are spent in the best way. The NHMRC has been criticised that its priorities are seen to reflect those of the medical and scientific communities and might not necessarily reflect the broad community interest.15 The NHMRC has responded to these criticisms by adopting a research strategy to achieve the following objectives:

- provide a core scientific capacity undertaking research across a wide range of disciplines and employing a variety of techniques and methodologies;
ensure that the overall research effort meets the health needs of the Australian population;
provide training and career opportunities for researchers to maintain their skills to international standards; and
encourage the commercialisation to the benefit of Australia of the results of research where applicable.

The NHMRC established a Public Health Research and Development Committee (PHRDC) in 1986 to fund research in the field of public health. Funding for the PHRDC has grown from $0.8 million in its first year of operation to $3.8 million in 1990. It is planned to increase the funding to the order of $5 million by 1992 as the capability of the research community to undertake greater research in this area increases.

The Commonwealth Government has also responded to the challenges of the broader fields of health research and the World Health Organisation's (WHO) Health for All strategies, by establishing new agencies including the Australian Institute of Health, the National Centre for Epidemiology and Population Health, the Health Advancement Division and Research and Development Grants Advisory Committee (RADGAC) of the Department of Health, Housing and Community Services (DHHCS).

ASTEC was informed that some of these programs lacked coordination. Health strategies and relevant research are already being reviewed in detail through the National Health Strategy, the NHMRC's strategic planning process, and the internal review of all DHHCS research other than that supported through the NHMRC. ASTEC believes that these various reviews need to be brought together to identify the optimal balance between competing research needs. Together, they would form an excellent starting point for a high-level review of Australian medical research, the first since ASTEC's study in 1981.\textsuperscript{16}

### 6.4.2 Priority setting

The NHMRC 1990 Review recognised that strategic planning and priority setting will become increasingly important in determining the particular role of NHMRC in the health care field. The process for establishing priorities needs to take account of: the health needs of the Australian population, including disadvantaged groups; the research capacity of Australian medical and health science; and research funding directed through other funding bodies, especially within the health field, to avoid duplication.

The NHMRC has identified the following major issues in the Strategic Planning Process:

- reducing inequalities in health status between different population groups, particularly Aboriginal people;
- improving understanding of chronic disease, particularly where there is no cure or satisfactory treatment;
• understanding the impact of an ageing population on the health of the nation and the demand for services; and
• understanding environmental health, with strategies to reduce and prevent the effects on human health of environmental contamination.

Particular areas of need that have been identified include women’s health, Aboriginal health, homeless children, mental illness, environmental toxicology and health care evaluation. Priority is also given to supporting high level basic research and training highly skilled research workers.

ASTEC’s consultations have identified a concern that there is poor coordination among the many groups and agencies involved in research into the health of Aborigines and other disadvantaged people, and the aged. NHMRC, in collaboration with the Aboriginal and Torres Strait Islander Commission (ATSIC), is presently assessing the current state of research into Aboriginal health issues. On completion of this review the need for a wider study of the coordination of research into the health of the aged, Aborigines and other disadvantaged groups by all agencies within Australia should be assessed.

ISSUE:
Some areas of Australian health research are not supported well enough to meet national health goals and strategies, and some programs lack coordination.

OPTIONS:
(A) An independent review could be undertaken of the funding of health research and its relevance to national health goals and strategies.
(B) The coordination of research into the health of the aged, Aborigines and other disadvantaged groups could be reviewed.

6.5 Urban and rural issues
Urban and rural issues have attracted increasing attention in recent years, with concerns centred on:
• social inequalities in access to employment, services and facilities;
• increased pollution, congestion and crime in larger cities;
• inadequacies in urban infrastructure; and
• evidence of poor health and stress in rural areas.17

Urban issues are considered first. The structure and function of a nation’s cities have a profound effect on its potential for innovation and, therefore, its economic growth. The nature and quality of urban infrastructure, together with the way it is regulated, financed and priced determine the quality of life in those cities and affect the economic performance of the nation.
Because cities are the focal points for traded goods and services and are the location and primary sources of advanced technology and business innovation, the better they are planned and developed the more effective they can be in aiding wealth creation. Their structure, nature and functioning also affect social justice and equity, and the natural environment.

Australia is one of the most urbanised countries in the world with more than 85% of its population resident in towns and cities. Over the next 20 years an additional 1.3 million dwellings are likely to be needed and, on current trends, about half will be built on the fringes of the major cities. This and other developments will present complex and growing problems and:

...national leaders and commentators have warned that the present system of governance and institutional arrangements, the ecological consequences of our economic and social behaviour, our energy pricing policies and our increasing difficulty in raising public capital for infrastructure investment all force us into a reconsideration of the nature of our cities and how we develop them.

These issues are to be dealt with, to some extent, by the Commonwealth Government’s Better Cities Program announced in the Budget for 1991-92.

ASTEC believes that it is time to develop a strategy for cities which recognises the need to protect, foster and enhance those elements of the Australian city which preserve its cultural character, and which enshrines principles of sustainable development and energy conservation. It should be accepted that cities in their form or structure must not become instruments of discrimination, and environmental costs should be apportioned equitably through regulatory, fiscal and pricing mechanisms. Administrators of Australian cities should use the full potential offered by technology in waste minimisation, transport, building and construction.

Government policy on urban development needs to accept that technological innovations can offer challenges to conventional institutional arrangements. For example, research should explore:

- the consequences for city form and structure of average cost pricing for electrical energy rather than the marginal cost currently in use;
- new developments in sewage disposal compared with conventional sewerage systems;
- the full costs attributable to degraded air quality;
- transport innovations and their applicability to Australian cities;
- planning arrangements for the provision of health, education and welfare services given technological progress; and
- new administrative and institutional arrangements, taking account of new information processing capacities.
The current debate and approach to urban problems is being conducted with little recognition of the possibilities offered by research into new technological or other practices. Urban development in Australia is being determined by governments without wide consultation and underlying research. Better links need to be established between existing groups studying urban problems.

The challenge is to create an Australian urban environment that improves the quality of life of its citizens as well as contributing to industrial and economic growth. Social, environmental and economic research, combined with technological innovation and application, is needed to ensure that these goals are attained by the year 2000.

Research into rural issues and the problems associated with rural service provision has been relatively neglected.

Rural communities differ from urban communities in terms of economic, social and political structures and processes. Social problems differ in type and magnitude. Research into the specific nature of rural social problems is not being funded at an appropriate level. In fact, urban-based findings are often applied to rural communities and urban social welfare 'models' derived from city experiences are often applied in the country—exacerbating the very problems for which solutions are being sought.

Australia’s economy is largely dependent on a rural base and the communities that service it. How well the rural sector performs depends in part on ensuring the health and well-being of the rural population, and this is, in fact, less healthy and free of stress than might be supposed. Surveys have shown that country areas have:

- high rates of hospitalisation for respiratory diseases and accidents;
- high suicide rates for men under twenty-four; and
- high rates of industrial and vehicle accidents.

The Commonwealth Government is funding measures such as a survey of rural areas to identify specific regions affected by the rural downturn. It is also promoting economic development through greater value-adding and new and more diversified enterprises. Nevertheless, ASTEC believes that more research is needed on rural problems and their solution, and should be given appropriate priority in human settlement research programs.

ISSUE:

Research into urban and rural issues is poorly coordinated and does not contribute effectively to improving quality of life in harmony with industrial and economic growth.
Academic institutions, through their management structures, could continue to identify and implement urban and rural research strategies which will efficiently contribute to the resolution of human settlement problems within Australia; this may require an approach involving a principal centre which has visiting research students and visiting Fellows from a number of institutions.

The Commonwealth Government could work to establish urban and rural settlement priorities and implement a corresponding program of research through existing Commonwealth–State Ministerial Councils and supporting Working Parties, including representatives of community, industry and research interests.

The development of urban and rural research centres could be fostered to provide an interdisciplinary approach to research programs and priorities, including the caring and environmental costs of community support.

A study of Australian human settlement research could be commissioned, focusing on the adequacy of existing structures and the nature of future research priorities.

Chapter 6: Notes and references


2. Centre for International Research on Communication and Information Technologies, submission, p 2.

3. Australian Psychological Society, submission, p 3.

4. Ideas for Australia is a Commonwealth Government initiative carried out by the National Centre for Australian Studies at Monash University, in association with the Australia Council.

5. Because Australia does not possess the kind of large manufacturing sector characteristics of the European countries, the USA and Japan, its demand for engineers and scientists in the private sector is relatively low. In further consequence, enrolments and staff numbers in the social sciences and humanities in Australian universities are relatively high, and the research support of Australian academics in these fields is notable (as reported by ASTEC in Government Funding of Academic and Related Research in Australia—An International Comparison). There are no measures of performance for the humanities that are comparable to those widely used in the physical and biological sciences, although the Social Sciences Citation Index provides some illumination of the Australian contribution to those disciplines. It is generally agreed that Australia is very strong in fields like classical archaeology, prehistory, anthropology and linguistics, and strong in economics and history. There are individuals and groups of the highest quality in other disciplines.
and fields. While detailed work remains to be done, it is likely that the Australian contribution to the world in the humanities and social sciences at least matches that in the physical and biological sciences.


9. C Ewan, E Bryant, D Calvert, *Health Implications of Long Term Climate Change*, National Health and Medical Research Council (NHMRC), September 1990.

10. Medical Research Committee, NHMRC, submission, p 4.


13. ibid, p 202.

14. ibid, p 130.

15. NHMRC, op cit, Appendix C, p 62.


19. Australian National University, Urban Research Program, submission, p 1.

20. Charles Sturt University, submission, p 4.


22. EPAC, op cit, p 33.
Managing Australia’s research resources

Technology is dominated by two types of people: those who understand what they do not manage and those who manage what they do not understand.¹

Ultimately, the quantum of our investment in basic research will be determined by our national aspirations—by our view of how we wish to rate among and compete with the nations of the first world. Meanwhile, the comparatively distinguished place we have managed to achieve in basic research over a broad span of the sciences represents a base of knowledge and skill that we must treat as a national asset: easily dissipated and costly to reconstruct.²

7.1 Introduction

This chapter deals with the question of how Australia should manage its research and technology system so that it can both advance knowledge and meet the national requirements outlined in Chapters 4, 5 and 6. It discusses management of the research system as a whole, management at the level of research institutions and programs, the adequate supply of skilled people, the better use of research infrastructure and the management of information. It emphasises that better coordination and more extensive linkages between different elements of the research and technology system would serve to enhance its contribution to achieving international competitiveness.

7.2 Managing the system

Research and technology endeavours are essentially creative processes which take place in a complex environment of collaboration and competition. At the same time, research is not an end in itself; even the most basic research is carried out in order to achieve certain objectives. At the national level, these may be to generate wealth, to improve the quality of life, to improve national security, or to advance knowledge. At the level of the individual researcher or research team, the objectives may be the solution of a vexing puzzle, or victory in an intellectual race, the development of a better product or process, or the training of a new cohort of researchers. ASTEC believes that these objectives can be harmonised, and that a more effective focusing of Australia’s research effort towards clearly identified objectives should be fundamental to the research management process.

In proposing better management of Australia’s research and technology system, ASTEC is not advocating the adoption of a centralised, highly directive approach. Rather, its aim is to identify ways of strengthening and giving sharper focus to Australia’s research effort in an environment with significant resource constraints.

Improved management of research and technology resources and greater interaction among researchers and end-users, would encourage research which
is more purposeful and ultimately more satisfying. Recent initiatives by
government and the private sector recognise the need for improved
coordination and collaboration.

ASTEC's consultation program confirmed that important attitudinal and
cultural changes have occurred in Australia's research community during the
past five years. Every effort must be made to ensure that this process of
change continues.

The organisational structures and mechanisms now in place represent a sound
foundation for the development of further linkages between industry and
public sector research institutions. For example, the Cooperative Research
Centres (CRC) Program (Section 2.3.2) is proving to be an important catalyst
in changing attitudes to collaborative research. In submissions and in the
consultation process, governments, universities and industry all strongly
supported the CRC initiative. Moreover, it is significant that some groups
whose applications for a CRC were not successful in the initial round are
continuing to interact, in some cases with the support of State governments.

ASTEC considers that major implications for the future of CSIRO and the
universities are likely to arise from their commitment of key personnel and
funding to joint venture research through the CRC Program. While the effects
of this program on the public research system are difficult to predict at this
early stage, it is expected that high priority research, and related teaching and
training, will be conducted increasingly within CRCs or in other centres of
concentration such as those funded by the Australian Research Council (ARC).

The impact, in the medium- and long-term, of the CRC program on the
research and technology system should be monitored. It will not be enough
simply to measure the success or failure of individual centres by their
contribution to basic or strategic knowledge alone.

To give impetus to interaction and collaboration between Australia's research
organisations and users of research, ASTEC suggests that all agencies
responsible for funding and performing research should direct their attention
to the nature of the problems to be solved, rather than just to the disciplinary
or technological fields within which the research is to be done. The Australian
Bureau of Statistics (ABS) has made an initial move towards the development
of an Australian Standard Research Classification (ASRC) and the Council
strongly urges that departments and agencies which fund or perform research
use the ASRC socioeconomic objectives to describe their research effort (see
Section 7.6.2).

The need for better coordination and collaboration between the
Commonwealth and States in managing research and technology matters
emerged as a significant issue from the consultation program. Discussion of
this issue is reserved until Chapter 8.
7.2.1 Is the international dimension of research and technology sufficiently recognised?

The Australian research system operates in, and needs to be seen as part of, a global research system. Research is international in its scope and ramifications. Researchers publish in ‘international’ journals which are read everywhere. They also read each other’s books, attend each other’s conferences, and visit each other’s laboratories. The nationalities of researchers are becoming less important than the extent of their networks. The same trend is true in technology: a British idea, developed in the USA and marketed by a Japanese company, is bought by people everywhere from Norway to New Zealand. While Australia performs only a small proportion of the world’s research, that small proportion provides access to the research conducted elsewhere, and to those who produced it.

The success of Australian researchers in developing international links has rested on individual initiatives and on the country’s excellent research reputation over the years. Both commercial and academic linkages must be developed judiciously, not naively. Australia’s intellectual knowledge base and the skill of our researchers are the major bargaining tools we have in the international research and technology arena. The nation should nurture these by providing adequate research support and infrastructure at home as well as appropriate funding to encourage access to institutions and facilities abroad. Currently, the proportion of Australia’s research budget spent on international activities appears very small indeed (see Chapter 2).

ISSUE:
Insufficient emphasis is being given to the provision of funds to enable Australian researchers, especially the younger ones, to travel overseas to gain experience and develop our international networks.

OPTIONS

(A) All government departments with a responsibility for research could identify the opportunities for participation in international research programs in their area, and could ensure that such participation is funded adequately. The Working Group on International Science and Technology Coordination (of the Coordination Committee on Science and Technology) could review all international agreements and treaties, with a view to ensuring Australia has a consistent, coordinated and adequately funded approach to its international science and technology cooperation and linkages.

(B) The ARC and NHMRC could move to increase substantially funds to support the travel of postgraduate and postdoctoral researchers to overseas conferences and facilities.

In addition to fostering more extensive international linkages, ASTEC attaches importance to ensuring that information available internationally is acquired.
and used more effectively by organisations throughout Australia. The collection, analysis and dissemination of data and information from other countries is covered in Section 4.4.1 (industry aspects) and in Section 7.6 (for the research and technology system as a whole).

7.3 **Better management of research organisations and programs**

It may once have been true that 'research management' was thought unnecessary or, as an apparent contradiction in terms, impossible. In the past, research has been viewed as basically an individual activity, characterised by autonomy, serendipity and unfettered creativity. While this image was always to some degree at odds with the facts of organisational life in that virtually all researchers this century have worked in organisations, it is especially incongruous in the 1990s, when companies, universities and government laboratories such as CSIRO are all large, complex and bound by accountability, staff development and strategic planning requirements.

ASTEC's consultations highlighted a number of problem areas in the evolving system that are essentially matters of management, for example:

- there seem to be too few people who are well-equipped to manage research in a manner that facilitates the achievement of defined goals;
- while large research organisations such as CSIRO have taken initiatives to improve management of their research programs, they need to evaluate carefully the impacts of external funding requirements on their programs to ensure that their capacity to conduct strategic research is not eroded;
- there is a need for university management to ensure that the capacity of academic staff to carry out research of high quality is not compromised by the time and financial constraints resulting from the restructuring of the higher education system and the unprecedented rate of expansion in student numbers.

7.3.1 **Training better managers**

ASTEC holds the view that management training of high quality is required to achieve efficiency, productivity and innovation throughout the research system. It endorses the lead taken by CSIRO to improve its research management, which represents a move away from the presumption that the best researchers are necessarily the best people for management positions. Recently, CSIRO has been placing increasing emphasis on leadership and management skills in senior appointments and has committed resources to assessing and realising management potential in the organisation. In addition, the CSIRO career structure, based on merit, has the advantage of enabling its better researchers to achieve salaries commensurate with those of senior managers, so that a move into management is not the only way to advance.

The need for experienced managers of research is escalating rapidly; for example, establishment of the CRCs is creating a major demand for
outstanding research leadership combined with a high degree of management skills and insight.

ISSUE:
There is, in Australia, a dearth of managers experienced in running research enterprises.

OPTIONS:
(A) Some universities could develop, as a matter of urgency, specialised post-graduate MBA-type courses for training Australian research managers.
(B) Commercial training companies could develop extension courses specifically for training research managers.
(C) All Australian research organisations could ensure that staff with management potential receive appropriate training.

7.3.2 Strategic management of public sector research

The need for strategic planning in the research and technology system has led to major priority setting exercises conducted recently by CSIRO (see Section 2.3.2) and the Australian Nuclear Science and Technology Organisation (ANSTO). These exercises recognise the importance of management techniques and reporting structures that encourage common objectives with industry, and the establishment of multidisciplinary teams. These new management arrangements seem likely to work satisfactorily, although it was drawn to ASTEC's attention during the consultation process that industry should be involved at an earlier stage when CSIRO formulates priorities or programs which relate to industry objectives.

These management changes, the requirement that major government research organisations attract outside funds, and the 150% tax concession for research and development, have played complementary roles in stimulating better linkages with industry and in increasing the levels of research commissioned by industry (see Figure 2.8).

However, universities have found it more difficult to change. Research in the higher education system is linked to the funding of teaching: the introduction of the unified national system (UNS) and the dramatic expansion in student numbers have had complex effects on the research activities of universities (Section 2.3.3). One obvious result is the greater number of potential researchers now in the university system. In addition, university groups are now in competition with CSIRO for some research grants.

In this changed environment it is no longer appropriate for all academic staff to be required to pursue research as an essential part of their contract with the institution. Since there is now a wider range of abilities and interest among
academic staff in the UNS, motivation and capability for undertaking research will vary greatly. This issue is a central one for university administrators and requires flexibility in staff management in allocation of teaching, research and administrative duties. Furthermore, promotion criteria in future will need to include a range of teaching and other skills as well as research. However, it is crucial that sufficient funds are allocated from university operating grants to ensure that those academic staff who wish to carry out research of high quality, and who are judged by their peers as being capable of doing so, are well supported. Otherwise Australian research and research training will fall below international standards.

Australia has, for the most part, employed two forms of support for its publicly funded research: appropriation (or block) funding, characteristic of research organisations like CSIRO, and competitively allocated research grants from funding bodies like the ARC. There is scope for greater emphasis on other forms of research support, such as the university research centre funded for a fixed term (the ARC’s Special Research Centres are an example), or the research organisation whose constituent parts are reviewed and often are closed once their directors retire (eg the German Max Planck institutes) or the ad hoc research enterprise whose stimulus is community-based and whose funding flows from a mixture of private and public sources (eg some social research organisations in Europe). The essence of such centres is that they usually have a specific purpose, a more or less fixed term, and a mixture of funding sources. They also require innovative management.

7.4 **How can Australia ensure an adequate supply of skilled people for the research and technology system?**

Australia’s future development depends in large part on an adequate supply of suitably qualified people to carry out research and development, to train the students who will constitute the future skilled work force, and to help foster the competitive and innovative ethos needed to achieve national objectives.

Around eight in every thousand of the Australian work force are employed in research and development activities, as researchers, technicians or other support staff. This proportion has increased markedly over the last decade but is still lower than in many larger OECD countries, largely because of the smaller scale of Australian manufacturing industry and its lower level of research and development expenditure. The pattern of research and technology employment is changing. Increasing numbers of research and development personnel are being required by the business sector, while demand from the traditional employers of researchers in Australia is almost static (in the case of government research organisations), or growing at a slower rate (in the case of the higher education sector).

If Australia is to become more competitive in the global economy and to deal more effectively with national problems and opportunities, measures must be taken to encourage demand for researchers and technologists, particularly from industry. Government can play crucial roles in:
attracting sufficient numbers of people to research careers generally and to specific research areas;

motivating them to perform high-quality work through the provision of world class facilities;

supporting career development and change through effective retraining programs and incentives; and

supporting a high-quality and flexible education system capable of providing a range of skills to meet current and future employer needs.

In the past, government has influenced the research labour market by increasing the level of public spending on research and technology and through control of immigration. Attracting qualified immigrants may be more difficult in future if, as seems likely, other countries such as the United Kingdom and USA face shortages of professionals and if working conditions for scientists and researchers in Australia become relatively less competitive.

ASTEC’s consultations have identified three major research-related human resource challenges for Australia:

- ensuring the provision of research and technology skills for the future;
- improving the image and status of science, engineering and research as professional careers; and
- developing research and technology skills for industry, which is dealt with in Chapter 4.

7.4.1 Provision of research and technology skills for the future

Planning for future personnel needs is essential given the long lead time required to train research staff and the changing patterns of research and technology employment. Forecasts of demand for research and technology personnel must both inform and be informed by the national direction-setting process and be directly linked to education, training and immigration policies. Forecasting needs to become a routine rather than a spasmodic activity of governments and large organisations.

Most recent analyses of research and technology labour force requirements predict shortages (i.e., an excess of projected demand over projected supply) over the next decade. For example, there is little doubt that "the requirements for additional [academic] staff over the next decade are substantial and these requirements will not be able to be met from the flow of Australian-produced higher degree graduates." On the other hand, the study by the National Institute of Economic and Industry Research considers that, in the absence of a significant reorientation in Australia towards high-technology industries, the supply of scientists or engineers (broadly defined) is likely to be adequate in the 1990s.

The supply of skilled people depends on population trends (in the mid to late 1990s there will be fewer people in the age range from which most students are drawn), the numbers of students entering and completing certain courses
and levels of immigration. Demand for research and technological skills is determined by the evolution of the structure of Australian industry and government spending on science and technology. Projection of demand may be based on extrapolations of historical growth rates, on econometric projections of likely growth in various sectors of the economy or by comparison with other economies that Australia might seek to emulate.

Forecasting must also focus on the training appropriate to likely future research and technology needs. It is useful to consider the balance in the curriculum between general and specialised training (eg in relation to doctoral degrees) and between basic theory and practical application. The training system should be flexible enough to allow the rapid development of courses which are more responsive to the needs of employers. More doctoral research could be structured more closely around problems rather than on specific disciplines (eg on climate change, soil degradation, or the distribution of wealth and income, rather than on physics, geology or economics).

If the capacity to respond to challenges or opportunities is the criterion, the consequences of an under-supply of skilled people would be worse for the nation than the consequences of an over-supply. The national interest requires an adequate supply margin of research and technology personnel to be maintained so that opportunities can be seized at the peaks of economic growth. This is no simple matter since, as already noted, training programs, immigration and emigration, changed demands from the labour market, and the state of the economy itself all have an effect on the availability of skilled personnel.

ASTEC considers that the longer term government strategy for human resources must emphasise:

- increasing the national demand for researchers, scientists and engineers, particularly from industry;
- building a broader domestic base of qualified students entering research and technology professions; and
- better integration with the international market for research and technology professions.

To achieve this, there has to be maintenance in real terms of the current capacity of the higher education sector for research training founded on advancement of knowledge across a broad range of fields. In addition there has to be expansion of the capacity for applied research training, in response to industry demand and with complementary funding from industry where industry will directly benefit.

ISSUE:

There will be major shortages of appropriately qualified researchers and technologists during the decade if Australia continues to raise its national research and development effort.
OPTIONS:

(A) The number of Australian Postgraduate Awards (Industry) could be adjusted annually to accord with the number of high quality proposals advanced jointly by industry and higher education; and

(B) Additional places and scholarships could be provided for students undertaking research and other higher degrees, up to the level that can be adequately supervised.

Funding agencies should monitor the relative demand for places in their postgraduate and postdoctoral schemes and should report on the balance between demand and supply for skilled people in areas of particular need.

The mechanisms used to allocate postgraduate scholarships should encourage greater mobility in the undergraduate and postgraduate student population to entice potential research students to move to centres of highest quality education and research training in their chosen field. In addition, all students in their honours year should be exempted from Higher Education Contribution Scheme (HECS) liabilities, if a review shows that these are proving a financial barrier to undertaking training for a research career.

Australia is part of the global market in research and technology personnel. Overseas students account for nearly 20% of enrolments in postgraduate research degrees in Australian universities and for more than 40% of PhD candidates in agriculture and engineering. It emerged during the consultations that there is widespread discontent about present policies on charging fees for foreign research students, and immigration regulations which make it difficult to retain those who could make significant contributions to Australian research and technology. Australia needs to assess carefully the best ways of attracting and retaining good overseas research students, researchers and technologists in fields that are strategically important to the nation. Transnational companies could play a significant role in developing international research training linkages.

Technical and support staff are an essential component of the research and technology work force. The question of career paths and training for these staff has not received sufficient attention in Australia. The balance between training in the Technical and Further Education (TAFE) system and technological training within the UNS of higher education may require review.

Building a more responsive and adaptable education and training system is not a task for government alone. It will necessarily involve cooperation with industry and professional groups in identifying needs and in implementing appropriate training strategies.
7.4.2 Improving the image and status of science, engineering and research as professional careers

Science, engineering and research in Australia are in competition with other professions for human resources. They are also in competition with other countries. If the most able students, particularly those in internationally sought-after disciplines and fields, perceive limited remuneration, facilities and professional opportunities in Australia they will select rewarding careers elsewhere, to the ultimate detriment of Australia's research and technology system.

There is a clear need to improve the professional status of scientists and researchers in Australia and to provide career paths for young scientists and researchers even if these cannot be as clearly defined as those in medicine and law, for example. Historical patterns of recruitment and tenure in the public sector have curtailed job opportunities for younger researchers and may lead to widespread shortages once the older age cohort retires. ASTEC has supported a move towards longer term, renewable, contract employment for researchers in the public sector.13

Research training and academic career paths must be more flexible to allow both an interdisciplinary view of problems and an opportunity for people to move between research, teaching and other functions within universities, or to outside employment. ASTEC has supported the establishment of a Visiting Fellowship Scheme to facilitate mobility and interaction between researchers in higher education, government research agencies and industry.14

ASTEC's consultations revealed widespread concern that too few of the better university entrants are now enrolling in courses in natural sciences, engineering and technology, and that an inadequate proportion of these students will go on to pursue research training to meet the country's future needs. It may be that the views of clever young people on the careers available in research and technology represent an accurate assessment of present and likely future prospects. However, under-supply of students in natural sciences, engineering and technology could have two further causes:

- a negative image among school students of the worth of natural sciences and engineering as professions, perhaps reflecting a similar perception in the more general community (including their parents and school career advisers); and

- a lack of competence in the basic skills of potential entrants who might wish to enter science and research training.

The ways that science and technology are taught in the primary and secondary education system are critical in forming student attitudes towards science, research and technology generally and towards career choice in particular. Old-fashioned curriculum materials, strongly discipline-based courses rather than holistic approaches to major social and environmental problems and opportunities, underqualified teachers and limited course options can all contribute to poor student interest.15 Programs like the National Science Summer Schools and mathematics competitions, sponsored by the private sector, are a good way of improving student interest and
knowledge. The Department of Employment, Education and Training (DEET) should actively encourage growth of these programs, which also have the potential to improve the quality of teaching.

ASTEC has argued in several reports (and the theme was echoed in the consultative process) that scientific literacy should be part of the basic education for all school students. Special programs may be needed for those groups currently with poor participation in science and mathematics in schools and in the research and technology work force, notably females. ASTEC has also suggested that State Governments should look to conserving scarce resources and talents in these areas by establishing special high schools for mathematics, the ‘hard’ sciences and foreign languages, for example.

ISSUE:
School leavers are frequently not attracted to, or well prepared for, careers in science, research and engineering because of a poor understanding of technology and of the role played by industry in contributing to the national well-being.

OPTION:
(A) DEET, in consultation with the States, could investigate:
   - methods to fund and implement a National Science and Technology in Schools Program;
   - ways to improve the skills of those teaching science and mathematics, eg by enabling teachers to retrain or to gain industrial or research experience in mid career, and rewarding advanced skills appropriately; and
   - the introduction of innovative curricula which focus on process-oriented, problem-solving learning as the Commonwealth Government did for the National Computer Education in Schools Program (1983-88).

7.5 Making the best use of Australia’s research infrastructure
The quality and range of research achievable is increasingly constrained by the infrastructure—the physical facilities (comprising buildings and equipment) and support services—that research requires. Indeed, the most adventurous research is often defined by the state-of-the-art equipment and instrumentation that make it possible. Efficient and effective research is coming to depend more and more on an advanced infrastructure, such as high-speed computers and networks and other support facilities, including rapid information location and expert technical services. In consequence, shortcomings in the provision of infrastructure are likely to lead to a serious decline in the quality and relevance of research and technology training and competence throughout the system.
Research infrastructure equal to the best in other countries is also a necessary condition to maintain Australia's international standing across the broad fields of research and technology. Without it, there is less chance of Australia's developing linkages with international business and researchers as a credible participant in world research and technology.

Access to major research facilities is becoming a prerequisite for national involvement in some areas of research endeavour. Increasingly, some major facilities are an international concern, since their cost places them beyond the resources of single countries. Australia needs to consider subscribing to these facilities, to achieve efficient use of research and technology resources and to participate fully in international scientific undertakings, and the networks and dialogues that accompany them.

### 7.5.1 Funding and managing the research infrastructure

An ageing infrastructure and decline in equipment quality are major problems afflicting Australia's public sector research system. That this remains a major and widespread concern is abundantly clear from the consultative process for the present study and from ASTEC's concurrent study of major national research facilities. There appear to be several reasons for these problems: an inadequate level of funding over many years, inappropriate funding mechanisms, and poor planning and management.

As noted in Chapter 2, Australia's overall public sector performance of research (in government research organisations and universities) is at least on a par with comparable countries. It is likely that the major part of any increased spending on the general research infrastructure will have to be found from within existing research budgets. This involves an examination of the balance between recurrent costs (primarily salaries) and capital investment in infrastructure. Support should also be sought from outside the traditional channels of infrastructure funding.

A long-standing criticism of current research and development funding has been that it spreads research infrastructure too thinly. Major changes have taken place over recent years in the balance of research funding to the universities and government research organisations (especially CSIRO). In particular, there has been a shift from appropriation funding to the provision of funds through competitive grants and research contracts.

However, many Commonwealth competitive grant schemes have never attempted to cover the full cost of the research they support or commission. This practice of 'marginal funding' has therefore contributed to the severe pressure on equipment and other facilities in both the universities and government research organisations. ASTEC has recently examined the question of pricing public sector research and proposed that:

- research sponsored by industry or government granting agencies which has primarily a commercial objective and little intrinsic value to the performing agency should normally be carried out on a full cost-recovery basis;
• the proportion of institutional support for research funded by ‘mission-oriented’ agencies and for collaborative research projects is best determined by negotiation between research performing and funding agencies; and

• the current arrangements for financing the bulk of non-mission-oriented research in the higher education sector through a mix of operating funds and competitive project, program and infrastructure grants are generally appropriate and should be retained.\(^19\)

This set of proposals presumes that institutions carrying out research have in place accounting practices that enable them to identify the full cost of research activities. Implementing such a pricing regime would help to halt the rundown of public sector research infrastructure.

Research institutions will have to give more attention to longer term planning for major infrastructure needs, partly because of the Government’s past ‘one-off’ approach to funding capital facilities for research. Institutions seem likely to face further pressure to concentrate their research resources, based on evaluations of which is best qualified to do what sort of research. To be competitive internationally, Australia’s limited infrastructure funding must be concentrated: it must reward the best research performers and contribute to excellence in university and government research laboratories in specialist research areas. There may also be scope for further cooperative use of existing facilities. Researchers cannot expect equality of research resources, but they should be allowed equality of access to resources on the basis of the excellence (and relevance if appropriate) of their research, determined through a peer review process. In other words, the best researchers must be guaranteed access to the best facilities.

Funding bodies, research users and research institutions recognise the urgent importance of ensuring that the provision of infrastructure is appropriate to the needs and talents of the best researchers. Options in this chapter are intended, therefore, to assist that process. They are all feasible and, except for major national facilities (see Section 7.5.2), do not require major funding increases.

ISSUE:
The infrastructure supporting the public sector research system is inadequate to maintain Australia’s international research competitiveness.

OPTIONS:
(A) Any increased funding for research infrastructure in government research institutions and universities could be clearly tied to strategic planning for capital facilities; strategic plans could be considered in the context of the White Paper process. It could be useful for ARC, the Higher Education Council (HEC) and the National Health and Medical Research Council (NHMRC) to define the current condition of research infrastructure in the universities and medical research institutes and assess the likely needs for the next three to four years.
(B) The level of competitive funding for research infrastructure available to universities and government research organisations could be increased, for example, by raising the proportion of infrastructure funding through the ARC’s ‘Mechanism C’ grants for cooperative projects.

(C) Wherever practicable, significant research facilities could be made available for more than one kind of user. The criterion for access should be excellence as determined by peer review.

(D) ARC and NHMRC could work to achieve an appropriate balance between equipment and personnel funding in their granting programs and ensure that adequate resources are earmarked for competitive allocation for major items of equipment.

(E) In allocating the research-related component of universities’ operating funds, the ARC and HEC could move quickly to take account of external research grants and contracts from all sources, not just Commonwealth granting bodies.

(F) Research organisations could adopt pricing practices that recognise the full costs of research in the universities and government research organisations.20

(G) Where a choice has to be made, increases in research funds could normally be directed to improving infrastructure rather than widening the list of researchers.

(H) Research organisations could increase efforts to attract funds for infrastructure from the private sector.

7.5.2 Provision of major national research facilities

Representations to ASTEC suggest a pressing need for funding for large capital facilities in Australia and for appropriate mechanisms to guide our investment in major national and international research facilities.

The Council is currently studying the provision of major national research facilities for the next five to ten years. The aim is to identify and rank specific proposals for the upgrading or establishment of facilities which are likely to require government funding in excess of $5 million and to establish criteria for assigning relative priorities to proposals for investment in such facilities. Of 93 preliminary proposals for funding major national research facilities, 27 sought a dedicated building to house staff and equipment as a major component. This may reflect a backlog caused by the decline in funding of capital works, particularly in the higher education sector, during the early 1980s (see Figure 2.10).

The development of major national research facilities must be closely integrated with long-term national research and technology planning, based on criteria of scientific excellence and national socioeconomic needs and benefits. This will allow the effective establishment and operation of facilities which cross portfolio boundaries and permit the cost of major facilities to be
weighed against the cost of responding to other emerging research and technology opportunities.

There are three approaches to gaining access to major research facilities:

- build the facility in Australia;
- join or initiate an international consortium to construct the facility here or overseas; or
- arrange access for Australian researchers to an existing international facility.

The benefits of interacting with researchers in an overseas facility must be balanced against those that would result from the development of a local facility.\(^{21}\)

ASTEC plans to review the potential benefits of establishing stronger formal links with leading major research facilities overseas, and to investigate the effectiveness of various models for the management and control of major joint use facilities in Australia.

**ISSUE:**

There is an urgent need for new or upgraded major national research facilities in Australia.

**OPTIONS:**

(A) The Government could take into account the recommendations of ASTEC's study into major national research facilities in the development of the 1992 White Paper.

(B) A similar survey and assessment of proposals for major national research facilities could precede subsequent White Papers.

(C) Guidelines for the evaluation of proposals for major national research facilities could be adopted to assist in better strategic planning by proponent bodies.

7.6 How can the information needed for research, technology and policy development be provided?

The recent report of the House of Representatives Standing Committee for Long Term Strategies identified 'an urgent need...for information to become part of the political, bureaucratic and business agenda, to recognise its centrality as a central organising principle, a tool for understanding and a vital element in trade expansion.'\(^{22}\)

The level and type of research and technology information required by industry, government and research institutions vary. Through consultations, ASTEC identified two main issues:
access to information, including the difficulty experienced by some parts of industry in obtaining research and technology information, and pricing policy; and

inadequate categorisation of information on the national research and technology effort.

The challenge for Australia is to ensure that research and technology information of the highest quality is readily available to both researchers and end-users of research in private and public sectors.

7.6.1 Access to research and technology information

Australian industry and government decision making require a broadly based understanding of trends, advances and opportunities in research and technology, both in Australia and internationally. This need can be met through effective linkages with, and awareness of, researcher networks, better access to information, and more effective understanding of the information needs of different communities. The general lack of awareness by senior management (in both public and private sectors) of how to access technological information was highlighted in consultations.

Obtaining information requires an investment (whether large or small) of money, time and know-how. Access to most research information has traditionally been unrestricted, but as the value of knowledge becomes more widely recognised, constraints are being more widely applied. Both owners and providers of information are keen to recover costs.

The Government's cost recovery measures have had two outcomes which are unacceptable. The first is that government departments now charge each other for information initially collected and paid for by government. The Coordination Committee on Science and Technology is attempting to rationalise this situation. The second is that some costs have increased to levels which appear to be restricting access to data and information, a situation that is counter to the national interest. The short-term gains from cost recovery have to be balanced against the benefits which can accrue from the wide dissemination of relevant national interest data and information, which could, for example, lead to the discovery of a significant mineral deposit or to improved land management strategies.  

There is no central or coordinated mechanism in Australia for the systematic capture of local and global information about research and technology although databases are available through libraries and research agencies such as CSIRO. Access to information is currently driven by researchers, and the information gained often remains with individuals or their research groups. Such an approach does not necessarily provide comprehensive coverage of the full range of information available—for example, ASTEC found that environmental research project databases were incomplete because there is no formal requirement to register such information. The establishment of the Australian Academic Research Network (AARNET) is a timely and important
initiative to provide an access and dissemination mechanism for academic researchers. However, its capacity is rapidly becoming saturated.

The Commonwealth and State Governments have made significant progress in recent years in improving information collection, management and access. The National Resource Information Centre (NRIC) and Environmental Resource Information Network (ERIN) are major initiatives by government to collect research data, manipulate it for better decision making and make it available to all users. Australian progress in geographic information systems (GIS) is world class and expected to increase rapidly over the next decade.

The Australian Science and Technology Counsellor Network (ASTCON) and AUSTRADE are examples of existing resources for gathering broadly based research and technology information which ASTEC believes could be more fully used. This would require more resources in the networks, more effective use of the counsellors and, perhaps more important, better management of the information gathered (see also Section 4.4.1). All information received should be appropriately indexed and cross-referenced for easy access, something which is not possible with the current resources.

ASTEC proposes to assess Australia's research and technology information needs and the adequacy of existing coordination arrangements.

ISSUE:
Research and technology decision making is being inhibited by the lack of ready access to high quality data and information.

OPTIONS:

(A) The Department of Industry, Technology and Commerce (DITAC) could take action to increase awareness and use by industry of existing databases on research and technology.

(B) To provide up-to-date trends on research funding, discipline strengths and gaps, the ARC, in conjunction with relevant organisations could:
- assess the needs for information about Australian and international advances in knowledge;
- identify means of better coordinating the gathering, interpretation and dissemination of that information (for example, provide research-in-progress databases with current funding proposals).

(C) DITAC and AUSTRADE could improve information collection and management mechanisms through their overseas networks.

(D) Key scientists travelling overseas could be used, at minimal increased cost, to gather and pool information of interest.

(E) The Commonwealth Government, in collaboration with states and territories, could regularly review the pricing of data and information,
with a view to ensuring that cost does not become a barrier to access by any user groups.

7.6.2 Categorisation of information

Quantitative information for government policy making falls into two categories: information about existing Australian conditions or circumstances (such as baseline environmental data) for portfolio-based policy development, and information about the performance and funding of research for policy development in relation to the research effort as a whole. There are significant gaps in both areas.

For example, in the course of the industry analyses for this paper, ASTEC considered four key pieces of information: gross value of production, value added, exports and imports. ASTEC is indebted to CSIRO for access to its commissioned data which were not otherwise available. In ASTEC's view, this kind of information is one of the important factors to be considered in determining national directions for research and technology. For example, OECD regularly publishes information on business enterprise expenditure on research and development (BERD) as a proportion of domestic product of industry.

Quantitative information about the Australian research effort is principally collected by the ABS through its biennial survey of research and experimental development. The survey of research and development in the higher education sector is carried out by DEET. CSIRO found that some quantitative data about the Australian research effort, which it desired for its recent priority-setting exercise (outlined in Section 2.3.2), either was not available or did not adequately meet its requirements. ASTEC has had similar experiences with several recent studies.

Recent changes to the classifications used in the ABS Survey—both in fields of research (FOR) and socioeconomic objective (SEO)—will provide a more comprehensive database and make analysis easier. ASTEC endorses the ABS proposal to develop the classifications into an Australian Standard Research Classification (ASRC). A major weakness, however, is that only the government sector is required to respond using the full detail of the classification; the higher education sector responds using an abridged SEO format and the business sector is not asked to classify its research at all.

Considerable value could be added to the survey of research and experimental development if major national accounts data were more readily available in a format compatible with the SEO classification. Information on imports and exports, gross value of production and value added for each of the SEO subdivisions is critical in setting research directions and priorities. As mentioned above, ASTEC was able to access CSIRO's analyses on this basis, but future White Papers on Science and Technology would benefit from a more systematic compilation of such data.
ISSUE:
The current collection of data in research and economic development by socioeconomic objective is inadequate.

OPTION:
(A) In consultation with the user community, ABS could identify and map relevant sets of quantitative information to the SEO classifications, regularly update these, and make them available.

Chapter 7: Notes and references


   Japan, Germany, France, Switzerland and Sweden employ 11.0 or more R&D personnel per thousand of the work force; R&D employment in Australia (8.1 per thousand labour force in 1988) is about on a par with Canada (8.2 per thousand) or Denmark (8.5). In terms of research scientists and engineers alone, according to OECD figures, the Australian employment level of 4.8 per thousand of the work force is the same as in France and Ireland and close to that in Canada (4.5) and the United Kingdom (4.6). Germany, Japan and the United States employ the highest proportion of research scientists and engineers.

4. DITAC, Australian S&T Data Brief, 1989-90, AGPS, Canberra, 1990, Table 1.3.


7. ASTEC/OCS, op cit, Figure 2.8, ‘Population forecasts: 17-19 year olds’.

9. As recommended in the submission from the Australian Research Council (ARC) and Higher Education Council (HEC).


11. On average, there is around one technician for two researchers and one other supporting staff member for every four researchers in Australia. ABS, *Research and Experimental Development All-sector Summary 1988–89*, Catalogue No. 8112.0, ABS, Canberra, 1990, Table 6.


15. ‘Too many teachers of science and mathematics are underqualified for the teaching they are doing’; Prime Minister’s Science Council, *Science and Mathematics in the Formative Years*, AGPS, Canberra, 1990, p 36.

16. ASTEC recommended in 1987 that ‘education authorities, both state and federal, ensure that as many young people as possible have skills in fundamental areas of literacy and numeracy, and take measures to increase participation and competence in mathematics and science’ (*Education and National Needs*, op cit, Recommendation 3). ASTEC also noted that the capacity to implement this recommendation would be limited by teacher shortages and further recommended that ‘positive measures be implemented to attract well qualified graduates to become mathematics and science teachers’ (ibid, Recommendation 5).


18. ASTEC is currently undertaking a study of the need for major research facilities and has recently assessed specific proposals for national and international facilities (*The Future of Australian Astronomy*, AGPS, Canberra, 1989; *Small Country, Big Science—A Report to the Prime Minister on Australian Participation in Major International Accelerator and Beam Facilities*, AGPS, Canberra, 1990; *An Australian International Gravitational Wave Observatory—A Case Study for Construction of Large National Facilities*, AGPS, Canberra, 1991).

20. ASTEC’s *Funding the Fabric* paper (ibid) provides principles on pricing research (i.e., the allocation of costs) and guidelines for determining full research costs.

21. The question of access to international facilities was addressed in a recent ASTEC report *Small Country, Big Science*, op cit.


23. This was discussed in the submission received from the Bureau of Mineral resources, Geology and Geophysics.


25. ASTCON is part of the Department of Industry, Technology and Commerce (DITAC).

26. ASTEC identified this as an issue in its report *Setting Directions for Australian Research*, AGPS, Canberra, 1990.
While the activities of the States and the Federal Government intersect at many points, in science and technology as in other fields, such interactions are ad hoc and designed to resolve particular difficulties rather than create a framework for co-operation.1

8.1 Introduction

ASTEC consulted widely on matters relevant to this report and placed great importance on gathering the views of state government representatives;2 holding a series of meeting in each of the state capitals. At these meetings, the Council had extensive discussions with organisations and individuals representing community interests, industry, higher education and government.

This chapter summarises the status of research and technology in the states, and identifies issues arising from the current functioning of the federal system.

8.1.1 Developments in the 1980s

During the 1980s, all governments in Australia became much more aware of the potential contribution that research and technology can make to economic development and to improving the community's quality of life.

Regardless of their political persuasion, there was general recognition among governments that sustained higher levels of technological innovation are essential to increasing the competitiveness of existing industries and to fostering the development of innovative products and services.

Governments at both Commonwealth and State levels developed new policies and other initiatives to promote greater awareness and use of new technologies. The Commonwealth followed a generally non-interventionist approach, exemplified by the introduction of the research and development tax concession in 1985, whereas most states believed they should be more active participants in the process of economic and social development. Several embarked on ambitious programs involving public sector support for new ventures. In addition, some 15 technology parks, based on existing state-wide or regional research or commercial strengths, were established through the 1980s, in all States except the Northern Territory. The States also became more involved in technology transfer and in technical information activities. In common with the Commonwealth, all States sought to achieve greater integration and coordination between their research and technology policies, and other policies.

There are at present two views about the role of the States in the national research and technology system. One, expressed by several speakers at a
recent Workshop on *Science, Technology and Australian Federalism*, is that the States have been ahead of, and provided many of the formative elements for, a national approach to research and technology over the last decade. The other, held in some areas of the Commonwealth administration, is that the States have essentially a secondary role in supporting research and technological innovation and should aim to orient their activities more towards goals identified by the Commonwealth.

### 8.1.2 The contribution of the States to Australia’s research and technology effort

Expenditure by State Governments on research and development in 1988–89 totalled $453 million or almost 11% of the national effort. Over time, specific economic or social differences between states have resulted in research characteristics and priorities which clearly differ from those of the Commonwealth. The research role of the States is especially apparent in agriculture, forestry and fisheries which, in 1988–89, amounted to 67% of overall state government research expenditure. By comparison, the Commonwealth committed 17% of its research resources to these areas. The States also fund higher proportions of medical and social science research than does the Commonwealth (see Figure 2.4). In addition, they generate and make use of practical technologies, many of them directly related to the quality and efficiency of urban and rural services and to the development and application of safety standards.

Data from the Australian Bureau of Statistics indicate that the geographic distribution of public sector research facilities corresponds broadly with the existing economic or social characteristics of Australia’s States and regions. The Commonwealth has traditionally been a major provider of research facilities, so it is not surprising that exceptions to this pattern may be explained in terms of the location of Commonwealth research establishments, often the result of political decisions rather than economic factors.

Commonwealth–State relations in research and technology are now beginning to change. In large measure, this can be linked to recent Commonwealth initiatives such as the establishment of Cooperative Research Centres, the formation of rural research and development corporations, and other research programs which are discussed later in this chapter.

### 8.2 The need for more cooperation and better policy coordination

The key Commonwealth–State issues identified in ASTEC’s consultative process relate to the need for greater cooperation and better coordination of research and technology policy.

These were raised most strongly in submissions from the New South Wales Science and Technology Council, the Western Australian Government and two departments of the Northern Territory Government, and in consultations
in each of the state capitals. They were also discussed at the Workshop on Science, Technology and Australian Federalism.\(^4\)

The Commonwealth has been able to shape significant parts of Australia’s research system because it controls or influences the bulk of the nation’s research expenditure. In some cases, State Governments have identified research areas which they wish to promote in order to underpin their particular industries, or to develop centres of research excellence in their own right. However, because of their restricted resources, State Governments have only limited capacity to support this kind of activity.

National research and technology policies should reflect to a far greater degree the regional diversity and complexity of the Australian economy and society. To this end, the States should play a more important role in Australia’s overall research and technology effort by providing a strong and distinctive regional dimension to national policies and programs. In line with the spirit of the new federalism, the States should also be active in setting their own broad social and economic goals, as most are now beginning to do, and should assess their research and technology needs in the light of these.

The differing perceptions of the role of the States in the innovation process provide a clear indication that existing levels of cooperation and coordination are, on the whole, inadequate. Although there are comprehensive inter-governmental networks across many prominent areas of research and technology, each level of government tends to pursue its own agenda to foster development and innovation.

While most States formed science and technology advisory bodies during the 1980s, only New South Wales and Western Australia now possess adequately resourced bodies of this type. In recent years ASTEC has initiated regular meetings of the science and technology advisory bodies and State Government officials in an effort to strengthen open communication and the exchange of information. ASTEC found the range of views and options afforded by the diversity of membership of these advisory bodies to be most valuable. There are mutual advantages in all States developing research and technology policy coordination mechanisms compatible with those of the Commonwealth.

**ISSUE:**

The States are where the bulk of the public sector research is performed, and where most of the expenditure on industry development programs occurs, but insufficient cooperation and policy coordination between the Commonwealth Government and the State Governments is leading to national policies and programs which commonly do not adequately reflect important regional dimensions.
OPTIONS:
(A) The Commonwealth Government could convene a Special Premiers' Conference on development of a national approach to research and technology policy and program administration.
(B) State Governments could develop properly resourced coordination arrangements compatible with the Commonwealth to assist the development of a national approach to research and technology policy development.

The remainder of this chapter discusses a number of sub-issues related to better cooperation and coordination.

8.2.1 Role of the States in appraising applications for Commonwealth research and development funding

The consultation process with State Governments produced strong arguments that decision making in disbursement of Commonwealth funds for research, technology and related aspects of industry development would be improved if the states were to be more closely involved.

The implementation of the CRC program has led most State Governments to develop mechanisms for choosing between various CRC proposals seeking endorsement and support. The States believe that this experience, together with that arising from their involvement in other major programs such as the National Industry Extension Service (NIES), means that they are now competent to advise on the administration of important national research and technology programs.

The NSW Science and Technology Council considers that 'moves by the Australian Research Council and the [National Health and] Medical Research Council and similar bodies to seek State Government involvement in their priority setting process should be endorsed and encouraged'.

States need to participate more in reaching decisions on the allocation of funding for research or technology programs. They could be given a more significant and formal role in the evaluation of proposals for CRCs. In addition, the Department of Industry, Technology and Commerce could seek greater state involvement in programs such as the National Procurement Development Program (NPDP) or other programs where familiarity with the structure of specific industry or technology sectors and the performance of individual firms are important elements in program effectiveness.

8.2.2 Effectiveness of State funded or State performed research

The efficient provision of a wide variety of services and infrastructure by State Governments requires significant inputs from research and development programs. However, ASTEC understands that many State government
departments and agencies, and State business enterprises, do much less research and development work than they should be doing.\textsuperscript{6}

There is considerable scope for the States to improve the efficiency and effectiveness of their scientific activities by encouraging agencies to develop their own research strategies as a basis for more interstate networking. Moreover, the priorities determined by State Governments in this area should be an integral part of national research and technology objectives.

Further, research relating to the development or delivery of products or services provided by the States should be contracted out to the private sector to the maximum extent possible. The success of the National Procurement Development Program demonstrates how important this kind of support can be for industry development, especially for emerging firms.

8.2.3 Technology diffusion and support

There is considerable scope in Australia for upgrading the technical competence of small to medium-sized firms. Notwithstanding the achievements of NIES, it suggests that much more could be done to bring Australian firms closer to international best practice across a broad range of industries and technologies.

Comparative studies of other countries with federal systems has shown that testing, accreditation and scale-up facilities are a well established feature of the support services offered to business by regional governments overseas and that these services are often provided either free of charge or at subsidised rates.\textsuperscript{7} Both the Commonwealth Government and State Governments should consider whether laboratories under their control could provide more effective support to meet the needs of specific sectors or regions in this way.

ASTEC proposes to undertake a study of research and technology-related support services, both Commonwealth and state, which are available to industry in Australia's principal economic regions to determine whether these services meet the requirements of the business community and, if not, how their provision might be improved.

8.2.4 Location of research facilities

The distribution of Commonwealth research facilities has implications for the extent to which the states can develop concentrations of complementary research and industrial expertise.

The Western Australian Government has emphasised the isolation of some states from effective involvement with research funded and performed by the Commonwealth.\textsuperscript{8} It was claimed that the relative lack of Commonwealth research facilities adversely affected the ability of Western Australia to win further funding and to build on its industrial strengths, as illustrated by that State failing to gain a Cooperative Research Centre in the first round.
There has been rationalisation over recent years of the location of some CSIRO facilities which were remote from the main users of their research, and this is obviously a welcome initiative. In Western Australia, CSIRO now has research laboratories dealing with many areas of vital importance to that State—agriculture, minerals, forestry, water resources, construction and the natural environment—and the headquarters of two of its 33 divisions are located in Perth. In addition, CSIRO researchers based elsewhere in Australia are involved in major programs which benefit that State.

In a country as large and as sparsely populated as Australia, the combination of funding and critical mass considerations means that there cannot be a strictly equitable distribution of national research facilities. The location of many such facilities is not as important as fostering more extensive and effective linkages between users and performers, and between performers engaged on similar projects, wherever they are.

Clearly, in the longer term, the location of the Commonwealth’s research activities will depend on State government views on a range of research and technology issues and the measure of involvement and support they choose to give to the development and implementation of national policies and programs. Recent experience with the CRC Program indicates that the role of the States in research and technology in the 1990s has the potential to be far more significant and varied than it has been over previous decades.

8.2.5 Research and information for the national interest

There is existing intergovernmental research and information cooperation in several fields of national interest. Five important examples are:

- **the National Geoscience Mapping Accord** which coordinates field and related laboratory studies, to provide a range of geological, geochemical and geophysical information of importance to land management and the minerals and energy industries;

- **the Murray–Darling Basin Commission** which coordinates studies into the water and land resource problems of concern to rural communities and industries in south-eastern Australia;

- **the National Soil Conservation Program** which coordinates and funds research and land conservation projects, and assists community-based organisations;

- **the National Forests Inventory** which is compiling information on the composition and extent of Australia’s forest resource, to provide a factual basis for forest conservation and resource use decisions; and

- **the Great Barrier Reef Marine Park Authority** which is coordinating research programs into the care and management of the Great Barrier Reef.

However, Australia has a long way to go in achieving optimal levels of consultation, cooperation and coordination on issues relating to urban and rural problems. Action is needed now to ensure that significant
improvements are achieved in the 1990s. The States and the Commonwealth and, where appropriate the private sector, should contribute funds for coordinated programs in applied research areas where mutual benefits can be identified.

**Environmental research**

Over 80% of Australia's environmental research is funded by the Commonwealth and performed in its agencies and in universities. Yet the responsibility for implementing the results of such research (through extension services or the setting of standards and monitoring) lies with the States. Moreover, the States are responsible for the establishment and maintenance of management information systems and data on forestry, water resources and fisheries.

ASTEC's report *Environmental Research in Australia—The Issues* found an urgent need for increased Commonwealth/state cooperation in producing environmental quality standards and guidelines. This need is clearly recognised by the Commonwealth Government through its new Environmental Protection Agency:

Collaboration among the Commonwealth, State and Territory governments is necessary for the effective determination of national standards, policies and programs for environment protection.

ASTEC supports the efforts of the Commonwealth government to establish uniform standards for management of environment data through the Commonwealth Coordination Committee on Science and Technology, the Australian Surveying and Land Information Group (AUSLIG), the Australian Land Information Council (ALIC), the National Resource Information Centre (NRIC) and Environmental Resource Information Network (ERIN). The success of such directions is dependent on effective state representation in these agencies.

**Rural research**

Historically, Australia's rural research and extension system has been characterised by strong state or regional orientation and an emphasis on achieving steady improvements in industry productivity and product quality. As a traditional provider of research services to the rural sector, State Governments met most, and often all, of the regional infrastructural cost of these services.

However, in recent years, the rural research system has come under mounting pressure from a number of sources.

First, rural research projects and the development of technologies for use in agricultural and pastoral industries are becoming increasingly complex in terms of their human skill and network requirements. They are also
demanding more resources in the form of sophisticated equipment and facilities.

Second, as the influence of the Commonwealth’s rural research and development corporations grows, the disinclination of these bodies (except for the Wool Research and Development Corporation, formerly the Australian Wool Research Council) to fund major equipment and other infrastructure is straining the capacity of state research organisations to provide their researchers with the best or most appropriate facilities.

Third, all this is coming at a time when State Governments are confronting budgetary problems which may severely limit their ability to maintain existing services and activities. In fact, there is now a pressing need to rationalise resources, within and between States, and between the States and the Commonwealth. Furthermore, some of the States have severely reduced their capacity to provide effective extension services to underpin their research activities. Therefore, the process of restructuring rural research will require careful planning. It must be based on a strategic examination of opportunities and requirements as agreed amongst the major interested parties. As noted by Lazenby and Williams:

It should be possible for the legitimate requirements of state governments (state economic development); the Commonwealth government (sustaining a scientific capacity and supporting research into generic issues such as sustainable agriculture); and the industry corporations (industry development) to be accommodated within agreed overall strategies.11

To contribute fully to the achievement of broader national goals, Australia must take stock of the resources being allocated to the funding and performance of rural research.

Australia’s governments should give more emphasis to developing coordinated research efforts in fields relevant to our own environmental and climatic conditions. Special attention should be directed to fields which have potential to produce techniques which could be applied in other countries, particularly in Southeast Asia. Tropical agriculture is an example mentioned in several submissions and in discussions held in capital cities (see Section 5.7).

ISSUE:

As many problems and opportunities bear no relation to state boundaries, there is a compelling need to develop stronger and more extensive consultation, cooperation and coordination arrangements for research, technology and service initiatives of national interest.
OPTIONS:
(A) Bodies with expert representation from the Commonwealth, the States
and industry could be convened to report on the scope for coordinated
research activities in important areas such as public health, transport,
construction, rural industries and the management of urban
environments.

(B) The vital contribution of the States in formulating standards for, and
management of, national databases could be recognised through state
representation on national bodies.

(C) A series of stakeholders' conferences could be organised, initially
under the auspices of Bureau of Rural Resources, to discuss means of
optimising Australia's rural research and technology effort and the
provision of appropriate extension services.

(D) Availability of information on the work of the industry research and
development corporations could be improved by the maintenance of a
register of their research funding and program activities by the Depart-
ment of Primary Industries and Energy.

Chapter 8: Notes and references

1. J Stewart, 'Mapping the System', in National Purposes, Federal
   Government—Science and Technology in Australia, Canada and the Federal Republic of
   Germany, ASTEC, 1990, p 25.

2. For convenience, 'State' is used to refer to an Australian State or Territory.

3. ASTEC, Science, Technology and Australian Federalism—Getting the Best from the
   System. Proceedings of Joint ASTEC/Federalism Research Centre Workshop,

4. C Walsh, 'Intergovernmental relations and science and technology policy', in
   ibid.

5. NSW Science and Technology Council submission, p 3.


8. Joint submission from Western Australian Government.


10. DASETT, Proposed Commonwealth Environment Protection Agency—Position Paper

11. A Lazenby and R Williams, 'Rural research—realities and opportunities', in
    Science, Technology and Australian Federalism—Getting the Best from the System, op
    cit, p 26.
9 Issues and insights: what have we learned?

The difficulty lies, not in the new ideas, but in escaping the old ones, which ramify, for those brought up as most of us have been, into every corner of our minds.¹

9.1 Introduction

This issues and options report has drawn on a store of knowledge in reports and on the collective wisdom and experience of a great many individuals and organisations. It represents the first attempt to identify issues relating to research and technology from a truly national perspective and to suggest to government some practical policy options. Throughout the report, ASTEC has aimed to adopt a far-sighted view of the major issues which emerged from its consultation program. However, in certain fields such as the management of Australia’s research resources or the environment, the issues are analysed more comprehensively because many aspects have required detailed discussion.

The major issues provide the substance of Chapters 4 to 8 and are discussed against the background set by Chapters 1 to 3. The issues are brought together in this concluding chapter to provide an overview of the strategic direction which ASTEC believes government research and technology policy should follow for the remainder of this century.

9.2 Research, technology and international competitiveness

Achievement of more effective links between government organisations, higher education institutions and industry was a prominent issue in ASTEC’s consultations. While governments have a central role in stimulating better economic performance by industry, there is a complementary role for industry to respond to the challenges of international competition by making a strong commitment to technological innovation. That commitment must extend well beyond research and development; it must embrace initiatives relating to total quality control, the achievement of steady increases in enterprise productivity, better product design, and to the development of products and processes that are less intensive in their use of energy and materials.

9.3 Energy and the environment

The links between economic performance, energy efficiency and environmental protection are complex. Historically, abundant supplies of cheap energy have supported economic growth. Increasingly, the production of energy must be considered in terms of its environmental cost. The realisation of the potential impacts of climate change due to increased emissions of greenhouse gases has focused worldwide attention on energy conservation and better energy management. A long-term challenge for
Australia is to develop alternative energy sources and to ensure that ecologically sustainable development is achieved in ways which preserve the country's unique environment for the benefit of future generations.

Decision making on environmental issues requires more effective long term monitoring, the establishment of national standards for environmental data and better coordination of Commonwealth and state government activities. While data from overseas provide useful guidelines, there is no substitute for data specific to Australian conditions; the unique features of the Australian environment mean that many of these data will need to be generated within Australia.

9.4 Quality of Australian life

The maintenance and improvement of the quality of life in Australia is a major issue that recurred during consultations. It is intimately linked to economic performance and to the generation of sufficient wealth to ensure that all Australians can enjoy social justice, adequate housing, high standards of health and access to recreational amenities. Researchers in the social sciences and the humanities must be encouraged to make a much greater contribution to the resolution of many fundamental socioeconomic problems.

The costs of social security, and health and welfare services are increasing rapidly: it must be recognised that responsibility for personal health and safety is not solely a function of governments but a responsibility to be shared by individuals and companies. Research that leads to recognition of the factors which underlie, for example, drug abuse, alcoholism, violent crime, traffic accidents, accidents at work, and increased mortality due to heart attacks, strokes and cancer, will contribute to a higher quality of life for all Australians.

9.5 Managing Australia's research resources

There is a strong link between the economic development of a nation and its research and technology base. Basic research, which is of international standard, is often a necessary condition but of itself it is not enough, as the comparative performance of nations clearly shows. The ability to translate research results, whether from Australia or overseas, into commercial products and processes that are internationally competitive is the critical factor. The benefits of Australia's excellent record in research in many fields have too often not been captured by Australian industry.

Better management of our research and technology resources—people, equipment and funds—is a major issue for both the public and private sectors. Hard decisions must be made in allocating limited resources to the best people for the most appropriate mix of basic and applied research. The supply of skilled people is seen to be a vital factor in ensuring Australia's future growth, and governments and industry need to recognise that long-term investment in human resources is essential for the nation's growth and development. Australia's ailing research infrastructure, which ASTEC described in a previous Occasional Paper as 'the very fabric of our research system', must
be restored to a level comparable to that of other industrialised nations. Its top researchers must be given access to state-of-the-art equipment.

Since Australia generates only 2% of the world's research, access to the remaining 98% of the world store of research knowledge is vital to ensure that the country improves its competitive position in world trade. Networking, both within Australia and internationally, can facilitate the rapid flow of information to a wide range of potential users in industry, government and the higher education sector.

9.6 Commonwealth and States: a national approach

The role of the States in developing Australia's research and technology policies is a major issue since they provide the location for many of the Commonwealth's research programs. It was suggested during consultations that the relationship between the Commonwealth and the States must be improved if Australia is to increase its prosperity in the future. While the states clearly have individual and varied needs for research and technology—because of differences in climate, natural resources and population distribution—a coordinated national approach would be advantageous in many cases. Moreover, environmental challenges such as those posed by degraded air and water quality, soil degradation, feral animals, fires, floods and droughts are not confined by local or State government boundaries. These, and a range of other matters of national interest, require overriding cooperation at all levels of government.

9.7 The future

These major issues are not new. They reflect the concerns of a wide range of Australians involved in research and technology in all its dimensions and diversity. ASTEC believes that this issue and options report, the precursor of the 1992 White Paper, will stimulate continuing debate on the role of research and technology in Australia's future. It can be only in the national good to ensure that many of the issues are re-examined and reviewed regularly. The proposed structured process of a four-year cycle of an issues and options report would lead to future White Papers (see Figure 3.1) in 1996 and 2000, thereby setting the Government's research and technology directions into the 21st century.

Chapter 9: Notes and references


Appendix A  Methodology

A.1  Introduction
Chapter 3 of this report examines the nature of the direction-setting process and briefly describes the scope and methodology of this report. This appendix provides further information on ASTEC’s consultative process and the steps it took in reviewing and analysing its results.

A.2  Gathering information
The work program implemented by ASTEC had four main components: literature review, quantitative information, preliminary meetings, extensive consultations.

A.2.1  Literature review
At the outset of the study, ASTEC recognised that considerable analytical work had been done in recent years on Australia’s research effort and how it could be applied to improve the nation’s economic, social and cultural development. The list of ASTEC reports shows that the Council has played a central role in helping to shape national decision making on research and technology and their application to national well-being (a list of ASTEC reports appears at the end of this document).

Against this background, ASTEC undertook an extensive review of relevant articles and monographs to identify common issues across industry sectors or broad fields of research. Many were produced by ASTEC, including *Science, Technology and Australia’s Future (1990)* and *The Core Capacity of Australian Science and Technology (1989)*. Other significant studies reviewed included *The Global Challenge—Australian Manufacturing in the 1990s*, published by the Australian Manufacturing Council in 1990, and *Developing Australia’s National Competitiveness*, a report prepared for The Business Council of Australia in 1991. A selected bibliography appears elsewhere in this report.

A.2.2  Quantitative information
Quantitative information to support the development of the report was collected from several sources. The basis for much of the information was the Australian Bureau of Statistics interim Australian Standards Research Classification socioeconomic objectives (ASRC-SEO) and the results of successive Surveys of Research and Experimental Development (SRED), the most recent of which had been completed for the 1989–90 financial year.

With assistance from CSIRO, key economic information in the form of gross value of production, value-added, exports and imports was collected for each of the major economic subdivisions of the ASRC-SEO, in order to assess the economic significance of these sectors to the nation. Analyses were made of
the 1989–90 SRED results and key data are presented in Chapter 2. Time series data were also examined and taken into account.

In addition, significant information about research and technology trends in overseas countries was obtained in collaboration with the Science and Technology Resource Analysis Group at the Department of Industry, Technology and Commerce.

Important information about the higher education sector was provided by the Department of Employment, Education and Training while data about the national welfare areas, such as the environment and health, were obtained from reports published by departments and organisations working in those areas. Where appropriate, these sources are acknowledged and referenced in the body of this report.

A.2.3 Preliminary meetings

In late 1990, preliminary meetings were held with senior Commonwealth government officials to discuss the background to, and purpose of, the study and to identify initial issues. These proved very valuable in the formative stages of the report.

A.2.4 Extensive consultations

As explained in Chapter 3, consultation was a central aspect of the study on which this report is based. Following preliminary consultations, ASTEC undertook an extensive consultation program with industry, government and higher education sectors. It sought the views of a wide range of policy advisers and funders, performers and users of research and technology in Australia and overseas, including members of State government science and technology advisory bodies and other State government departments and agencies. A list of individuals and organisations consulted is included at Appendix 2 of this report.

Throughout the development of the report, the Office of ASTEC maintained close contact with senior managers in the industry, government and higher education sectors. These consultations helped to explore a broad range of problems and opportunities facing Australia, and to identify the major issues for which policy or other actions could be developed.

A further contribution was from the consultations undertaken in connection with ASTEC's forthcoming study on the provision of major facilities in Australia, which involved a further 90 organisations, principally in the government and higher education sectors.

The Council's formal consultation program comprised four elements.
A call for written submissions

ASTEC called for submissions by invitation and through the press in November 1990. Some 190 were received from a wide cross-section of individuals and organisations in the private and public sectors in all states and territories. They offered ASTEC valuable insights into problems, opportunities and possible options for action. These are discussed more fully in Chapter 3.

Meetings in the capital cities

These were planned in cooperation with state science and technology advisory bodies and they enabled ASTEC to make contact with over 200 people from a wide range of organisations in industry, higher education and government. They provided the opportunity to follow up matters raised in submissions and to identify new issues and possible options. The cross-fertilisation of ideas created by bringing people from different sectors in round-table meetings proved to be most fruitful.

Industry interviews

An intensive interview program with over 150 top-level managers in industry and government obtained their views on:

- the importance of research and technology in maintaining or improving the competitiveness of specific sectors;
- how these sectors obtain the technologies they need; and
- whether Australia’s research system is contributing as fully as it might to meeting their technology requirements.

The results of these interviews were used largely in Chapter 4 of this report, and will be published as a supplementary report. ASTEC undertook approximately one-third of the interviews in-house and contracted the remainder to the Centre for Technology and Social Change.

International consultations

Australia’s Industry, Science and Technology Counsellors in London, Paris, Bonn, Brussels, Tokyo and Washington provided current information on overseas policy developments. In addition, several Council members held their own consultations overseas in connection with the Future Directions study.

A.3 Evaluating information

ASTEC established a management group to guide the study as a whole and working groups to consider issues relating to specific issues. All Council members were involved in working groups; management group membership comprised Professor Ray Martin (Convener of the Management Group and
Chairman of Council), Professor Don Aitkin and Professor Ron Johnston. Dr Susanne Pearce and later Mr Randall Wilson acted as secretary to the management group. Secretaries to the working groups were Ms Elizabeth Smith, Dr Geoff Thompson and Mr Ron Murnain.

During the consultation program, ASTEC gathered extensive qualitative information. The following criteria, adapted from those employed by the Australian Research Council, were used to filter the issues from the qualitative information:

- is the issue long-term or short-term in nature?
- is it essentially Australian (rather than international) in character?
- is it significant in financial terms?
- is it an opportunity or problem in itself, or merely a symptom? and
- is research an important aspect of dealing with the opportunity or problem?

The Council used these criteria to identify a range of principal and subsidiary issues, and to develop the chapter structure of this report.

The issues raised in consultations, submissions and the literature were far too numerous to be dealt with individually in the final report—nearly three hundred were raised in consultations and nearly four hundred in submissions. Furthermore, they ranged from the specific, for example ‘We need more research on the impacts of coastal development’; to the general, for example, ‘There must be proper pricing of public sector R&D’.

Issues were ranked from one-star (minor issue) to five-star (major issue) using the criteria above. Provisional ranking was done by the Office of ASTEC then reviewed by working parties and the management group. Ranking was based on judgment, rather than a quantitative weighting of different criteria.

An example of a five-star issue is ‘More emphasis on development and commercialisation’. It was ranked as such because it has long-term implications, is specific to Australia (as well as other countries), is a problem not a symptom, has major financial implications and research is an important part of the problem.

‘Provide additional fellowships for researchers in physics’ was identified as a one-star issue because it is very narrow in its concern, and more appropriate to operational or strategic direction setting; it is not particularly an Australian issue, the financial implications are not large and it is not dealing with a problem, but the symptom. The broader issue of the supply and demand of researchers to meet Australia’s needs was identified as important.

Major issues were grouped under broad headings such as ‘Research for industry development’ and subheadings such as ‘Funding arrangement’ and ‘costs of development’. After further consideration of these broad headings against the above criteria, thirteen broad issues were identified;

- economic development,
• internationalisation and globalisation,
• quality of life,
• ecologically sustainable development,
• human resources,
• focusing on research outcomes,
• research infrastructure (equipment and facilities),
• microeconomic impediments,
• institutional structures,
• federal, state and regional issues,
• strategic management of research,
• energy
• integrating the social sciences and the humanities into the nation’s research effort.

This list was further grouped to create the present chapter structure of Research and Technology—Future Directions. During the drafting of chapters, the authors referred back to the detailed issues to explore the nature of the specific problems or opportunities, and to develop possible options for action. This mode of operation allowed a detailed study of the individual issues followed by a general examination of a number of broader areas, such as the overall quality of Australia’s research infrastructure. Because this report relates to direction setting at the national level, the issues and options identified in its core chapters are expected to be most relevant to governments, major industry associations, universities and organisations representative of professions and the workforce. Consistent with advice contained in ASTEC’s earlier report, Setting Directions for Australian Research, it is appropriate that direction setting at the more detailed strategic and operational levels should be a responsibility of specific organisations.
Appendix B  List of those consulted through submissions, meetings, interviews and continuing liaison

B.1  Submissions

B.1.1 Submissions from organisations

Academy of the Social Sciences in Australia
Advanced Materials Institute
Agricultural Technologists of Australia
Alcoa of Australia Ltd (WA Operations)
Amcor Ltd
Association of Australian Aerospace Industries
Astronomical Society of Australia
Attorney-General’s Department
Australasian Society of Clinical and Experimental Pharmacologists
Australian Academy of Science
Australian Academy of Technological Sciences and Engineering
Australian Academy of the Humanities
Australian and New Zealand Association for the Advancement of Science
Australian Association of Social Workers Ltd
Australian Biotechnology Association
Australian Bureau of Agricultural and Resource Economics
Australian Centre for International Agricultural Research
Australian Conservation Foundation
Australian Industrial Research Group
Australian Institute of Agricultural Science
Australian Institute of Marine Science
Australian Institute of Physics and Applied Physics
Australian Institute of Marine Sciences Association
Australian Maritime College
Australian Mathematical Sciences Council
Australian Mathematical Society
Australian Meteorological and Oceanographic Society Inc
Australian National Committee on Large Dams
Australian National Parks and Wildlife Service
Australian National University
Australian National University, Research School of Biological Sciences
Australian National University, Urban Research Program
Australian Neutron Beam Users’ Group
Australian Newsprint Mills Ltd
Australian Nuclear Science and Technology Organisation
Australian Pharmaceutical Manufacturers’ Association
Australian Plant Pathology Society, WA Branch
Australian Psychological Society

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Australian Safeguards Office
Australian Society for Immunology
Australian Society for Medical Research
Australian Society for Microbiology Inc
Australian Space Office
Australian Vice-Chancellors' Committee
AWA Ltd
BHP Co Ltd (Technology and Development)
Biotech Australia Pty Ltd
Bunnings Ltd
Bureau of Meteorology
Bureau of Mineral Resources, Geology and Geophysics
Bureau of Rural Resources
Burmot Australia
Carlton and United Breweries Ltd
Centre for Design, Royal Melbourne Institute of Technology
Centre for International Research, Communications, Information and Technology
Centre for Research Policy, University of Wollongong
Charles Sturt University
Commonwealth Bank of Australia
CRA Ltd
Cray Research (Australia) Pty Ltd
CSIRO
CSIRO Division of Oceanography
CSIRO Officers Association
Curtin University of Technology
Dairy Research and Development Corporation

Department of Defence
Department of Employment, Education and Training
Department of Finance
Department of Foreign Affairs and Trade
Department of Industry, Technology and Commerce
Department of Primary Industries and Energy
Department of Primary Industries and Energy and CSIRO—Liaison Committee on Minerals Research and Development
Department of the Arts, Sport, the Environment, Tourism and Territories
Disabled Peoples' International (Australia) Ltd
Edith Cowan University
Egg Industry Research and Development Council
Electricity Supply Association of Australia
Energy Research and Development Corporation
Federal Airports Corporation
Federated Australian University Staff Association
Federated Council of Academics and Union of Australian College Academics
Federation of Australian Scientific and Technological Societies
Government of Tasmania
Griffith University
Hosokawa Mikropul Australasia Pty Ltd
Humanist Society of Victoria
ICI Research Group
Illawarra Technology Corporation
Industry Research and Development Board
Institute of Foresters of Australia
Institute of Metals and Materials Australasia Ltd
Institution of Engineers, Australia
Intelligent Manufacturing Systems, National Steering Committee
James Cook University
James Cook University, Department of Mechanical Engineering
James Cook University, Department of Zoology
John Shearer Ltd
Liquor Trades Union
Macquarie University
Medical Industry Association of Australia
Memtec Ltd
Metal Trades Industry Association of Australia
MIM Holdings Ltd
Monash University
Monash University, Department of Electrical and Computer Systems Engineering
Monash University, Department of Geography and Environmental Science
Mulgrave Shire Council
Murdoch University
Murray–Darling Basin Commission
N W Shaw and Associates
National Board of Employment, Education and Training
National Health and Medical Research Council, Medical Research Committee
National Standards Commission
New South Wales Department of Agriculture and Fisheries
New South Wales Science and Technology Council
Nissan Motor Company
Northern Territory Department of Industries and Development
Northern Territory Department of Primary Industry and Fisheries
Norton Mining Services
Oceanroutes (Australia) Pty Ltd
Ogilvie Research Pty Ltd
Peptide Technology Ltd
Pro Vice-Chancellors' (Research) Committee
Queensland Department of Primary Industries
Royal Australian Chemical Institute
Royal Melbourne Institute of Technology
Royal Society of Victoria
Sola International Holdings Ltd
Strategic Research Foundation
Sugar Research Institute
Telecom Australia
University College, Australian Defence Force Academy
University College of Central Queensland with CSIRO Division of Tropical Animal Production and the Queensland Department of Primary Industries, Rockhampton
University of Adelaide
University of Adelaide, Department of Architecture
University of Canberra
University of Melbourne
University of New England
University of New South Wales
University of New South Wales, School of Architecture
University of New South Wales, School of Chemical Engineering and Industrial Chemistry
University of New South Wales, School of Electrical Engineering and Computer Science
University of Newcastle
University of Northern Territory
University of Queensland
University of Queensland, Department of Civil Engineering
University of South Australia
University of Sydney
University of Tasmania
University of Tasmania, Institute of Antarctic and Southern Ocean Studies

University of Technology, Sydney
University of Western Australia, Division of Arts and Architecture,
University of Western Australia, Centre for Water Research
University of Western Australia, Department of Education
University of Western Sydney
Victorian College of Pharmacy
West Australian Department of State Development, West Australian Technology and Industry Advisory Council and the Institute for Science and Technology (Murdoch University) (joint submission)
West Australian Trades and Labour Council
Western Mining Corporation Engineering Services Pty Ltd

B.1.2 Submissions from individuals

Mr Robin Bailey
Mr John Balfour
Dr Keith Brillings
Dr Anwar Chaudhri
Dr Roger Clay
Mr Kelvin Croese
Dr Geoff Cumming
Dr C A J Fletcher and Professor G de Vahl Davis
Dr David Fox
Dr Ian Furzer
Dr T J Hicks
C T Highett and Dr W W Emerson
Dr Alan Hipkiss and Dr Robin Holliday
Dr R R M Johnston

Mr Girish C Joshi
Dr Graham Lang
Mr John P Murphy
Mr Murray A Muspratt
Professor Barry Rolfe
Mr David Scienceman
Dr J Gurcharan Sekhon
Mr Tony Smith
Mr Paul Smith
Dr Duncan Steel
Dr Peter Thistlethwaite
Ms Pamela Thompson
Ms Louise Wilson
Mr Noel Wilson
B.1.3 Other comments

Australia Post
Dr Richard Jones

Office of National Assessments
Shell Company of Australia

B.2 Capital city consultations

The following participated in individual and round table meetings in capital cities. In a few cases the individual named did not attend or send a representative.

B.2.1 Adelaide

Australian Institute of Physics and Applied Physics
Professor A W Thomas

CSIRO Division of Water Resources
Dr Peter Dillon

Cooperative Research Centre for Tissue Growth and Repair
Dr John Ballard

Defence Science and Technology Organisation
Mr Colin Evans

Department of Agriculture
Dr Peter Gibson
Dr Andrew Scott
Mr Jim Walkley
Mr Glyn Webber
Mr Roger Wickes

Department of Industry, Trade and Technology
Ms Susan Andrews
Dr Peter Crawford
Mr Brian Sheehan

F H Faulding and Co Ltd
Dr Ian Pitman

Flinders University of South Australia
Associate Professor John Skinner

Office for Tertiary Education
Dr Adam Graycar

Sola International Holdings Research Centres
Dr Matthew Cuthbertson

South Australian Centre for Manufacturing Pty Ltd
Mr Daniel Moriarty

South Australian Health Commission
Dr Ian Calder
Mrs Jill Fitch
Dr David Roder

Technology Development Corporation
Mr Barry Orr

Techsearch Inc
Mr Bob Taylor

United Trades and Labour Council of SA
Mr Tony Evans

University of Adelaide
Professor Andrew Smith

University of South Australia
Professor David Lee
Professor John Ralston

Waite Agricultural Research Institute
Professor Harold Woolhouse

B.2.2 Brisbane

Australian Cane Farmers' Association
Mr David Crawford
Mr Joseph Farley

Australian Institute of Marine Science
Dr Joe Baker

Australian Sugar Milling Council
Mr John Cameron

Bundaberg Sugar Co Ltd
Mr Grant MacLean
Bureau of Sugar Experiment Stations
  Dr Bob Mullins

Comalco Mineral Products
  Dr Arthur Bursle

CSIRO Division of Tropical Animal Production
  Dr Dave Mahoney

CSIRO Division of Tropical Pastures and Field Crops
  Dr Bob Clements

Department of Premier, Economic and Trade Development
  Mr Ian Johnston

Department of Primary Industries
  Dr John Leslie

Department of Primary Industries, International Food Institute of Queensland
  Mr John Aston

Department of Business, Industry and Regional Development
  Mr Ron Boyle

Evans Deakin Industries Ltd
  Mr Ian Ross

Griffith University, Division of Science and Technology
  Professor Ian Lowe

James Cook University
  Professor Peter Arlett
  Professor Ray Golding

MIM Holdings Ltd, Marketing and Technology
  Mr Robert Greenelsh
  Mr Cliff Williams

Professional Officers' Association
  Dr Patrick Blackall
  Miss Kate Fitzgerald

Princess Alexandra Hospital
  Professor Susan Pond

Queensland Canegrowers' Council
  Mr Bernie Millford

Queensland Confederation of Industry
  Mr Clive Bubb

Queensland Institute of Medical Research
  Dr Ian Taylor

Queensland Office of Science and Technology
  Mr John Humphreys

The Sugar Board
  Dr David Rutledge

Sugar Research and Development Corporation
  Mr Eion Wallace

University of Queensland
  Professor Cliff Hawkins
  Professor Alban Lynch

B.2.3 Canberra

Academy of the Social Sciences in Australia
  Professor H G Brennan
  Professor J D B Miller
  Professor Oliver MacDonough

Attorney-General's Department
  Mr Jeff Windell

AUSTRADE
  Mr John Lightfoot

Australian Academy of the Humanities
  Professor John Mulvaney
  Professor Gerhard Schulz
  Professor Graeme Clarke
  Professor Ken Ruthven

Australian Bureau of Agricultural and Resource Economics
  Dr Gordon Macaulay

Australian Chamber of Commerce
  Mr Brent Davis

Australian Defence Force Academy
  Professor Harry Heseltine

Australian National Parks and Wildlife Service
  Dr Dan Walton
  Dr John Busby

Australian Nuclear Science and Technology Organisation
  Mr Pat Bull
  Dr David Cook
B.2.4 Hobart

Australian Furniture Research and Development Institute
Mr Jim Bowler

Australian Maritime College
Dr Martin Renilson

Australian Newsprint Mills Ltd
Dr Robert Cox

CSIRO Division of Oceanography
Dr Angus McEwan

Department of Industry, Technology and Commerce, State Office
Mr Peter Cummins

Department of Premier and Cabinet
Dr Peta Colebatch

Department of Primary Industry
Dr Simon Stanley

DSTO Materials Research Laboratory
Dr Ross Richards

Forestry Commission
Mr Ken Felton

Moonraker Australia Pty Ltd
Mr Chris Edwards

Tasmanian Development Authority
Mr Wayne Morgan

Tasmanian Trades and Labour Council
Mr Jim Bacon

University of Tasmania
Professor Phillip Hamilton

University of Tasmania, Institute of Antarctic and Southern Ocean Studies
Professor Garth Paltridge

University of Tasmania, Key Centre for Aquaculture
Professor Nigel Forteath

Aeronautical Research Laboratories
Mr David Humphries

AMECON Ltd
Dr Ernie Banks

Australian Conservation Foundation
Mr Bill Hare

Australian Mineral Industries Research Association
Mr Jim May

Australian Neutron Beam Users’ Group
Dr Roderick Hill

Australian Road Research Board
Mr Ian Johnston

Baker Medical Research Institute
Professor John Funder

BHP Co Ltd
Dr Graham Glover

Bureau of Meteorology
Dr Doug Gauntlett
Dr Mike Manton

Centre for International Research on Communications and Information Technology
Professor Bill Melody

Comalco Aluminium Ltd and Australian Industrial Research Group
Dr Tony Kjar

Commission for the Future
Ms Susan Oliver

CSIRO Institute of Industrial Technologies
Dr Tom Spurling

Deakin University
Professor Stephen Kemmis

Department of Agriculture and Rural Affairs
Dr Robin Lawson

Department of Manufacturing and Industry Development
Mr Rob Reid Smith

DSTO Materials Research Laboratories
Dr Maurice de Morton

Howard Florey Institute
Professor John Coghan

B.2.5 Melbourne

Australian Academy of Technological Sciences and Engineering
Professor John Bennett
Professor Ken Juhb
Dr John Nixon
IBM Australia/New Zealand
Mr Douglas Reid

Industry Research and Development Board
Mr Bill Kricker

Kodak Australasia Pty Ltd, Research Laboratories
Dr Peter Harvey

LaTrobe University
Professor Fred Smith

Royal Australian Chemical Institute
Professor James Beattie

Royal Melbourne Institute of Technology
Dr David Wilmoth

SIROTECH Ltd
Dr Colin Adam

Strategic Research Foundation
Mr Kim Sweeney

Telecom Research Laboratories
Mr Geoff Willis

University of Melbourne
Professor Frank Larkins
Professor Adrienne Clarke

B.2.6 Perth

Alcoa of Australia Ltd, Western Australian Operations
Dr David Debney

Bunnings Ltd
Mr John Oldham

Council of Australian Postgraduates' Associations
Ms Teresa Chia

CRA Advanced Technical Development
Dr Ian Smith

CSIRO Division of Exploration Geoscience
Dr Ray Smith

Curtin University of Technology
Professor John De Laeter

Delta West Pty Ltd
Mr Rod Unsworth

Department of Industry, Technology and Commerce, State Office
Mr John Styants

Department of State Development
Mr Keith Antonisz
Mr Reece Waldock

Edith Cowan University
Dr Ken Jack
Dr Anne McMurray

Murdoch University
Professor John Dilworth
Professor Fred Jevons

Murdoch University, Institute for Science and Technology Policy
Dr John Phillimore

Oceanroutes (Australia) Pty Ltd
Dr Ray Steedman
Mr Tony Tate

Technology and Industry Advisory Council
Mr Mal Bryce
Mr Earl White

University of Western Australia, Centre For Water Research
Professor Jorg Imberger

University of Western Australia, Education Department
Dr Mike Lally

University of Western Australia, Division of Arts and Architecture
Professor John Jory

Western Mining Corporation Engineering Services Pty Ltd
Dr Michael Wort

B.2.7 Sydney

Amalgamated Metal Workers’ Union
Mr Brian Beer

Australian Meat and Livestock Research and Development Corporation
Dr Ian McCausland

Bankers Trust Australia Ltd and Megacom
Mr David Hoare

Australian Biotechnology Association
Dr Peter Gray
Professor Neil Willetts
Boral Resources NSW Pty Ltd
  Professor Alek Samarin

CSIRO Institute of Animal Production and Processing
  Dr Alan Donald

CSIRO Institute of Information Sciences and Engineering
  Dr Bob Frater

CSIRO Institute of Minerals, Energy and Construction
  Dr Alan Reid

Department of Minerals and Energy
  Dr Bob Crawford

Department of State Development
  Mr Derek Roche

ICI Australia, Research Group
  Ms Barbara Gibson

Illawarra Technology Corporation
  Mr Paul Howlett

Macquarie University
  Professor John Clark

Memtec Ltd
  Dr Douglas Ford

New South Wales Science and Technology Council
  Mr Alex Dix
  Mr David Ellyard
  Ms Ene Juurma
  Dr Ed Sciberras

Nucleus Ltd
  Mr Keith Daniel
  Mr Jim Patrick
  Mr Garry Richardson
  Dr Mike Skalsky

Pritchard Associates Pty Ltd
  Mr Bob Pritchard

The Profit Fountain
  Mr Paul Martin

TCG
  Mr Peter Fritz

University of New South Wales
  Professor Tony Wicken

University of New South Wales, Department of Physics
  Professor R G Clark

University of Sydney
  Professor Bruce Thom

University of Sydney, Institute of Transport Studies
  Professor David Hensher

University of Technology, Sydney
  Professor Gus Guthrie
  Professor Colin Phillips
  Professor Bob Raison

University of Wollongong, Centre for Information Technology Research
  Dr Ian Reinecke

University of Wollongong, Department of Management
  Professor G A Freed

B.3 Industry-specific interviews

Ampol Petroleum
  Dr Peter Power

Amrad Corporation
  Mr John Grace

APTFCCH Australia Pty Ltd
  Dr Mark Rehn

AUSSAT Pty Ltd
  Mr Graham Gosewinckel

AUSTRADE
  Dr David Guy
  Mr Peter Schultz
  Mr Paul Trainor

Australian Bureau of Agricultural and Resource Economics
  Brian Dawson

Australian Chemical Industry Council
  Dr Alan Cope

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B.4 Other consultations

In addition to submissions, capital city meetings and industry-specific interviews, ASTEC pursued a program of consultation throughout the period over which the report was prepared. Those consulted include the following.

Aboriginal and Torres Strait Islander Commission
- Mr Bill Gray
- Mr Bill Miller
- Mr Ron Moroney

Australian Institute of Family Studies
- Dr Don Edgar

Australian Institute of Health
- Dr John Donovan
- Mr Tony Greville
- Dr David Hailey
- Dr Leonard Smith

Australian Mining Industry Council
- Dr Geoff Belton
- Mr Jim May
- Mr John Moyle
- Dr Max Richards

Australian National University, Urban Research Program
- Mr Patrick Troy

AWA Defence Industries Pty Ltd
- Dr Rob Potter

CSIRO
- Dr Ian Elsum
- Dr Beth Heyde
- Dr Don Macrae
- Mr Malcolm Robertson
- Dr John Stocker

Defence Manufacturers' Council
- Brigadier Ian Meibusch

Victorian Gas and Fuel Corporation
- Mr Roy Palmer

West Australian Department of Mines
- Dr Des Kelly

Western Mining Corporation Ltd
- Mr Ian Duncan

Woodside Offshore Petroleum
- Dr Don Henery
Department of Industry, Technology and Commerce
  Mr Noel Benjamin
  Dr John Bell
  Ms Pat Boling
  Mr Adrian Caddy
  Mr Keith Croker
  Mr Kym Fullgrabe
  Dr Alan Laird
  Ms Chris Patterson
  Dr Michael Pitman
  Dr Les Rymer
  Dr Joy Selby-Smith
  Dr David Williamson

Department of Primary Industries and Energy
  Mr Bob Allen
  Mr Brian Hill
  Mr Stephen Munchenberg
  Ms Annette Quinn
  Dr John Tilley
  Mr Ian Walker
  Mr Charles Willcocks

Department of Social Security
  Ms Judi Robinson

Department of the Arts, Sport, the Environment, Tourism and Territories
  Ms Robyn Bromley
  Ms Bettye Dixon
  Ms Sally Gordon
  Mr Rod Holesgrove
  Ms Christine Lawrence
  Mr Bob Pegler
  Mr Nelson Quinn

Department of the Prime Minister and Cabinet
  Ms Dawn Casey
  Mr Eric James
  Professor Ralph Slatyer
  Mr Peter Thomas
  Mr Mike Waller

Department of Transport and Communications
  Mr Mike Hutchinson
  Mr Geoff Luther

Electricity Commission of NSW
  Mr Bob McCredie
  Mr Patrick McMullen
  Mr Bob Rollinson

Metal Trades Industry Association of Australia
  Mr Peter Morris

National Capital Planning Authority
  Mr Lindsay Neilson

National Health and Medical Research Council
  Dr Diana Horvath
  Professor Ian McCloskey

National Resource Information Centre
  Dr Dave Johnson

Office of the Supervising Scientist for the Alligator Rivers Region
  Mr R M Baker

Resource Assessment Commission
  Dr Richard Kenchington

Royal Melbourne Institute of Technology
  Dr David Wilmoth

TEC Aust Pty Ltd
  Mr Steven Armstrong

University of New South Wales
  Professor Martin Green

University of New South Wales, Social Policy Research Centre
  Dr Peter Saunders
  Dr Sheila Shaver

University of Sydney, Institute of Transport Studies
  Professor Peter Hensher
  Dr Nariida Smith
  Mr Paul Hooper
  Mr Frank Milthorpe
Appendix C  Members of Council and of the Office of ASTEC

C.1 Members of ASTEC during the course of the Future Directions study

Professor Ray Martin, AO FAA FTS
(Chairman)
Department of Chemistry
Monash University

Mr Lloyd Zampatti (Deputy Chairman)
Managing Director
Brett & Co Pty Ltd

Professor Don Aitkin, FASSA
Vice-Chancellor
University of Canberra

Dr Greg Clark
Director of Science and Technology
IBM (Australia) Ltd

Mr F M Davidson, OBE *
Grazier, Company Director

Professor Ashley Goldsworthy, AM, OBE
Bond University

Professor Bob Gregory, FASSA
Department of Economics
Australian National University

Professor Ann Henderson-Sellers
Director
Climatic Impacts Centre
Macquarie University

Ms Margaret Jackson
Partner
KPMG Peat Marwick
Management Consultants

Professor Ron Johnston, FTS
Director
Centre for Technology and Social Change
University of Wollongong

Mr Peter Laver
Corporate General Manager
Technology and Development
BHP Co Ltd

Mr J P Maynes, AM *
National President
Federated Clerks Union of Australia

Professor Jim McLeod, AO FAA FTS
Department of Medicine
University of Sydney

Professor Don Nicklin, FTS
Pro-Vice-Chancellor
(Physical Sciences & Engineering)
University of Queensland

Dr W James Peacock, FRS FAA **
Chief
CSIRO Division of Plant Industry

Professor Alice E-S Tay, AM FASSA
Challis Professor of Jurisprudence
University of Sydney

Mr John D Vines **
Executive Director
The Association of Professional Engineers, Australia

* Retired during the course of the study.
** Appointed August 1991.
C.2 Staff of the Office of ASTEC

The following list includes those who contributed directly to the research, analysis, drafting and preparation for publication of the report. Council also wishes to acknowledge the valuable contribution of the behind-the-scenes staff of the Office of ASTEC who undertook all the administrative tasks necessary for the smooth running of such a project.

C.2.1 Management

Dr Greg Tegart, FTS
Secretary

Dr Ian Cumming (to April 1991)
Branch Director, Assessment and Management

Dr Gordon Burch (from April 1991)
Branch Director, Assessment and Management

Dr Susanne Pearce (to January 1991)
Branch Director, Studies and Research

Mr Randall Wilson (from January 1991)
Branch Director, Studies and Research

C.2.2 Project Staff

Ms Elizabeth Smith
Dr Geoff Thompson
Dr Ian Lambert
Ms Patricia Berman
Dr Sam Garrett-Jones
Mr David Rumble
Dr Tony Weir
Mr Deane Larkman
Ms Kathleen Gallagher
Ms Kathy Schmutter

C.2.3 Seconded Staff

Mr Ron Murnain (CSIRO)
Dr Jan Henderson (ANSTO)
Mr Malcolm Robertson (CSIRO)

C.2.4 Support Staff

Ms Beth Mason
Ms Bridget Anderson
Ms Denise Fragnito
Ms Margaret Borucinski
Ms Liz Quilter
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATSIC</td>
<td>Aboriginal and Torres Strait Islander Commission</td>
</tr>
<tr>
<td>ABS</td>
<td>Australian Bureau of Statistics</td>
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<tr>
<td>AARNet</td>
<td>Australian Academic Research Network</td>
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<tr>
<td>AIMS</td>
<td>Australian Institute of Marine Science</td>
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<tr>
<td>ALIC</td>
<td>Australian Land Information Council</td>
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<tr>
<td>AMBRI</td>
<td>Australian Membrane and Biosensor Research Institute</td>
</tr>
<tr>
<td>AMC</td>
<td>Australian Manufacturing Council</td>
</tr>
<tr>
<td>AMIRA</td>
<td>Australian Mineral Industries Research Association</td>
</tr>
<tr>
<td>ANSTO</td>
<td>Australian Nuclear Science and Technology Organisation</td>
</tr>
<tr>
<td>ARC</td>
<td>Australian Research Council</td>
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<tr>
<td>ARGs</td>
<td>Australian Research Grants Scheme</td>
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<tr>
<td>ARS</td>
<td>Australian Standard Research Classification</td>
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<tr>
<td>ASTCON</td>
<td>Australian Science and Technology Counsellor Network</td>
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<tr>
<td>ATG</td>
<td>Australian Technology Group</td>
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<tr>
<td>AUSLIG</td>
<td>Australian Surveying and Land Information Group</td>
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<tr>
<td>AUSTRade</td>
<td>Australian Trade Commission</td>
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<tr>
<td>BCA</td>
<td>Business Council of Australia</td>
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<tr>
<td>BERD</td>
<td>Business expenditure on research and development</td>
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<tr>
<td>CCST</td>
<td>Coordination Committee on Science and Technology</td>
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<tr>
<td>CRCs</td>
<td>Cooperative Research Centres</td>
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<tr>
<td>CSIRO</td>
<td>Commonwealth Scientific and Industrial Research Organization</td>
</tr>
<tr>
<td>DASETT</td>
<td>Department of the Arts, Sport, Environment, Tourism and Territories</td>
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<tr>
<td>DEET</td>
<td>Department of Employment, Education and Training</td>
</tr>
<tr>
<td>DHHCS</td>
<td>Department of Health, Housing and Community Services</td>
</tr>
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<td>DITAC</td>
<td>Department of Industry, Technology and Commerce</td>
</tr>
<tr>
<td>DSTO</td>
<td>Defence Science and Technology Organisation</td>
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<tr>
<td>EPAC</td>
<td>Economic Planning and Advisory Council</td>
</tr>
<tr>
<td>Epa</td>
<td>Environment Protection Agency</td>
</tr>
<tr>
<td>ERIN</td>
<td>Environmental Resource Information Network</td>
</tr>
<tr>
<td>ESD</td>
<td>Ecologically Sustainable Development</td>
</tr>
<tr>
<td>FOR</td>
<td>Fields of Research (Australian Bureau of Statistics Survey)</td>
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<tr>
<td>GBEs</td>
<td>Government business enterprises</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross domestic product</td>
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<tr>
<td>GIRD</td>
<td>Grants for Industry Research and Development</td>
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<tr>
<td>GIS</td>
<td>Geographic Information Systems</td>
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<tr>
<td>HEC</td>
<td>Higher Education Council</td>
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<td>HECS</td>
<td>Higher Education Contribution Scheme</td>
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<td>IAS</td>
<td>Institute of Advanced Studies (Australian National University)</td>
</tr>
<tr>
<td>ISTP</td>
<td>International Science and Technology Program</td>
</tr>
<tr>
<td>MBA</td>
<td>Master of Business Administration</td>
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<tr>
<td>MFPI</td>
<td>Multifunction Polis</td>
</tr>
<tr>
<td>MIC</td>
<td>Management and Investment Companies Program</td>
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<tr>
<td>NHMRC</td>
<td>National Health and Medical Research Council</td>
</tr>
<tr>
<td>NIES</td>
<td>National Industry Extension Service</td>
</tr>
<tr>
<td>NMSc</td>
<td>Non-melanoma skin cancer</td>
</tr>
<tr>
<td>NPDP</td>
<td>National Procurement Development Program</td>
</tr>
<tr>
<td>NRIC</td>
<td>National Resource Information Centre</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Cooperation and Development</td>
</tr>
<tr>
<td>PDP</td>
<td>Partnerships for Development Program</td>
</tr>
<tr>
<td>PHRDC</td>
<td>Public Health Research and Development Committee</td>
</tr>
<tr>
<td>PMSC</td>
<td>Prime Minister's Science Council</td>
</tr>
<tr>
<td>PNP</td>
<td>Private non-profit</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
</tr>
<tr>
<td>RAC</td>
<td>Resource Assessment Commission</td>
</tr>
<tr>
<td>RADGAC</td>
<td>Research and Development Grants Advisory Committee</td>
</tr>
<tr>
<td>RDC</td>
<td>Research and Development Corporation</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>SEO</td>
<td>Socioeconomic Objectives (Australian Bureau of Statistics Survey)</td>
</tr>
<tr>
<td>SRED</td>
<td>Surveys of Research and Experimental Development</td>
</tr>
<tr>
<td>TAFE</td>
<td>Technical and Further Education</td>
</tr>
<tr>
<td>UNS</td>
<td>Unified national system (of higher education)</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organisation</td>
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</table>
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