1992–93 BUDGET RELATED PAPER No. 6

SCIENCE AND TECHNOLOGY STATEMENT 1992–93

CIRCULATED BY
THE HONOURABLE ROSS FREE, M.P.,
MINISTER FOR SCIENCE AND TECHNOLOGY
AND MINISTER ASSISTING THE
PRIME MINISTER

AUSTRALIAN GOVERNMENT PUBLISHING SERVICE
CANBERRA 1992

ISBN 0644 25276 6

Printed in Australia by P. J. GRILLS, Commonwealth Government Printer, Canberra

CONTENTS

STATEMENT 1 – DEVELOPING AUSTRALIAN IDEAS

A Blueprint for the 1990s

Contents

1

EXECUTIVE SUMMARY

Since 1983, the Government has given a high priority to science and technology. Commonwealth support for research and related activities has increased in real terms by 39% since 1982–83, and has also grown strongly as a proportion of total government outlays.

In its 1989 policy statement, *Science and Technology for Australia*, the Government explicitly recognised the role of science and technology in Australia's future, and provided significant new funding.

This White Paper, Developing Australian Ideas, endorses and builds on that statement. It clearly establishes, perhaps for the first time, a national policy for science and technology. The Paper stresses the importance of capturing the benefits of our creativity, imagination and intelligence. Four interrelated themes are discussed, which encompass the actions necessary to improve the effectiveness of our national investment in science and technology.

Innovation: To create an environment that will encourage investment in technology, and the use of technological innovation in the development of internationally competitive private and public enterprises.

Awareness: to develop a greater understanding in the wider Australian community of the important roles played by science, technology and innovation in all aspects of our life, and particularly in economic and social development.

Skills: to provide the skills to create and sustain competitiveness and quality of life, through enhancing post–school education in science and engineering at all levels.

Infrastructure: to ensure that the research base in the universities and government laboratories is responsive to Australian needs, and of leading international standards.

The initiatives announced in the White Paper include:

- retaining the R&D tax concession at 150% indefinitely beyond June 1993 and waiving the $10 million limit on pilot plant;
- a $30 million boost to CSIRO, ANSTO and AIMS to complete a capital infrastructure program;
- 200 new postgraduate research awards, worth $24 million to 1995–96;
- $13 million to upgrade the capacity and speed of Australia's research data network;
- a renewed commitment to a national space program;
- the establishment of a Genetic Manipulation Authority;
- additional funding for the national measurement infrastructure and for medical research;
- a new marine science research facility in north–west Australia;
- an Industry Support Office in DSTO; and
- initiatives to encourage higher levels of science and technology awareness and international collaboration.

This statement reaffirms the Government's commitment to a vigorous science and technology system which contributes to the prosperity of all Australians.

DEVELOPING AUSTRALIAN IDEAS

Science and engineering are central to the Government's vision of Australia in the twenty–first century – a nation that is internationally competitive and environmentally responsible; a nation investing in technology and capturing the benefits of a strong scientific and engineering base to provide its citizens with economic prosperity, social equity, ecologically sustainable industries and a high quality, fulfilling life.

Australia faces major challenges and exciting opportunities as the distribution of economic power changes, and as technology–based manufactured goods and services increase their contribution to world trade. Unprecedented advances in computing, electronics and communications are leading to the internationalisation and globalisation of economic activities, while at the same time altering the way we work and live. Science and engineering are increasingly recognised as key determinants of international competitiveness.

At the same time, there has been growing awareness of the state of the global environment and the pressures to which it is exposed by industrial development, natural resource utilisation, and continued population growth. Science and technology have a vital role to play in finding ways to maintain the Earth's natural life–support systems.

Australia is not, and cannot be, isolated from global change. We must continue to influence it where we can, be aware of what it means for us, and address the problems and opportunities that it offers.

Australia's challenge is to become more outward looking, to recognise and adapt successfully to the challenges of rapid change and to integrate better into the world economy. We need a nation of highly skilled people, productively employed in challenging and rewarding jobs in internationally competitive institutions and enterprises.

To do this we must make maximum use of our strong science and engineering base.

The Government recognises the business sector as the main force in applying research findings to generate wealth. For this reason Government science and technology policy operates to increase business sector performance of

research and development, and to develop better links between research users and the public sector research effort in order to harness this effort to national objectives.

Government policy also recognises that the relatively large public sector research base is a major asset – one that must be maintained and nurtured. Nevertheless, Australians expect a return on their investment in science and technology. Scientists and engineers supported by the taxpayer should encourage a greater understanding and appreciation of their work, and should place greater emphasis on its outcomes – on the discoveries, advances in understanding, or commercial opportunities created.

In the past our excellent public sector research produced world–class results but often without reference to Australia's ability to use that research. As a result the research sometimes withered on the vine or was too often developed overseas. The need to ensure greater relevance of Australian science and engineering through closer links to those who will use it is the thread that runs through this paper.

Through its financial and policy commitment, the Government has shaped our science and technology system. This White Paper endorses and builds on the May 1989 policy statement, *Science and Technology for Australia,* in which the Government recognised that science and technology have a central role to play in the nation's future. It should be seen in the context of related initiatives. For example, the Government's education and training initiatives generally have added significantly to skill levels, which in itself expands Australia's ability to benefit from science and technology.

In framing this document, the Government has identified four interrelated themes which address the key initiatives and actions necessary to improve the effectiveness of our national investment in science and technology. These themes are:

. To create an environment that will encourage investment in technology, and the use of technological innovation in the development of internationally competitive private and public enterprises.

. To develop a greater understanding in the wider Australian community of the important roles played by science, technology and innovation in all aspects of our lives, and particularly in economic and social development.

. To provide the skills to create and sustain competitiveness and quality of life through enhancing post–school education in science and engineering at all levels.

. To ensure that the research base in the universities and government laboratories is responsive to Australian needs, and of leading international standards.

SETTING DIRECTIONS

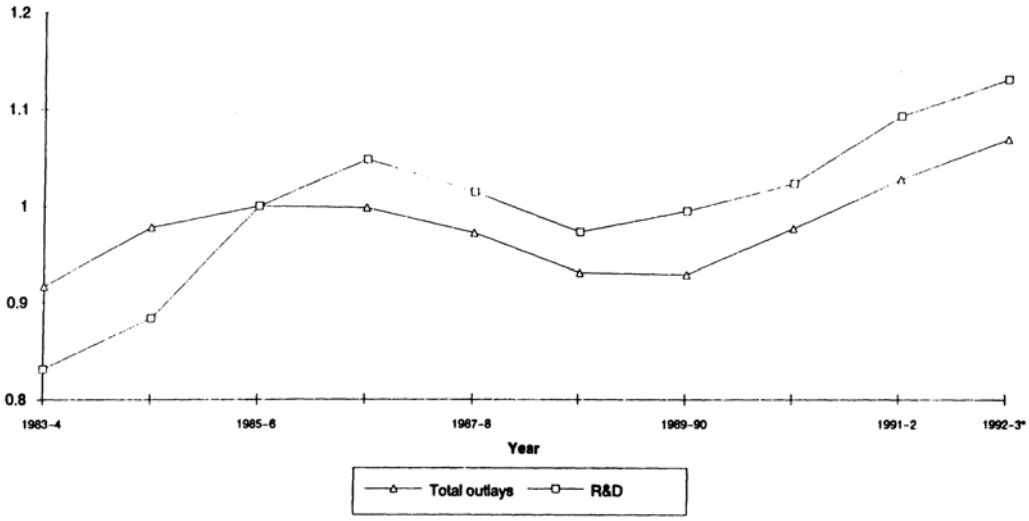
A commitment to science and technology

Commonwealth support for research and related activities has increased in real terms by 39% since 1982–83, and has also grown strongly as a proportion of total government outlays (see graph). The Government has reaffirmed its commitment in the 1992–93 Budget, with a 2.2% real increase in funding, the fourth successive increase. Support for research and related activities will grow to a projected $2857 million in 1992–93, as shown in the table.

As well as the growth in funding, there have been significant changes in funding arrangements to ensure that science and technology contribute to national goals. Major initiatives such as the tax concession for industrial R&D, establishment of the Australian Research Council, the setting of external funding targets for government research agencies, the Cooperative Research Centres Program, and increased use of special–purpose competitive grant schemes, have all helped to improve the quality of research and ensure its relevance.

These and other changes have been spelt out in a series of major policy statements. The 1988 higher education statement devoted considerable attention to the role, organisation and funding of basic research. The May 1989 science and technology policy statement was a major advance in Government policy for, and funding of, science and technology. It was accompanied by papers which established the role of research and innovation in higher education and in the primary and energy industries.

Total Commonwealth Support for R&D vs Total Outlays, 1983–4 to 1992–3 (est) 1984–5 Prices, Index 1985–6=1.00



COMMONWEALTH SUPPORT FOR SCIENCE AND INNOVATION, 1991–92 AND 1992–93

Type of Support	Support Level ($ million)	
	1991–92	1992–93 (est)
Research in higher education	1084	1143
Industrial research and innovation	448	479
Competitive research grants	264	321
Government research agencies	912	914

The May 1989 science and technology policy statement and associated papers provided significant new funding for a wide range of activities, including higher education infrastructure, government research agencies, postgraduate research careers, community awareness, and international science and technology.

Since 1989 Government science and technology policy has been reaffirmed in the annual Science and Technology Budget statement. In addition, Government statements on the economy, industry policy and the environment have included science and technology initiatives, in recognition of the need to apply science and technology in achieving broader economic and social objectives.

The context within which science and technology operates is constantly changing, yet it takes time to build up infrastructure, skills and a strong research base in a particular area. Research is a long term activity requiring planning over several years. For this reason the Government will make further statements on its future directions for science and technology when appropriate.

Framing a national science and technology policy

Setting directions for research must take into account Australia's complex science and technology system. The different sectors – business, higher education and government – have their own roles and responsibilities in funding, performing and using research and technology. An important task of science and technology policy is to encourage a balance of public and private sector R&D which promotes efficiency and competitiveness in these sectors.

Priority setting and evaluation for publicly supported R&D

Science and technology priorities should be set according to the contribution they can make to meeting society's goals. This contribution may include:

. advancing knowledge and developing a better understanding of ourselves, our country and our place in the universe;

. improving the performance and international competitiveness of the primary, manufacturing and service industries;

- improving the quality and effectiveness of social services and enriching the quality of life for all Australians through, for example, better health care and health knowledge, improved and cheaper communications, and environmental management;

- maintaining national security;

- meeting international responsibilities and representing Australian interests in areas such as standards setting, meteorology, nuclear non–proliferation, and global issues; and

- ensuring that development takes place in a sustainable way to guarantee the well being of future generations of Australians.

It is the Government's role to identify the overall national goals and objectives, and establish the principles, mechanisms and incentives necessary for researchers and users to determine their own priorities. Individual institutions and agencies must establish their own priorities and strategies within that overall framework.

This form of decentralisation of science and technology priority setting creates a more responsive, flexible and effective system. Priorities set in this way are relevant and better focussed on needs and opportunities.

An important prerequisite to an ordered system of priority setting is an analysis of the costs and benefits of individual activities. The main advantage of this approach is that it identifies all the costs and benefits of each proposal. Where dollar values can be calculated for benefits and costs, further precision is added to the analysis. Decisions on priority setting can then be made with a better understanding of the merits of individual proposals.

Funders and performers of research in the public sector have adopted a range of models to help them set priorities and allocate resources accordingly. The Parliamentary Joint Committee of Public Accounts has, in its recent report "Public Sector Research and Development", pointed to the model developed by CSIRO, and considers that other agencies could also adopt such an approach.

One of the most simple and direct mechanisms of priority setting is to have the users pay directly for the research they intend to use. This has been implemented through the setting of external funding targets for some government research agencies.

Evaluation is a central element of any priority setting process. Prospective evaluation should take into account the benefits or outcomes expected, as well as the research potential and feasibility of projects and programs. Evaluation should also consider whether a particular mechanism is the best way of achieving an objective, and from time to time examine whether the objective itself is still worthwhile.

Evaluation can take many forms, because of the diverse nature of research and the variety of objectives towards which it is directed. Markets and cost–benefit analyses will often play important roles. The benefits of research, however, are not always easy to determine, given uncertainties about the chances of success and about the opportunities to appropriate the benefits of that success.

Policy coordination

Australia's diverse science and technology system requires effective coordination, a fact recognised by successive Australian Governments.

The Australian Science and Technology Council (ASTEC) was established in 1978 and has provided independent advice to Government on a wide range of topics. A performance and effectiveness review of ASTEC is currently being conducted.

The May 1989 science and technology policy statement put in place formal coordination mechanisms within the Commonwealth Government. These are the position of the Chief Scientist, the Prime Minister's Science Council and the Coordination Committee on Science and Technology, supported by the Office of the Chief Scientist in the Department of the Prime Minister and Cabinet.

The Prime Minister's Science Council has been a highly effective means of bringing science and technology issues to the attention of the Prime Minister and other Ministers, in consultation with senior representatives of the business and research communities.

Engineering plays a strong role in capturing the full benefits of our scientific knowledge, and the Science Council has addressed a range of important engineering–related issues. The Government has therefore decided to rename the Science Council, which will become the Prime Minister's Science and Engineering Council. The current President of the Institution of Engineers Australia will be invited to join the Council.

The Council will be given the following terms of reference:

1 To address important issues in science, technology, engineering and relevant aspects of education and training

2 To examine the contribution of science, technology and engineering to the economic and social development of Australia

3 To enhance awareness in the community of the importance of science, technology and engineering for Australia's economic and social development

4 To examine Australia's science and engineering resources and the effectiveness of their organisation and utilisation.

5 To examine Australia's science and engineering infrastructure and the effectiveness with which it achieves the application of science and technology in the economic and social development of Australia.

These terms of reference reflect the Government's view that science, technology and engineering must be integrated into the broader policy debate. For this reason, the Treasurer will become a member of the Prime Minister's Science and Engineering Council, taking the number of senior Ministers on this peak body to nine, and spanning portfolio interests in the economy, industry, health, environment, primary industries and energy, education and trade.

At the officials level, the Coordination Committee on Science and Technology provides an effective mechanism for discussing and coordinating programs and policies across Commonwealth departments and agencies. It has already produced valuable work on the coordination of international science and technology activities, and on principles for costing and pricing of

public sector research. The Coordination Committee will report to Government on the mechanisms used to set science and technology priorities, and will address the adequacy of these mechanisms and the resulting priorities.

About a third of all government agency research in Australia is carried out in State government agencies, many of which pre–date those created by the Commonwealth. Most of this research is in agriculture, forestry and fisheries and is closely linked to industry requirements.

Commonwealth–State cooperation can take place at the policy, funding and operational levels. Mechanisms such as Ministerial Councils already exist which facilitate cooperation in certain areas at all these levels. The active involvement of a range of State government bodies in Centres established under the Commonwealth's Cooperative Research Centre Program has significantly increased cooperation at the research level.

INNOVATION

> *To create an environment that will encourage investment in technology, and the use of technological innovation in the development of internationally competitive private and public enterprises.*

Innovation is the introduction of change in order to improve performance. It is a consequence of the search for new ways of doing things, including new processes, new products and organisational structures and procedures.

Innovation is important to Australia's future prosperity, and is necessary across all activities, from research and teaching to manufacturing and marketing. It affects a wide range of social activities including the provision of health services, environmental management, and national security.

Science, technology and engineering are agents of change and important sources of innovation. Moreover, investment in science and technology reflects an openness to change and a willingness to innovate that is likely to extend to other activities.

Government policy and action

The Government identified increasing the degree of innovation as one of Australia's main challenges for the future. It has therefore consistently promoted policies that encourage innovation as integral to its approach in all industry sectors.

A more internationally competitive and export oriented manufacturing sector requires innovation leading to the emergence of new firms and new industries, and the development and dissemination of generic technologies.

Resource industry policy includes a recognition that research, development and technological innovation have been central factors in productivity improvement that has enabled Australian primary and resource industries to survive in an increasingly competitive climate. A key element of Government policy in this area has been the establishment of the Rural Industry R&D Corporations and Councils. These are jointly funded by industry and government to encourage greater end–user participation in research. The organisation of research within the Primary Industries and Energy portfolio harnesses the energies of all sectors with an interest in research and development and will become even more important in the future to ensure the viability of these industries.

The recent work on ecologically sustainable development (ESD) has pointed to the role of innovation in achieving ESD goals across a wide range of economic and social activities. Understanding of the complex interactions between economic activity and the environment is necessary to ensure that the sustainability of existing practices is properly understood, and innovative new approaches are developed. The health services field also provides many examples of how innovation has resulted in more effective health care and a significant increase in the range and quality of services provided.

The development of a strong, innovative culture in Australia requires government action at a range of levels.

The Government has implemented changes to the business environment which have helped to create conditions that encourage firms to invest in science and technology. Low inflation encourages investment in productive rather than speculative areas, including science and technology, while tariff

reductions increase competitive pressures and stimulate innovation. Continuing microeconomic reform has also contributed towards an improved environment for investment.

Government has also implemented a package of measures specifically designed to stimulate technological innovation in industry. The tax concession for R&D introduced in 1985 has been central to this package. The importance of the concession in changing industry attitudes and creating a new and more innovative culture was recognised in the 1991 statement *Building a Competitive Australia*, which announced that the tax concession would become a permanent feature of the taxation system. The tax concession is complemented by a range of measures in support of industrial research and innovation. These include the grants schemes of the Industry Research and Development Board, research and technology aspects of industry sectoral plans, and support for research interactions between the public and private sectors.

Government has also stimulated innovation through the purchasing activities of its departments and agencies, which are the major national purchasers in some industry sectors, such as information technology, telecommunications equipment and pharmaceuticals. This has been done, for example, with the Partnerships for Development program in information technology, and the Factor ‘f’ program in pharmaceuticals.

Technology transfer between sectors is particularly important in Australia, given the comparatively low level of research found in much of the business sector, and the concentration of our research effort in the public sector. For this reason, the Government has introduced policies and programs to encourage the public sector research effort to become more responsive to business needs. These measures have included external funding targets for research agencies, Industry Research and Development Generic grants, the Cooperative Research Centres program, the Australian Postgraduate Research Awards (Industry) and the Cooperative Research Grants of the Australian Research Council.

The May 1989 science and technology policy statement provided funding for involvement by Australian researchers in major international pre–competitive research programs. As a result of this funding, the International Science and Technology Program has been able to support multi–year collaboration

involving Australian research consortia – including business – on areas with specific relevance for Australian industries.

The recognition that many exploitable ideas and discoveries have not been proceeding through to commercialisation in Australia led the Government to commission studies in 1991 by the Task Force on Commercialisation of Research (the Block report), and the Working Party on the Commercial Development of Medical Research (the Coghlan report). One major result of Government consideration of these reports was the announcement in *One Nation* of the intention to establish an Australian Technology Group as a company operating on a commercial basis to boost the effective commercial utilisation of Australian research.

Other measures announced in *One Nation* that provide encouragement for innovation include: significant changes to depreciation rates, to make them more comparable to international practice and to encourage firms to invest in new plant and equipment; improvements in the concessional arrangements for small business capital gains; concessional taxation treatment for investment companies established and registered as Pooled Development Funds, which will raise the level of patient capital for small to medium sized Australian firms; and a development allowance for projects over $50 million, which will encourage international best practice and stimulate R&D.

In a further response to the Block Report, Government has amended taxation legislation to exempt grants made under the CRC Program from the application of the R&D "claw−back" provisions of the Act. This will ensure that the benefit potentially available to companies under the R&D tax concession provisions, for R&D undertaken by a CRC, is not reduced by virtue of the Commonwealth grant to Centres. In addition, the new CRC guidelines issued in January 1992 make strong commitments from industry and other end users an important criterion for selection.

Outcomes

Expenditure by the business sector on research and development is low by international standards, even after allowance is made for the structure of Australian industry. However, this situation is improving.

The R&D tax concession, together with the associated measures such as grants for industrial research and development, has contributed to significant

growth in industrial R&D. Business expenditure on R&D (BERD) was $2017 million in 1990–91, corresponding to 0.53% of GDP. In 1981–82 BERD was only 0.25% of GDP. Australia has had the strongest rate of increase in business R&D of any country in the OECD over the 1980s, and investment in this area in recent years has held up well in comparison with overall business investment. Over the same period, R&D–related employment in industry increased from just under 8,500 to about 20,000 persons.

Overseas patent applications made by Australians have been increasing – the annual average rate of 17% is by far the highest in the OECD.

The Partnerships for Development and Factor ‘f’ programs have contributed to increased levels of research and development, investment and exports in the information technology and pharmaceuticals sectors. Expenditure on R&D by companies participating in the Partnerships for Development Program increased from $59.7 million in 1988 to $251.6 million in 1991. In the five years from 1988, additional expenditure of $120 million was stimulated in the pharmaceutical industry by the Factor ‘f’ program. There have also been some significant successes in exports of high–technology products and services, with the four high–technology industries of information technology, aircraft and parts, pharmaceuticals and scientific instruments exhibiting the highest growth rates of exports of all manufacturing sub–sectors between 1978–79 and 1988–89.

Industry interest in innovation is shown by the strong level of private sector support for the Cooperative Research Centres. Industry is contributing over 20% of all funding by participants in Centres, in long–term contractual arrangements. In the third selection round industry is proposing to commit around 28% of all participant funding.

The funding contributed by industry and other research users to government research agencies has also grown significantly. CSIRO funds coming directly from companies and other research users grew from 4.1% of cash expenditure in 1982–83, to 14.3% in 1991–92. Another 10% of CSIRO's funds comes from competitive grants schemes, most of which are jointly funded by industry.

Government matching arrangements for rural industry research have led to a three–fold increase in funding for rural R&D supported by rural R&D

Councils and Corporations since 1985. The average level of industry contributions has increased from 0.19% of gross value of industry production to 0.36% in 1991–92.

Australia's second largest research agency, DSTO, has played an important role in developing science and technology infrastructure in Australian firms through the products of its defence research activities. In particular, programs such as the JINDALEE over–the–horizon radar, the LADS laser airborne depth sounder, and the KARIWARA towed sonar array are transferring innovative technology to Australian industry through major defence development and procurement contracts. DSTO and industry are similarly involved in specialised technologies for other major defence programs, such as the Australian Submarine Project.

The way ahead

The Government's innovation strategy will continue to stimulate industrial R&D and promote co–operation between the various parties in the science and technology system. Such co–operation helps ensure the effective application of research findings for the benefit of Australia. It also assists in making the facilities and infrastructure in one sector available to those in other sectors and improves the quality and relevance of the education and training available in Australia.

The Government recognises the need to continue to provide a strong stimulus for business investment in R&D. Despite rapid growth in private sector R&D over the last decade, Australian firms still invest much less in R&D than their overseas counterparts in the same industry sectors. The Government will therefore retain the R&D tax concession at 150% indefinitely beyond June 1993, as a significant signal to business of the importance it attaches to the role of R&D in achieving international competitiveness. This incentive will continue to be a central element of Government science and technology policy, which aims to increase business sector performance of R&D in order to improve the capture of the benefits of research in Australia.

The Government has also decided to waive the $10 million limit on pilot plant purchased or commenced to be constructed on or after 19 August. It recognises the importance of this measure in the development of major new resource–processing industries, which often require investment in large–scale pilot plant facilities.

The joint registration provisions of the industrial R&D tax concession allow a group of companies to form a syndicate to undertake significant R&D projects which are beyond the resources of, or too risky for, a single entity. The Government has decided that the Industry Research and Development Board's guidelines on registering syndicates will be revised by the Minister for Industry, Technology and Commerce, in consultation with interested parties. Syndicates involving tax–exempt bodies, such as universities and government research agencies, will no longer be able to claim the research and development tax concession unless the investors are fully at risk. Transition arrangements will apply to syndicate proposals lodged between 30 March 1992 and 10 June 1992.

Granting programs administered by the Industrial Research and Development Board will now be funded by a single–line appropriation, which will ensure these schemes operate more efficiently and flexibly.

Specific opportunities have also been generated in the Government's International Science and Technology Program. These activities are now being extended to focus more specifically on commercial international collaboration. Funding of $750,000 per year (1992–93 dollars) will assist Australian firms and research agencies to acquire overseas industrial know–how, through involvement in industrial collaboration programs.

The Government recognises that research funding is a long–term investment, and that uncertainties over future arrangements may weaken the overall research effort. The introduction of triennial funding for agencies such as CSIRO has gone a long way to meeting this concern. In order to maintain an atmosphere of certainty, the Government will consider the possibility of establishing "resource agreements" with CSIRO, ANSTO and AIMS in the lead–up to the next triennium. The issue of the application of the efficiency dividend will be addressed in this context.

The Government will maintain rural R&D funding arrangements under which the Government matches industry contributions to R&D expenditure on a dollar–for–dollar basis up to the level of 0.5% of the gross value of industry production. In addition, the Commonwealth will continue to provide direct appropriations to the Rural Industry R&D Corporation and Land and Water Resources R&D Corporation (for 1992–93, these will be $10.46 million and $10.42 million respectively).

The Government will continue with the 30% external funding target for CSIRO, ANSTO and AIMS. However, these external funding targets are to be viewed flexibly to allow the quality and relevance of research output to be considered; notwithstanding this, 30% should not be viewed as a limiting factor. The target has been effective in helping these agencies redirect their research towards national, including industry, objectives. External earnings may include income from all customers of research services, recognising that research may be required for a wide range of purposes.

All defence operations, including defence research, are currently being examined through the Commercial Support Program to determine which can be more cost–effectively carried out by private enterprise. In future years this should result in further increases in research capability in industry arising from DSTO's defence research program. In a further response to the Block Report, (supported by the report on public sector R&D by the Parliamentary Joint Committee of Public Accounts), the Government is establishing an Industry Support Office at DSTO's Aeronautical Research Laboratory.

The Government has also introduced initiatives to strengthen innovation in the food and space industries (see Appendices 2 and 3).

The benefits of higher education research extend beyond research training and the advancement of knowledge, to innovation and social and economic development. Recognising this, allocation of higher education research funding, while continuing to be primarily on the basis of research excellence and broad science and technology priority setting principles, will in future also focus on requirements of research users, and the potential for innovation. This will encourage greater industry links, and promote the widespread acceptance in higher education institutions that innovation is just as important as invention and discovery.

In response to several reports on the commercialisation of research, the NH&MRC has nominated "Commercialisation of medical research" as a special initiative topic for funding. It also continues to support a number of commercial development projects which have potential to earn export dollars for Australia.

In the light of international trends to introduce more business content into science and technology courses, and a focus on innovation into business

courses, the Government will encourage efforts by universities and TAFE colleges to introduce greater innovation related topics to courses on science, technology, engineering and business.

AWARENESS

To develop a greater understanding in the wider Australian community of the important roles played by science, technology and innovation in all aspects of our life, and particularly in economic and social development.

It is important that all Australians understand the importance of science and technology in society – in the home, in school, in training, in the workplace, and in government. A society that is aware of developments in science and technology, and of their potential applications, is likely to benefit from those advances and put them to positive industrial or social uses. We should take pride in our achievements in science and technology, along with those in sport and cultural activities, so that success in science, engineering and innovation can become common images in our popular culture.

Government policy and action

The most effective means of lifting awareness of science and technology is by harnessing existing mechanisms in the public and private sectors. The Government supports several such institutions, including CSIRO's "Double Helix" club and the national network of seven CSIRO Science Education Centres (CSIROSEC), the Australian Science Teacher's Association, the medical research community's Medical Research Week, and the ACTU's Work Education Package. Developments such as establishment of the new CSIROSECs, the Institution of Engineers' public awareness strategy and campaign, and the Australian Academy of Science's Foundation significantly increase awareness opportunity.

The National Science and Technology Centre was opened in 1988 as a bicentennial project funded by the Australian and Japanese Governments and business sectors. The Centre has developed outreach programs of travelling exhibits and the "science circus", which has visited some of Australia's most remote communities.

The May 1989 science and technology policy statement identified the need to improve community understanding of science and technology. It announced the commencement of a Science and Technology Awareness Program, administered by the Department of Industry, Technology and Commerce. This program includes the Australia Prize, an annual international award of $250,000 for outstanding achievement in science and technology promoting human welfare, and $550,000 annual funding for special projects.

A range of national initiatives are currently aiming to further improve the quality of teaching and learning in school science and technology education and the student retention rates in later school years. In particular, Commonwealth, State and Territory Governments are working through the Australian Education Council to develop a series of national curriculum and reporting frameworks across a number of areas of learning, including science, mathematics and technology. These frameworks aim to increase student participation and performance, including under–represented groups, particularly girls. Commonwealth, State and Territory governments are also pursuing strategies to increase access and equity in school education provision.

The Science and Technology Awareness Program has supported texts and teaching materials for school students which highlight the contribution of science and technology to development and the opportunities for careers involving science and technology. Career Reference Centres of the Department of Employment, Education and Training provide students with information on science and technology careers.

Outcomes

General community interest in science and technology can be measured indirectly by media coverage of the subject. Incorporation of the Michael Daley awards for Journalism into the Science and Technology Awareness program has assisted with raising awareness in the media of the importance of science and technology for Australia's future prosperity. The number and quality of entries in 1991 reflect a continuing increase in science and technology reporting through the decade.

Evidence of increased awareness of the value of science and technology in industry is indicated by the growth in industrial R&D, and in industry funding of research in CSIRO and the Cooperative Research Centres. Business and

industry association journals and newsletters also provide increased coverage of research and technology.

The numbers of Year 12 students in physics, chemistry and double mathematics has grown, reflecting the increase in Year 12 retention rates (from 41% in 1983 to 71% in 1991, for Australia as a whole). The proportion studying Year 12 physical sciences or a single mathematics subject has either remained stable or increased slightly since the 1970s and the proportion studying biology has increased.

The way ahead

The Government will provide an additional $1.8 million (1992–93 dollars) over the next two years to extend the Science and Technology Awareness Program. The intention is to increase the reach of the Program, and to emphasise activities targeted to young people and their teachers; currently under–represented groups such as girls and women; and business leaders. The emphasis of the program will continue to be on building links among those who deliver awareness, and on assisting projects initiated by those groups. Information programs that address community concerns will also receive increased attention. Existing awareness mechanisms in both the public and private sectors will be harnessed.

New activities will include:

. Engineering scholarships: support for the graduate scholarships program of the Institution of Engineers Australia;

. CSIROSEC: additional funding will be provided for increased CSIRO outreach education programs through CSIRO Science Education Centres;

. Science curricula: support for curriculum development for primary school science and technology;

. Eureka Awards: an extension of the Eureka/Australian Museum Speakers Program to the national electronic media;

. ASTA Badge Scheme: support to the Australian Science Teachers Association for implementation, in association with the Institution of

Engineers, of an Australian Science and Technology Awards Scheme for school students; and

. Understanding innovation: projects aimed at improved understanding within the business community of the roles of science, technology and innovation in developing profitability and international competitiveness.

SKILLS

To provide the skills to create and sustain competitiveness and quality of life, through enhancing post–school education in science and engineering at all levels

Australia's ability to use high–quality science and technology depends very much on the creativity and capacity of our scientists and engineers. The quality of Australia's post–secondary education system – vocational, professional and general – will be central in determining the future level of our scientific and technological progress and, more broadly, our economic and social development.

In 1983 the Australian vocational education and training system was essentially State and industrial–award based, largely uncoordinated and lacking a national system of credentials. TAFE stood in need of fundamental reform designed to foster the development of a flexible approach to skill formation capable of responding rapidly to industry and enterprise demands, particularly for those skills which serve to underpin the introduction of new technologies.

Government policy and action

The production of valuable scientific and engineering skills, and their application in Australian industry and society, can only be achieved through a flexible, responsive and efficient education system. Government policy and funding has focussed on developing a system which is more responsive to national social and economic needs, contributes to national industrial development and economic restructuring, and produces graduates and diplomates with a broad educational foundation and well–developed conceptual, analytical and communication skills.

The training system is becoming more responsive to industry needs, through Government stimulation of greater investment by industry, to raise training capacity and promote relevance and quality, and by ensuring TAFE colleges are more competitive. The collaboration between higher education and industry has also been increased, through a number of specific initiatives including joint Commonwealth/industry funded places and collaborative research grants.

Links are also being developed within and between the TAFE and higher education sectors, through course articulation and credit transfer, to make the educational experience more integrated.

Flexibility of the higher education and training systems is improving, for example by the use of developments in information technology, to increase access and to make education more responsive to the trend towards recurring participation in education throughout life.

These initiatives represent an integrated approach to creating the full range of research, professional and technical skills, and making them available to industry, government and higher education itself.

Outcomes

Since 1983, the Government has provided funding for a major expansion of higher education; the total funding has grown by 43% over the period 1983 to 1989. This has enabled a considerable expansion in the numbers of students undertaking higher education, with a 23% increase between 1984 and 1989. Outputs of numbers of students from higher education over this period also grew, by 29%. This growth has been combined with increases in equity in participation, improvements in the responsiveness of the system to national economic and social needs, and strengthened links with industry.

Higher education has also undergone major structural change, as a result of the ending of the former binary system and through amalgamation of the institutions. There are now some 35 higher education institutions compared with 72 in 1988. More flexible management and planning processes have been made possible through funding reforms, which have included the introduction of a system of educational profiles, rolling triennial funding and single block operating grants.

Over the period 1984 to 1990, award completions in science and engineering have increased by 20% to over 17,200. Of over 58,000 Bachelor degree completions recorded in Australia in 1990, science accounted for 16%, engineering 7%, health 8%, and other science–based professional areas a further 4%. This reflects the overall rapid growth in the higher education system. However, the percentage of engineers in particular still falls behind that in leading industrial countries, where engineers make up a larger proportion of the workforce, and the ratios of engineering to science graduates is far higher than in Australia.

Funding for research in higher education has grown substantially, principally through the formation of, and increases in funding for, the Australian Research Council. Funding for ARC and related grants schemes grew from $46 million in 1983 to $241 million in 1991. Other specific funding schemes for higher education research have grown by 54%, to $160 million, over that period.

There have been substantial increases in numbers of, and funding for, post graduate research awards in the May 1989 science and technology policy statement and other statements; there were 510 doctorate course completions in Australia in 1990 compared with 414 in 1987.

Mathematics, problem solving and an understanding of science and technology were identified as key competencies in the Finn Report (1991) on young people's participation in post–compulsory education and training. Detailed work on the development of these key competencies is being carried out by the Mayer Committee, which is expected to report to Governments in the latter part of 1992.

The Government has encouraged industry and individual firms to develop their own technical training centres by providing funding to assist with initial building, equipment and related capital costs. Business is expected to contribute significantly towards the set–up costs, and to meet the recurrent costs associated with these centres. They have the capacity to provide training in the latest local and overseas developments in advanced technology. For example, seven skills centres have now been established in the plastics industry, and two in the electrical and electronics industry.

The Australian TAFE system has been strengthened to ensure its effective response to industry. TAFE now funds many joint ventures with companies

to establish training centres with a technical and industry focus. In addition, TAFE provides customised courses, skills analysis and consultancy and auditing services on a fee–for–service basis. However, vocational education and training growth rates in the 1980s have been slow compared to quite rapid growth in schools and higher education.

The way ahead

In response to increased demand for postgraduate research awards, and recognising the view of the Parliamentary Joint Committee on Public Accounts report "Public Sector Research and Development", the number of new Australian Postgraduate Research Awards (APRAs) awarded annually will be increased to 1500, commencing in 1993. The 200 additional new awards include provision for a further 25 APRAs (Industry) annually, bringing the total of new industry awards made each year to 125, commencing in 1993.

No less important than the numbers of postgraduate research students is the quality of research training. The need to improve the quality of research training is urgent and difficult. Methods of research training, the nature and quality of supervision, and the place of course work in research degrees, are all institutional responsibilities. Nevertheless the problem also needs to be addressed collaboratively at the national level. Given the importance of research training, in future the ability to contribute to effective research training will be one of the criteria used in the allocation of research funding to higher education institutions.

In its 1991 report *Engineering in Australia*, a working group of the Prime Minister's Science Council proposed that a number of Advanced Engineering Centres be established, to emphasise technical excellence in engineering training and research, and to promote industry collaboration. The Government accepted the recommendation and funding has been allocated to support the establishment and operation of three Centres:

. Advanced Engineering Centre for Manufacturing (The University of Melbourne and the Royal Melbourne Institute of Technology)

. Advanced Engineering Centre for Innovation (The University of Technology Sydney and the University of Sydney)

. Advanced Engineering Centre for Information Technology and Telecommunications (The University of Adelaide, The University of South Australia, the Flinders University of South Australia, and the South Australian Government Department of Employment and Technical and Further Education)

The Government will contribute $2.1 million per Centre as an establishment grant, plus $0.5 million per year for operating costs. Industry partners will be directly involved in planning and management of the Centres, and in program design and delivery. The higher education and industry partners will also contribute to establishment and operating costs.

The fields covered by the three Centres have great value–adding potential for a range of industries. The Centres are expected to make a significant contribution to the skills and technology base in Australia and, in the longer term, to the development of internationally competitive industries for Australia. They will make a significant contribution to industry's requirements for advanced engineering.

Government has endorsed targets that involve substantial growth in vocational education and training. The expansion of the TAFE system is one part of a broad reform agenda aimed at providing a more highly skilled and flexible workforce while ensuring that individuals gain an initial skill base that can be upgraded throughout their working life.

An historic agreement among all Australian governments, to establish a new national vocational education and training system, was announced by the Prime Minister on 21 July 1992. An Australian National Training Authority will be established, and all Governments will channel their funding for vocational education and training through ANTA. The new system will have an enhanced capacity to deliver the skills, including the most advanced technical skills, which will underpin the further development of Australian industry.

INFRASTRUCTURE

To ensure that the research base in the universities and government laboratories is responsive to Australian needs, and of leading international standard

Statements such as the May 1989 science and technology policy statement and the 1988 higher education White Paper have recognised the importance to research of a strong infrastructure. The Government expects the infrastructure to be developed in accord with the broad policy principles set out throughout this document; that is, the pursuit of excellence in science and engineering; its application to national goals; and its sound management.

Government policy, action and outcomes

A range of Government organisational and funding initiatives have influenced the growth and direction of the science and engineering infrastructure. These include:

. the formation of the Australian Research Council in 1987 from the former Australian Research Grants Committee and other small granting schemes, its assumption of a significant research policy role for higher education, and substantial increases in its funding; this has included the ARC taking some responsibility for funding higher education infrastructure;

. the reorientation of government research agencies through encouraging stronger links with research users, and a greater reliance on competitive grants schemes;

. substantial increases in funding for equipment and priority research areas for government research agencies in the May 1989 science and technology policy statement, and further support for buildings and other infrastructure in statements in 1991.

. introduction of the Cooperative Research Centres program; and

. regular Government contributions to the development of national research facilities. Six facilities are currently in operation. They are the HIFAR research reactor, the Australian Animal Health Laboratory, the research

vessel *Franklin*, the Australia Telescope, the Anglo–Australian Observatory, and the medical cyclotron and Positron Emission Tomography (PET) diagnostic facility.

The Government recognises the vital role of its own research organisations as components of an effective science and technology infrastructure. The thrust of Government policy has been to link the work of its research organisations to national priorities and the needs of industry and other users of research. Mechanisms used have included setting targets for the science agencies to earn funds from external sources, and allowing the agencies to retain earnings without impact on their appropriation funding. At the same time, the Government has not neglected the base funding of these agencies. The May 1989 science and technology policy statement provided $95 million over 5 years from 1989–90 to CSIRO and other agencies for equipment and support of priority research.

Government has also allowed the science agencies greater freedom to manage their own budgets in order to develop better tailored, more effective infrastructure. The new funding structures are systematically changing the orientation of the science agencies: the proportion of funding to agencies through Budget appropriations has declined, to be replaced by competitive grants, funding for CRCs, contracts with government instrumentalities and industrial research in part stimulated by the R&D tax concession. These programs are building strong links with users of research, a key part of any science and technology infrastructure.

Research infrastructure support is provided to higher education institutions through operating grants, and the ARC infrastructure support Mechanisms A, B and C, which were introduced in the May 1989 science and technology policy statement. The research component of operating grants was $217 million in 1992, and is meant to provide for a variety of research related purposes including both infrastructure and grants for research projects. The ARC Mechanisms provided $52 million in 1992: Mechanism A for block grants distributed on the basis of institutional success in obtaining Commonwealth competitive grants; Mechanism B for former advanced education sector institutions to promote research potential; and Mechanism C for cooperative infrastructure development across groups of institutions.

As a result of the 1988 structural reforms to higher education, many of the former colleges of advanced education merged with existing universities,

while others amalgamated with similar institutions or became new, free-standing universities. There has been a positive effect on research capacity, and the higher education system is now better placed to undertake a broader range of research activities. This trend has been strengthened as the former Institutes of Technology have improved their research capacities.

An important outcome of Government policy initiatives has been increased attention to research management planning, exemplified by the requirement for institutions to develop research management plans. This has led to the more precise identification of research priorities, and the more efficient management of resources, including a recognition of the need for a realistic approach to the costing and pricing of research undertaken for outside bodies.

By 1 July 1992, a total of 34 Cooperative Research Centres had been established. The first fifteen, announced in March 1991, have been in operation for up to twelve months. The major benefits apparent already at this early stage are:

. the strong links that are being established between groups of researchers and research users in the universities, individual business enterprises and industry sectors, CSIRO, and other Commonwealth and State agencies;

. the increased staff and student mobility, taking full advantage of the research expertise and specialised scientific equipment available within the participating organisations;

. the strategic and outcome oriented focus adopted by researchers involved in CRCs; and

. the substantial and long–term commitment made by industrial firms and other research users participating in CRCs.

While many industrialised countries have schemes aimed at fostering research interaction and collaboration between industry and publicly funded research institutions, the Cooperative Research Centres Program requires a long–term (typically seven years) commitment by all participants, including industry, to provide at least 50% of the total resources required by the Centre. The Government is confident that through this approach a solid base has been established for the success of the Centres. On average two thirds of all

resources available to CRCs established so far are provided by the participants, with CRC program funding covering the remaining third.

The way ahead

Government research agencies

Greater user–funded research requires changes in management practices which are now being introduced within the science agencies. Firstly, the re–orientation of research to better match national needs will require careful management of the resources devoted to infrastructure, if growing areas are to be adequately serviced. The second challenge is for the agencies to employ management techniques that enable them to judge the right balance of long term strategic research needed to provide a sustainable stream of shorter term contracts with end–users.

Government is also conscious that the infrastructure in its research organisations could be increasingly utilised to train researchers and technicians. Many agencies already have a good record in this area. This is especially the case where agencies contain expertise or facilities not contained within higher education. For example, the Antarctic Division, the Australian Nuclear Science and Technology Organisation, various CSIRO divisions, the Australia Telescope, and the Australian Institute of Marine Science all conduct basic research but are based outside the universities. Major national research facilities, such as the Telescope, are an important part of the nation's infrastructure for science and engineering.

In order to protect and maintain the nation's investment in the infrastructure of its research agencies, the Government provided $12 million in the 1991–92 Budget, and a further $10 million through the November 1991 Economy and Employment Statement to enable the science agencies to upgrade building assets without reducing research activity. The Government is now enabling this program to be completed by providing $30 million (1992–93 dollars) over the next two years for improvements in science agencies' infrastructure. These improvements will enable the agencies to increase their effectiveness, better service industry, and meet national interest objectives. This additional funding will have significant employment effects, including the creation of youth jobs, and jobs in the building industry from 1992–93 to 1993–94, and the maintenance of positions for technical and support staff over the same period.

The Government believes that scientific support for resource decisions should be provided in the most efficient way. The Bureau of Mineral Resources, Geology and Geophysics (BMR) is a central element in providing both that support and the knowledge necessary for the continued development of the exploration industries. BMR's role has changed in recent years, as it has been asked to do much more to help address national and global issues, including land management and protection of the environment. These changes in role have opened the possibility of a closer integration of some of BMR's work with that of CSIRO.

The Government has therefore decided to:

. conduct an inquiry into the administrative arrangements under which BMR operates, including whether it should become a separate Institute within CSIRO or remain with the Primary Industries and Energy portfolio;

. merge BMR's petroleum and minerals resource assessment activities with the Bureau of Rural Resources, to become the Australian Bureau of Agricultural and Resource Science (ABARS);

. change the name of BMR to the Australian Geological Survey Organisation (AGSO); and

. implement management systems within the Department of Primary Industries and Energy to link AGSO's scientific mapping with the resource assessment responsibilities of ABARS.

These new arrangements will enhance the scientific and economic resource information available to government and industries, and improve the performance of Australia's geoscience effort.

Principles for Costing and Pricing of Research

The Coordination Committee on Science and Technology has recently produced a paper on the costing and pricing of public–sector research, as a guide to researchers and funders on principles to be applied. The Government has endorsed the following principles for the costing and pricing of public sector research:

- all research performers should develop and maintain accurate accounting systems, recording all of the costs associated with any research project/program, with the best balance of accuracy, transparency and cost–effectiveness in doing so.

- pricing decisions should be based on knowledge of all relevant cost components, to ensure the long–term viability of the research enterprise and to meet the need for accountability for publicly–provided resources.

- decisions on price should be based on an understanding of the respective objectives and responsibilities of the research performer and funder, and the extent to which the benefits from the conduct and results of the research can be captured by each party.

Review of Funding for Higher Education Research Infrastructure

The Government recognises that changes in the higher education research system may have resulted in an imbalance between research infrastructure and the direct funding of research. Some of these changes have included:

- the general growth in the higher education system, without proportional growth in levels of student load funding;

- the development of research activity in the former advanced education institutions, as they become part of the university system;

- expansion of the research training function, tied to comparatively large increases in postgraduate research enrolments;

- the growing cost and decreasing obsolescence time of equipment and library, and information systems; and

- the shift to greater funding through direct research granting schemes, which largely provide only the direct or marginal costs of projects and programs that they support, and expect the research performer's institution to meet indirect costs.

The recent Parliamentary Joint Committee on Public Accounts report on public sector research and development also pointed to the need for monitoring of higher education's infrastructure funding.

The Government has decided that funding of research infrastructure in higher education institutions should be reviewed by the National Board of Employment, Education and Training. The Board has been asked to advise the Government on:

. the adequacy of the infrastructure in the higher education system to support high–quality research across the breadth of academic disciplines;

. the likely pattern of research infrastructure needs in the future, and the levels of research infrastructure funding required to meet them; and

. the mix of allocative mechanisms for research infrastructure funding at the national level that would best achieve the selectivity, concentration and value to industry that is a focus of Government policy for higher education research.

In addressing these issues, the Board will take account of the importance of research and research training as key functions of higher education institutions, accountability for ensuring balance between infrastructure and research, and the range of research activity and infrastructure in the system.

Pending the results of this review, current arrangements will continue to apply with regard to funding research in higher education institutions. Individual institutions are responsible for the level of resources (operational, capital and other infrastructure) allocated to research from within the total level of funding available to them. Those funds obtained from competitive granting schemes in the knowledge that they provide for less than the full costs of research therefore should be accepted only if the higher education institutions are prepared to supplement the grants to ensure that the research is adequately supported.

Major National Research Facilities

ASTEC has recently completed a study of the demand for major national research facilities in Australia. Its work has provided valuable inputs to Government decision–making, in terms of suggestions on the criteria to be

used in evaluating proposals for new facilities. ASTEC also identified some of the problems associated with the management of such facilities, suggesting that they may be under–utilised due to insufficient funds for operating costs. The Parliamentary Joint Committee on Public Accounts also drew attention to the need to set priorities for major research facilities.

The Government is responding to one of the major requirements for research infrastructure identified by ASTEC in its recent report on national research facilities: the upgrading of the research data network in Australia. This issue was also highlighted in a recent report to the Prime Minister's Science Council, which pointed in particular to the need to extend the network to industry and other research users. It is an important issue for the Cooperative Research Centres, which involve participants from the public and private sectors, often at several locations within and between States. The Government will provide up to $13 million (1992–93 dollars) over the next two years to support this development. This funding will not impede the support, rising to $119 million by 1995, to be provided to up to 50 Centres selected in three selection rounds of the Program. The Government will convene a working party to develop a proposal for the expansion of the existing computer and communications network and upgrading its capacity, through the formation of a Research Data Network Cooperative Research Centre. The proposal will be evaluated and supported as part of the Cooperative Research Centres Program.

The Government will establish an independent inquiry into the rationale for, and appropriate level of, Australia's involvement in nuclear reactor–based research and technology. The inquiry will examine whether on scientific, commercial, community and national interest grounds, there is a need for a new research reactor; costs and benefits of the current reactor, HIFAR and its remaining life and decommissioning costs; and locational, environmental and organisational issues associated with any new reactor.

The Coordination Committee on Science and Technology will keep a watching brief on the development of specific proposals for national research facilities, particularly those that cross departmental boundaries. The Minister Assisting the Prime Minister will bring high priority proposals to the attention of Government.

The Government has drawn on ASTEC's work to identify the following general principles for the establishment and operation of major national research facilities:

. Any new national research facility should be established in association with an appropriate host institution which has responsibility for the management of the facility. A steering committee should be appointed for each national research facility to establish policy guidelines for its operation, to promote full and effective use of the facility, and to prepare an annual report.

. All proposals for use of the facility, including those from industry, should be assessed on their merits taking into account national interest. There should be no guaranteed allocation of research time at a national research facility for the host institution or for any other users. The allocation of time to the host institution for purposes other than research, such as maintenance of the facility or testing new equipment, should be determined by discussion between the host institution and the steering committee.

. A charging policy should be developed for each facility by the relevant steering committee and agreed by the responsible Minister, with the main objective of optimising the use of the facility for the nation's benefit.

These principles are reflected in arrangements with the Australian Institute of Nuclear Science and Engineering, governing allocation of access by universities to the facilities of the ANSTO.

Vigorous pursuit of the world's best science and technology is vital to the development of a strong science and technology base, not only in terms of access to overseas major research facilities, but from the opportunity for Australian scientists and engineers to work with colleagues in other countries.

A major goal of research and higher education policy is to ensure continuing access to international knowledge, and the ability to usefully integrate it. In order to maintain the highest standards of research, the ability to contribute to international links will in future be one of the criteria for the allocation of research funding to higher education institutions.

The Government has also taken initiatives which address specific infrastructure needs and opportunities. These recognise important infrastructure elements such as setting and maintaining standards, research for the environment, and expansion of the marine science network. They are detailed in the appendices.

Appendix 1

THE PROCESS

The Government's decision to develop a White Paper followed a recommendation from ASTEC in its 1990 report "Setting Directions for Australian Research". In this report ASTEC addressed the need for a broad national framework for science and technology to assist researchers, departments and agencies to determine their priorities.

The then Prime Minister asked ASTEC to examine the issues which should be considered in developing such a framework and the options available to achieve it. ASTEC decided to focus on research and technology and sought the views of people from all sectors interested in science, technology and its application. Around 200 submissions were received and, in cooperation with State bodies, ASTEC held round table discussions in all capital cities.

ASTEC produced its issues and options paper "Research and Technology: Future Directions" in October 1991. It followed this with seminars in Canberra, Brisbane and Perth to explain the paper and receive further comment.

The Government has also received reports on the commercialisation of research (Block and Coghlan), and on national research facilities (ASTEC). These reports, together with advice from Government departments and advisory bodies, have been considered in the preparation of this White Paper.

The Coordination Committee on Science and Technology identified the four major themes to be addressed in the White Paper. These were endorsed by the Prime Minister's Science Council in December 1991.

Appendix 2

SUMMARY OF ORGANISATIONAL AND POLICY INITIATIVES

The Prime Minister's Science Council will be renamed the Prime Minister's Science and Engineering Council.

The Treasurer will become a member of the Prime Minister's Science and Engineering Council.

The current President of the Institution of Engineers, Australia will be invited to join the Prime Minister's Science and Engineering Council.

The Prime Minister's Science and Engineering Council will be given the following terms of reference:

1 To address important issues in science, technology, engineering and relevant aspects of education and training

2 To examine the contribution of science, technology and engineering to the economic and social development of Australia

3 To enhance awareness in the community of the importance of science, technology and engineering for Australia's economic and social development

4 To examine Australia's science and engineering resources and the effectiveness of their organisation and utilisation.

5 To examine Australia's science and engineering infrastructure and the effectiveness with which it achieves the application of science and technology in the economic and social development of Australia.

The Coordination Committee on Science and Technology will report to Government on the mechanisms used to set science and technology priorities, and will address the adequacy of these mechanisms and the resulting priorities.

INNOVATION

Schemes administered by the Industrial Research and Development Board, such as discretionary and generic grants, will now be funded by a single–line appropriation. This will ensure that these schemes operate more efficiently and flexibly, by overcoming current problems of fragmentation.

In order to maintain an atmosphere of certainty, the Government will consider the possibility of establishing "resource agreements" with CSIRO, ANSTO and AIMS in the lead–up to the next triennium. The issue of the application of the efficiency dividend will be addressed in this context.

The Government will maintain rural R&D funding arrangements under which the Government matches industry contributions to R&D expenditure on a dollar–for–dollar basis up to the level of 0.5% of the gross value of industry production. In addition, the Commonwealth will continue to provide direct appropriations to the Rural Industry R&D Corporation and Land and Water Resources R&D Corporation.

The Government will continue with the 30% external funding target for CSIRO, ANSTO and AIMS.

The Government will ask the newly–created Agri–Food Council to consult with food processing companies and develop a structure for a Technology and Innovation Association. If there is sufficient support, the Government will provide seed funding.

Allocation of higher education research funding, while continuing to be primarily on the basis of research excellence and broad science and technology priority setting principles, will in future also focus on requirements of research users, and the potential for innovation.

The NH&MRC has nominated "Commercialisation of medical research" as a special initiative topic for funding.

The Government will encourage efforts by universities and TAFE colleges to introduce more business content in science and technology courses, and a focus on innovation into business courses.

The Government proposes the establishment of a Forest and Wood Products Research and Development Corporation in the National Forest Policy Statement. The charter of the Corporation will be to identify priorities and to commission, administer and subsequently evaluate research into a broad range of issues relating to wood production, extraction, processing, economics and marketing. Among these issues will be the impacts of disturbance resulting from wood production, silviculture, and management of native forests and plantations, the commercial and economic aspects of wood production and research of relevance to forest products industries.

The Corporation will be funded on an agreed basis by an industry levy and by the Commonwealth. Before the arrangements for the Corporation are finalised the Government will hold further discussions with the relevant industry body.

SKILLS

Given the importance of research training, in future the ability to contribute to effective research training will be one of the criteria used in the allocation of research funding to higher education institutions.

The Government is establishing three Advanced Engineering Centres to emphasise technical excellence in engineering training and research, and to promote industry collaboration. The three Centres are:

. Advanced Engineering Centre for Manufacturing (The University of Melbourne and the Royal Melbourne Institute of Technology)

. Advanced Engineering Centre for Innovation (The University of Technology Sydney and the University of Sydney)

. Advanced Engineering Centre for Information Technology and Telecommunications (The University of Adelaide, The University of South Australia, the Flinders University of South Australia, and the South Australian Government Department of Employment and Technical and Further Education)

The Government has endorsed targets that involve substantial growth in vocational education and training, as part of a reform agenda aimed at providing a highly skilled and flexible workforce.

An Australian National Training Authority will be established, to provide an enhanced capacity to deliver the skills, including the most advanced technical skills, which will underpin the further development of Australian industry.

INFRASTRUCTURE

In order to enhance the scientific and economic resource information available to government and industry, and improve Australia's geoscience effort, the Government has decided to:

. conduct an inquiry into the administrative arrangements under which BMR operates, including whether it should become a separate Institute within CSIRO or remain with the Primary Industries and Energy portfolio;

. merge BMR's petroleum and minerals resource assessment activities with the Bureau of Rural Resources, to become the Australian Bureau of Agricultural and Resource Science (ABARS);

. change the name of BMR to the Australian Geological Survey Organisation (AGSO); and

. implement management systems within the Department of Primary Industries and Energy to link AGSO's scientific mapping with the resource assessment responsibilities of ABARS.

The Government has endorsed the following principles for the costing and pricing of public sector research:

. all research performers should develop and maintain accurate accounting systems, recording all of the costs associated with any research project/program, with the best balance of accuracy, transparency and cost–effectiveness in doing so.

- pricing decisions should be based on knowledge of all relevant cost components, to ensure the long–term viability of the research enterprise and to meet the need for accountability for publicly–provided resources.

- decisions on price should be based on an understanding of the respective objectives and responsibilities of the research performer and funder, and the extent to which the benefits from the conduct and results of the research can be captured by each party.

The Government has decided that funding of research infrastructure in higher education institutions should be reviewed by the National Board of Employment, Education and Training. The Board has been asked to advise the Government on:

- the adequacy of the infrastructure in the higher education system to support high–quality research across the breadth of academic disciplines;

- the likely pattern of research infrastructure needs in the future, and the levels of research infrastructure funding required to meet them; and

- the mix of allocative mechanisms for research infrastructure funding at the national level that would best achieve the selectivity, concentration and value to industry that is a focus of Government policy for higher education research

The Coordination Committee on Science and Technology will keep a watching brief on the development of specific proposals for national research facilities, particularly those that cross departmental boundaries. The Minister Assisting the Prime Minister will bring high priority proposals to the attention of Government.

The Government has identified the following general principles for the establishment and operation of major national research facilities:

- Any new national research facility should be established in association with an appropriate host institution which has responsibility for the management of the facility. A steering committee should be appointed for each national research facility to establish policy guidelines for its operation, to promote full and effective use of the facility, and to prepare an annual report.

- All proposals for use of the facility, including those from industry, should be assessed on their merits taking into account national interest. There should be no guaranteed allocation of research time at a national research facility for the host institution or for any other users. The allocation of time to the host institution for purposes other than research, such as maintenance of the facility or testing new equipment, should be determined by discussion between the host institution and the steering committee.

- A charging policy should be developed for each facility by the relevant steering committee and areed by the responsible Minister, with the main objective of optimising the use of the facility for the nation's benefit.

In order to maintain the highest standards of research, the ability to contribute to international links will in future be one of the criteria for the allocation of research funding to higher education institutions.

In recognition of the need to develop international research links in the education sector, the Department of Employment, Education and Training and the Australian Research Council have set up the International Reciprocal Research Fellowships Program. Agreements are already in place with Germany and Korea, with others soon to follow with France and China. The fellowships will support visits by outstanding Australian researchers to partner countries, and for overseas researchers to work in Australia.

Support has been provided to promote collaborative links between Australian universities with both research and industry counterparts in Asia through the Targeted Institutional Links Program, begun in 1990.

Appendix 3

SUMMARY OF FUNDING INITIATIVES ANNOUNCED IN THE 1992–93 BUDGET

INITIATIVE	BUDGET OUTLAYS ($ million)				
	1992–3	1993–4	1994–5	1995–6	TOTAL
INNOVATION					
Variations to tax concession, including retention at 150% (a)					
International Collaboration	0.75	0.78			1.53
DSTO Industry Support Office	1.50	1.55			3.05
National Space Program	1.29	1.80	1.80	1.80	6.69
AWARENESS					
Awareness Program	0.90	0.93			1.83
SKILLS					
Increased APRA Awards	1.45	4.67	7.82	10.40	24.34
INFRASTRUCTURE					
Science Agencies Infrastructure	15.00	15.64			30.64
Research Data Network	9.00	4.17			13.17
Inquiry into ANSTO Reactor	0.80	1.25			2.05
National Standards Commission	0.60	0.62	0.63	0.66	2.51
Extension of AIMS to north–west Australia	0.15	1.56	3.02		4.73
Genetic Manipulation Authority	1.20	1.37	1.64	1.69	5.90
NH&MRC Research Funds	1.50	3.09	1.59		6.18
TOTALS	34.14	37.43	16.50	14.55	102.62
S&T RELATED (b)					
ESD:– DASET	7.90	14.39	14.84	15.40	52.53
DPIE	7.90	14.00	14.00	14.00	49.90
Climate Change	4.10	1.00	1.10	1.10	7.30
TOTALS	19.90	29.39	29.94	30.50	109.73

(a) Revenue measure.

(b) New funding for Ecologically Sustainable Development activities (including work on the greenhouse effect and climate change), which includes a research component.

SUMMARY OF FUNDING INITIATIVES ANNOUNCED IN THE 1992–93 BUDGET

INNOVATION

Variations to 150% Tax Concession

(Revenue measure)

The Government recognises the need to continue to provide a strong stimulus for business investment in R&D. Despite rapid growth in private sector R&D over the last decade, Australian firms still invest much less in R&D than their overseas counterparts in the same industry sectors. The Government will therefore retain the R&D tax concession at 150% indefinitely beyond June 1993, as a significant signal to business of the importance it attaches to the role of R&D in achieving international competitiveness. This incentive will continue to be a central element of Government science and technology policy, which aims to increase business sector performance of R&D in order to improve the capture of the benefits of research in Australia.

The Government has also decided to waive the $10 million limit on pilot plant purchased or commenced to be constructed on or after 19 August. It recognises the importance of this measure in the development of major new resource–processing industries, which often require investment in large–scale pilot plant facilities.

The Industry Research and Development Board's guidelines on registering syndicates will be revised by the Minister for Industry, Technology and Commerce, in consultation with interested parties. Syndicates involving tax–exempt bodies, such as universities and government research agencies, will no longer be able to claim the research and development tax concession unless the investors are fully at risk. Transition arrangements will apply to syndicate proposals lodged between 30 March 1992 and 10 June 1992.

International industrial collaboration

($0.75 million in 1992–93; $1.53 million over two years)

The Government has introduced a new program to assist consortia of Australian firms and research agencies acquire overseas industrial know–how, including management, technology and marketing, through involvement in bilateral and multilateral industrial collaboration programs. There will be particular focus on collaboration with firms in Asia. Support will be provided through:

. competitive grants for the costs of negotiating access to bilateral and multilateral industrial technology programs

. provision of a brokerage function through which industry could identify appropriate relationships through short–term visits and missions; and

. seed support for demonstration projects.

DSTO Industry Support Office

($1.50 million in 1992–93; $3.05 million over two years)

The Defence Science and Technology Organisation has recently succeeded in commercialising technologies developed for military use, including crack patching for aircraft, long–life rubber components for vehicle suspensions, anti–corrosion technologies, and a marine dye marker for sea search and rescue.

It is important that DSTO's work and expertise become more widely known, and maximises the transfer of enabling technologies into Australian industry. DSTO's expertise should also be more accessible as a service to industry.

In order to build on the successes to date, an Industry Support Office is to be established at DSTO's Aeronautical Research Laboratory. The Office will provide aerospace related research services for industry on a commercial basis, and will promote the transfer of associated defence technologies through licensing and other commercial arrangements. Within portfolio

guidelines, revenue from these commercially oriented activities will be retained by DSTO.

National space program

($1.29 million in 1992–93; $6.46 million to 1995–96)

The operations of the Australian Space Office have recently been reviewed by an expert panel and by the Bureau of Industry Economics. The expert panel identified growing demand for earth observation data from satellites, and new space–based industry opportunities for Australia. At the same time, the Senate Standing Committee on Transport, Communications and Infrastructure produced a report on *Developing Satellite Launching Facilities in Australia and the Role of Government,* which, among other things, called for Government leadership in setting a clearly–defined space policy.

The Government reaffirms its support for an on–going national space program, recognising the major benefits likely to result from continued access to critical remotely sensed data. The Minister for Industry, Technology and Commerce will be designated the Minister responsible for space. An Australian Space Council will be created, supported by the Australian Space Office. The Council will prepare a five year strategic plan to maximise the benefits Australia can derive from space activities. A review of the program will be undertaken by March 1998.

AWARENESS

Awareness program

($0.90 million in 1992–93; $1.83 million over two years)

Increased resources have been provided to extend the Science and Technology Awareness Program. It is intended to increase the reach of the Program, and to emphasise activities targeted to young people and their teachers; under–represented groups such as girls and women; and business leaders. Information programs that address community concerns will also receive increased attention. Existing awareness mechanisms in both the public and private sectors will be harnessed.

Activities will include support for the graduate scholarships program of the Institution of Engineers Australia; assistance to develop outreach components of major CSIRO Science Education Centres; support for curriculum development for primary school science and technology; an extension of the Eureka/Australian Museum Speakers Program to the national electronic media; support to the Australian Science Teachers Association for implementation of a Science and Technology Awards Scheme for school students; and projects aimed at improved business understanding of the roles of science, technology and innovation in international competitiveness.

SKILLS

Increased APRA Awards

($1.45 million in 1992–93; $24.34 million to 1995–96)

In response to the increased demand for postgraduate research awards the number of new Australian Postgraduate Research Awards awarded annually will be increased to 1500 from the present level of 1300.

The 200 new awards include provision for an additional 25 new APRAs (Industry) annually, bringing the total of new industry awards made each year to 125, commencing in 1993.

INFRASTRUCTURE

Science agencies' infrastructure

($15.00 million in 1992–93; $30.64 million over two years)

$30.64 million will be provided from 1992–93 to 1993–94 for capital asset management in government science agencies. This is made up of $4.5 million to ANSTO to upgrade its site security; $1.5 million to AIMS for extensions, repairs and maintenance to equipment and facilities; and $24 million to CSIRO for essential repairs and maintenance. This additional funding will have significant employment effects, including the creation of 200 youth jobs, and jobs in the building industry from 1992–93 to 1993–94, and the maintenance of positions for technical and support staff over the same period.

Research data network

($9.00 million in 1992–93; $13.17 million over two years)

The Government will provide $13.17 million over the next two years to upgrade the research data network in Australia (AARNET). A working party will develop a proposal for the expansion of the existing computer and communications network and upgrading its capacity, through the formation of a Research Data Network Cooperative Research Centre. The proposal will be evaluated and funded under the Cooperative Research Centres Program, and will be required to meet the normal CRC selection criteria. In particular the proposal must be relevant to industry and other research users, and will be developed with their involvement and support. It will also be dependent on the provision of matching funds by industry and the research and user communities. Funding of this centre will not impede the support, rising to $119 million by 1995, to be provided to up to 50 Centres selected in three selection rounds of the Program.

The initiative will address one of the major needs for research infrastructure in Australia identified by ASTEC in its recent report on national research facilities, and also highlighted in a recent report to the Prime Minister's Science Council.

Inquiry into ANSTO reactor

($0.80 million in 1992–93; $2.05 million over two years)

An independent inquiry will be conducted into the rationale for, and appropriate level of, Australia's involvement in nuclear reactor–based research and technology. The inquiry will examine whether on scientific, commercial, community and national interest grounds, there is a need for a new research reactor; costs and benefits of the current reactor, HIFAR and its remaining life and decommissioning costs; and locational, environmental and organisational issues associated with any new reactor.

National Standards Commission

($0.60 million in 1992–93; $2.51 million to 1995–96)

Following an external review, the Government will increase the funding of the National Standards Commission in order that it take a more effective national policy and coordination role. A more effective Commission will be better able to coordinate the National Measurement System so that the necessary measurement infrastructure is available to support the development and expansion of high–technology industries, and to provide confidence in the validity of measurements used in industry, commerce, international trade, health and safety, and the community.

Extension of AIMS to north–west Australia

($0.15 million to 1992–93; $4.73 million to 1994–95)

It is the Government's intention that marine science be conducted in a truly national manner. As a first tep, it will establish an Australian Institute of Marine Science presence in north west Australia to enable detailed scientific investigations of the region's unique marine environment. This initiative will involve a staged build–up, with the centre becoming fully functional by the third year. Proposed research programs will initially focus on ecosystem analysis and environmental monitoring. A major objective of the proposal is to provide scientific information on which to base rational decisions on development in the north west marine environment.

Genetic Manipulation Authority

($1.20 million in 1992–93; $5.90 million to 1995–96)

The Government will allocate funds to establish, in consultation with the States and territories, a new statutory authority to assess and approve proposals for the planned release of genetically modified organisms (GMOs) into the environment. This was recommended by the House of Representatives Standing Committee on Industry, Science and Technology following a comprehensive public inquiry into issues relating to the development and use of genetic manipulation technologies. A full response to the Parliamentary Committee report will be made to the Parliament in the near future.

Additional research funds for NH&MRC

($1.50 million in 1992–93; $6.18 million to 1994–95)

The Government has approved an increase to health and medical research, through the NH&MRC, of $6.18 million over 1992–3 to 1994–5. The funding is in response to the NH&MRC research strategy and will be equally divided between public health research and medical research. It will foster continued development of public health research and will enable medical research to make some adjustment of priorities in accordance with the strategy.

Research–related initiatives – ESD and climate change

New initiatives to progress Ecologically Sustainable Development–related RD&D announced in the 1992–93 Budget include the establishment of the Best Practice Environmental Management Program in the Department of Industry, Technology and Commerce, additional funding for environmental and marine research and the Environmental Resources Information Network in the Department of Arts, Sport, the Environment and Territories, and additional funding for energy management, renewable energy and energy R&D in the Department of Primary Industries and Energy.

The Government has extended for a further three years its funding of climate change monitoring and research, in support of early clarification of the likely course and impacts of the enhanced greenhouse effect. In the first period of funding (1989–93) the augmentation of existing capabilities in CSIRO, the Bureau of Meteorology and universities contributed substantially to Australia's involvement in the work of the Intergovernmental Panel on Climate Change. This laid the groundwork for the draft convention on Climate Change for signing at the UNCED Conference in June 1992.

Effective national response to the challenge of climate and global change will depend on strong Australian participation in international monitoring and research programs such as the World Climate Program and the International Geosphere Biosphere Program. Our vulnerability to climate influences, and our established southern hemisphere leadership role in international atmospheric monitoring, are well recognised. Australian scientists play a key role in international research efforts to provide the scientific basis for climate prediction and for implementation of conventions on climate change. Commencing in 1993, the Bureau of Meteorology will initiate a series of annual summaries on Australian participation in international scientific climate programs.

STATEMENT 2 - SCIENCE AND TECHNOLOGY BUDGET STATEMENT 1992-93

CONTENTS

SUMMARY NOTES

SUPPORT FOR SCIENCE AND INNOVATION IN 1992-93

In 1992-93, Commonwealth support through major science and innovation programs is expected to rise by 2.2% in real terms to reach $2857m ($2708m) in 1991-92).

Funds under the control of the Australian Research Council (ARC), directed to supporting university research, have risen to $269m ($240m in 1991-92). This represents a real increase of 9%. Total funds for university R&D are estimated to rise by about 2%.

Total support for industrial R&D and innovation, including both direct support through appropriations and the estimated effects of tax revenue foregone, is expected to be $479m in 1992-93, up from $448m in 1991-92, an increase of 4% in real terms. For 1992-93, this support is boosted by $30m allocated to establishing the Australian Technology Group, which is aimed at improving the commercial return on research. However, the major component of these amounts is the estimated effect of revenue foregone through the industrial R&D tax incentive, which rises to $325, about the same real level as in 1991-92.

Since the mid 1980s, funding increases to support industrial R&D and innovation have followed policy changes which recognize the key role of these factors in improving competitiveness. Australian business R&D has been shown to be at comparatively low levels in relation to other OECD nations and there has also been concern on the level and effectiveness of interaction between industry researchers and those in government agencies and higher education. The Cooperative Research Centre (CRC) Program will help address this problem of interaction. Up to fifty CRCs are expected to be in place by the end of 1992-93.

Other specific purpose R&D grant schemes (support for rural R&D, the National Health and Medical Research Council grants, other health R&D and the smaller R&D grant schemes) together rise to $267m (up 5% in real terms).

Appropriations to the major research agencies will increase to $914m in 1992-93 from $912m in 1991-92. Excluding defence R&D, the increase is to $694m from $679m. These figures represent a decrease in real terms of 1.0% for the civilian research agencies and a 2.9% decrease overall. Budget support for CSIRO will rise to $464m and the Organisation's external earnings (funds from business, from licensing fees, and other sources) will bring its total funding to about $685m.

While there is a natural focus on financial inputs, it should be emphasised that all support is provided in the expectation of useful outcomes and applications, including the development of the national skills base. The *Science and Technology Budget Statement* provides many examples of the discoveries, advances in understanding and steps in commercialisation resulting from Government support for science and technology. The achievements are impressive and provide strong justification for the level of the Government's commitment.

SUMMARY TABLE

COMMONWEALTH SUPPORT FOR MAJOR PROGRAMS OF SCIENCE & INNOVATION

	1991-92 $m outlays	1992-93 $m est.	Real change
AUTRALIAN RESEARCH COUNCIL[1]	240.3	269.4	+ 9%
OTHER HIGHER EDUC. R&D	844.0	873.1	+ 0%
CO-OPERATIVE RESEARCH CENTRES	18.2	54.5	+ 189%
INDUSTRY R&D & INCENTIVES[2]	447.9	478.9	+ 4%
RURAL R&D	94.4	110.3	+ 13%
NH&MRC	103.3	108.7	+ 2%
OTHER HEALTH R&D	22.4	22.0	- 5%
OTHER R&D GRANTS[3]	25.5	25.9	- 2%
CSIRO[4]	453.7	464.2	-1%
DSTO	232.3	220.3	- 8%
OTHER R&D AGENCIES	225.5	229.7	- 1%
TOTAL	**2708**	**2857**	**+ 2.2%**

NOTE: Outlays are at current prices, the real changes shown are based on constant price estimates.

1 Represents total of Budget and HEF Act funding.

2 GIRD grants plus estimated effect of revenue foregone via the IR&D tax concession scheme

3 Australian Biological Resources Study, Greenhouse research grants, Energy R&D and Australian Road Research Board.

4 Includes funding through DPIE for Australian Animal Health Laboratories and through DITAC for the Kraft Pulp Mill study.

For more detailed information see Tables 1 to 5

INTRODUCTION

The *Science and Technology Budget Statement-was* first produced as a Budget Related paper in 1989, following the major policy statement, *Science and Technology for Australia* issued in that year. That policy statement clearly underlined the Government's understanding of the importance of science and technology to the economic and social well-being of the nation. *Developing Australian Ideas*, released with this *Science and Technology Budget Statement*, confirms the Government's continuing commitment to supporting scientific endeavours across a broad range of activities, a commitment which underlies the continuing development of policy for a strong science and technology capability in Australia.

This *Statement* covers only part of the science and technology system, concentrating mainly on Budget issues relating to research conducted in the major Commonwealth agencies and through major Commonwealth programs. Nevertheless, Government policy on science and technology recognises the critical and interdependent role of all elements in the science and technology system, including the private sector, in meeting national objectives. These include fostering the cultural role of science and technology, while placing greater emphasis on their role in addressing the economic and environmental problems facing the country.

SECTION 1:

RECENT MAJOR DEVELOPMENTS

Developing Australian Ideas - the Government Policy Statement on Science and Technology

Developing Australian Ideas, the Government policy statement on science and technology, is incorporated as part one of the *Science and Technology Statement 1992-93*. The origins of the policy statement can be traced back to the report *Setting Directions for Australian Research* (August 1990) by the Australian Science and Technology Council (ASTEC). Following the report, ASTEC was asked to initiate a process which would culminate in a Government policy statement. The Council subsequently undertook extensive consultations, received almost 200 submissions and conducted an interview program with over 150 top-level managers in industry and government. This process led to ASTEC's "issues and options" report *Research and Technology: Future Directions.*

Consideration of the latter report, together with the report on the commercialisation of research, *Bringing the Market to Bear on Research* (see below) and the ASTEC report *Major National Research Facilities*, led the Coordination Committee on Science and Technology to identify four major factors which relate to the effectiveness of our national science and technology endeavour. Subsequently endorsed by the Prime Minister's Science Council, these are innovation, awareness, skills and infrastructure. Together with the Government's approach to setting directions for the science and technology system, they formed the principal themes for *Developing Australian Ideas.*

Prime Minister's Science Council

Two meetings of the Prime Minister's Science Council were held during the year. Reports presented to the Council included:

- *Development of a Pharmaceutical Industry in Australia*, which encouraged an improved partnership between researchers in the medical research facilities and industry whether indigenous or transnational.
- *Information Technology and Telecommunications*, which stressed the essential importance of these sectors in modern economies for increasing productivity across a range of other industries.

- *Manufacturing Technology*, pointing to the need, if Australian manufacturing is to become internationally competitive, for a well coordinated national research and development, and education and training infrastructure which is more closely driven by industry requirements.
- *Scientific Aspects of Major Environmental Issues*, on biodiversity and climate change, which were presented by Australian scientific experts in this field.
- The Council also heard a presentation on community attitudes to science and technology.

Australian Science and Technology Council (ASTEC)

In 1991-92, the Australian Science and Technology Council met on seven occasions. Professor Ray Martin retired as Chairman of ASTEC in April 1992 and was succeeded by Professor Michael Birt.

A major achievement for ASTEC during the year was the completion of the report *Research and Technology: Future Directions* (referred to above). This report proved to be a broad-ranging and complex task. ASTEC 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 departments and agencies and State government science and technology advisory bodies. Throughout the study, ASTEC maintained close contact with senior managers in the industry, government and higher education sectors, which enabled ASTEC 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.

As well as making a significant input to the Government policy statement, *Developing Australian Ideas*, issues identified in *Research and Technology: Future Directions* provided direction for a number of studies. These included an examination of the need for major research facilities over the next decade, resulting in the report *Major National Research Facilities*. Other current studies cover tropical research and technology; energy; and social sciences, the humanities, science and technology in economic development.

Review of ASTEC

ASTEC is undergoing a review to assist in improving its performance as the principal source of independent advice to Government on matters relating to science and technology. A review committee of six has been appointed and is chaired by Sir Rupert Myers, President, Australian Academy of Technological Sciences and Engineering. It is anticipated that the committee will report in October 1992.

Coordination Committee on Science and Technology

Four meetings of the Coordination Committee were held during the past year. A major undertaking by the Coordination Committee was the preparation of a report on *Costing and Pricing of Public Sector Research.* Sub-committees of the Coordination Committee also examined issues relating to international science and technology, resource and environmental databases and the formulation of a Commonwealth response to the recommendations relating to Ecologically Sustainable Development (ESD) Research, Development and Demonstration contained in the reports of the ESD working groups.

Commercialisation of Research Results

The Block Report on the commercialisation of research in Australia *(Bringing the Market to Bear on Research)* was presented to the Government in November 1991. The main conclusion was that commercial returns from research are most effectively generated by research undertaken in response to market demand. The Report identified a number of significant factors that hinder the influence of market forces or commercialisation, including those arising from the structure and characteristics of Australian industry, capital availability, and those arising in the public research bodies or in the interactions between the research sector and industry.

The report *Innovation in Australia was* prepared for the IR&D Board by Pappas, Carter, Evans and Koop, and the Boston Consulting Group on the basis of the earlier Board commissioned research published as *Industrial Research in Australia. Innovation in Australia* concluded that projects were succeeding in developing excellent technologies, but were largely failing during the commercialisation process. The principal reasons were a lack of experience and understanding of the complexities of commercialisation and a lack of companies with a strong competitive position. The report pointed to a lack of awareness among decision makers of what innovation involves.

Australian Technology Group

The establishment of the Australian Technology Group (ATG) was announced in the Prime Minister's *One Nation* statement of February 1992. The Government's action followed a recommendation of the Block Report (see above). This decision, based on the need to translate the research results and breakthroughs of publicly funded research into commercial reality, requires an effective linking mechanism. Thus the ATG will:

- have a government equity contribution of $30 million,
- act as a small, commercially focused company,
- identify and invest in research with commercial potential, particularly but not limited to research from the public sector, and

- market research output.

Pooled Development Funds (PDFs)

Announced in the *One Nation* statement, the Pooled Development Funds (PDFs) program came into operation on 30 June 1992. The PDFs will be concessionally taxed investment companies which will provide patient equity capital ior small and medium sized firms. These firms often have difficulty in obtaining suitable equity capital, especially those that are technology based, or in the early stages of potentially rapid growth. Investors in PDFs can elect to receive their dividends free of tax. Any gains on the sale of shares in PDFs are tax exempt.

Advanced Engineering Centres

The Advanced Engineering Centres Program is part of a wider agenda aimed at enhancing the quality of engineering skills, and research and development in the evolution of internationally competitive industries in Australia. The role of the Centres is to promote collaboration between higher education and industry in improving the quantity, quality and relevance of advanced engineering education and to increase industry's capacity to apply and commercialise technology. They differ from Cooperative Research Centres by their focus on teaching and on short-term research and consultancy projects, as distinct from the long-term research focus of the Cooperative Research Centres.

Three new Advanced Engineering Centres are being established within universities. These Centres are:

- the Advanced Engineering Centre for Innovation in Sydney
- the Advanced Engineering Centre for Manufacturing in Melbourne, and
- the Advanced Engineering Centre for Information Technology and Communications in Adelaide.

These three Centres will receive establishment funding of $6.3 million and annual recurrent funds of $1.5 million.

Expansion of Science and Technology Awareness Program

Resources for the Science and Technology Awareness Program have been more than doubled to $1.7 million in the 1992-93 Budget. The expanded Program will emphasise activities targetted to young people and their teachers; to groups, such as women, who are under-represented in science and engineering; and the business community. Information programs that address community concerns will also receive increased attention. The program will continue to promote community awareness of the importance of science and technology to national economic and social well-being.

The Cooperative Research Centres Program

The Cooperative Research Centres Program, launched in May 1990, completed its second selection round in December 1991 when twenty Centres were announced (see Section 2 for further details).

Other Initiatives in Support of Science and Technology

Other measures taken to increase support for science and technology and related initiatives included:

- in industry, science and technology

- to protect and maintain the national research infrastructure ,$15 million is being provided to the science agencies (CSIRO, ANSTO and AIMS) in each of 1992-93 and 1993-94 to complete a three-year building upgrade program, supplementing the $22 million provided to initiate the program in 1991-92
- an Australian Space Council will oversee the development of a five year strategic plan for the National Space Program, which will give priority to a greater involvement by Australia in international Earth observation programs from space
- $40 million was allocated to the Multifunction Polls from the Building Better Cities Program
- annual funding of $0.75 million for two years will assist groups of Australian firms to gain access to industrial technology development programs such as the France-Australia Industrial Research Program and to develop strategic links with firms in Asia, Europe and North America
- the R&D tax concession scheme was extended so that it would not prevent the claiming of the concession by companies involved in R&D through the Cooperative Research Centres Program
- guidelines for the registration of syndicates under the provisions of the R&D tax concession scheme will be revised to ensure that syndicates involving tax-exempt research bodies can be registered only where investors' funds are fully at risk
- approval has been given for the staged establishment of a research facility for the Australian Institute of Marine Science (AIMS) in north-west Western Australia, which is set to become a major centre for marine-based industries

- in education and research training

- an additional 200 Australian Postgraduate Research Awards, including 25 Australian Postgraduate Research Awards (industry), to be awarded annually, commencing in 1993

- in environment

- a Commonwealth Environment Protection Agency was established
- the National Rainforest Conservation Program was completed, having supported over 70 ecological surveys and studies

- the Continental Forest Overview, the first comprehensive overview of Australia's forests, was completed
- an International Tropical Marine Resource Centre, located in Townsville, was established to serve the world community by providing quality tropical marine research, education and management expertise in support of ecologically sustainable development
- the Environmental Resources Information Network was implemented through the provision of $2.4 million to the Australian National Parks and Wildlife Service
- a Genetic Manipulation Authority will be established, to assess and approve proposals for the planned release of genetically modified organisms
- funding of almost $6 million over three years will be provided to extend research into climate change

- in defence

- DSTO's Aeronautical Research Laboratory (ARL) in Melbourne will establish an industry support office, on a one-year trial basis, to provide access to ARL s research services and promote the transfer of defence technologies to Australian industry through licensing and other commercial arrangements
- scientific support was given to Australian initiatives on international disarmament

- in primary industry

- an Australian Starter Culture Research Centre and a Dairy Industry Quality Centre were established for support of the dairy industry

- in health

- a CSL Centre has been designated as a World Health Organisation Influenza Reference Centre

- in science and technology awareness

- an evaluation has been conducted by Woolcott Research, of the attitudes of Australians to science and technology
- a second Australia Prize was awarded in January 1992
- a second edition of *Register of Science and Technology Communicators* has been published

Significant Statements, Reviews and Reports

Significant statements and publications include :

- Department of Prime Minister and Cabinet:
  - *Statement on the Economy and Unemployment, by the Prime Minister, the Hon. R. J. L. Hawke, M.P., November 1991*

  - *One Nation, statement by the Prime Minister, the Hon. P. J. Keating, M.P., February 1992*
  - *Ecologically Sustainable Development Working Groups, Final Reports: Agriculture; Energy Use; Energy Production; Fisheries; Forest Use; Manufacturing; Mining; Tourism; Transport, November 1991*
  - *Ecologically Sustainable Development Working Group Chairs, Intersectoral Issues Report, January 1992*
  - *Ecologically Sustainable Development Working Group Chairs, Greenhouse Report, February 1992*
  - *National Greenhouse Steering Committee, Draft National Greenhouse Response Strategy: A Discussion Paper, 1992*
  - *Draft National Strategy for Ecologically Sustainable Development, Discussion Paper, June 1992*
- Minister for Science and Technology:
  - *Science and Technology Budget Statement 1991-92, Budget Related Paper No. 6*
- Reports presented to the Prime Minister's Science Council:
  - *Development of a Pharmaceutical Industry in Australia - the Challenge of Partnership, December 1991*
  - *Information Technology and Telecommunications Looking to the Year 2000, May 1992*
  - *The Changing Role of Manufacturing Technology, May 1992*
  - *Scientific Aspects of Major Environmental Issues: Biodiversity, May 1992*
- Coordination Committee on Science and Technology reports:
  - *Costing and Pricing of Public Sector Research, January 1992*
- ASTEC reports:
  - *Research and Technology: Future Directions*
  - *Research and Technology: Future Directions, Summary Report*
  - *Environmental Research in Australia: Case Studies*
  - *Major National Research Facilities: A National Program*
- ASTEC Occasional Papers:
  - *Seminar Proceedings October 1990, Setting Directions for Australian Research*
  - *Science, Technology and Australian Federalism: Getting the best from the system*
  - *Major National Research Facilities: Expressions of Interest*
  - *Research Data in Australia: Proceedings of a Workshop held on 14 November 1991*
- Department of Industry, Technology and Commerce
  - *Bringing the Market to Bear on Research, Report of the Task Force on the Commercialisation of Research, November 1991*

- *Australian Science and Innovation Resources Brief 1992, Measures of Science and Innovation 3, A Report in a Series on Australia's Research and Technology and their Utilisation*
- *Titanium - From Mining to Biomaterials, December 1991*
- *Lasers in the Service of Australian Industry, May 1992*
- *Artificial Neural Networks in Australia, May 1992*
- *Marine Industries Consultancy - Satellite Ocean Sensing, December 1991, Draft Report*
- *The Australian High Speed Vessel Shipbuilding Industry - Report to the Marine Industry Section, December 1991, Draft Report*
- *Marine Technologies Industry Study - Final report, April 1992*
- *Innovation in Australia, July 1991 - Report for the Industry, Research and Development Board*
- *Economic Evaluation of CSIRO Industrial Research (BIE)*
- *An Evaluation of the Attitudes of Australians to Science and Technology, conducted/or the Science and Technology Awareness Program, by Woolcott Research Pty Limited, August 1991*
- *Register of Science and Technology Communicators, Second Edition, 1992*

- Department of Industry, Technology and Commerce and Australian Trade Commission
  - *Environment Industries*
- Department of Employment, Education and Training:
  - *Higher Education: Quality and Diversity in the 1990s, a policy statement by the Hon. Peter Baldwin, M.P., Minister for Higher Education and Employment Services*
  - *Report of the Panel Appointed to Review the Special Research Centres Programs and the Key Centres of Teaching and Research Program*
  - *Australian Research Council Awards 1991: Grants and Fellowships awarded in 1991*
  - *Quality of Higher Education: discussion papers*
  - *Science and Technology Issues in Management Education: a report to the National Board of Employment, Education and Training and the Department of Industry, Technology and Commerce*
- Department of the Arts, Sport, the Environment and Territories
  - *Environmental Regionalisation - Establishing a Systematic Basis for National and Regional Conservation Assessment and Planning: Proceedings of an Australian Workshop, Canberra, May 1992*
  - *A National Climate and Global Change Program for Australia (a prospectus). May 1992*

SECTION 2:

BUDGET ALLOCATIONS AND PORTFOLIO ACHIEVEMENTS

Introduction

This Section presents selected information on science and technology arranged by ministerial portfolio. For each portfolio, there is a brief summary of pertinent allocations for the 1992-93 Budget compared with the expenditure outcome for 1991-92. The financial summary for the portfolio is followed by an account of recent research outcomes arranged by program or agency.

The focus of this Section is on major programs and agencies, particularly those engaged in R&D. On financial aspects, the bias is towards brevity of discussion. For additional information, it may be useful to refer to Statement Number 3 of Budget Paper Number 1, which provides a discussion of financial trends for those scientific programs classified to the Budget function *general and scientific research n.e.c.*

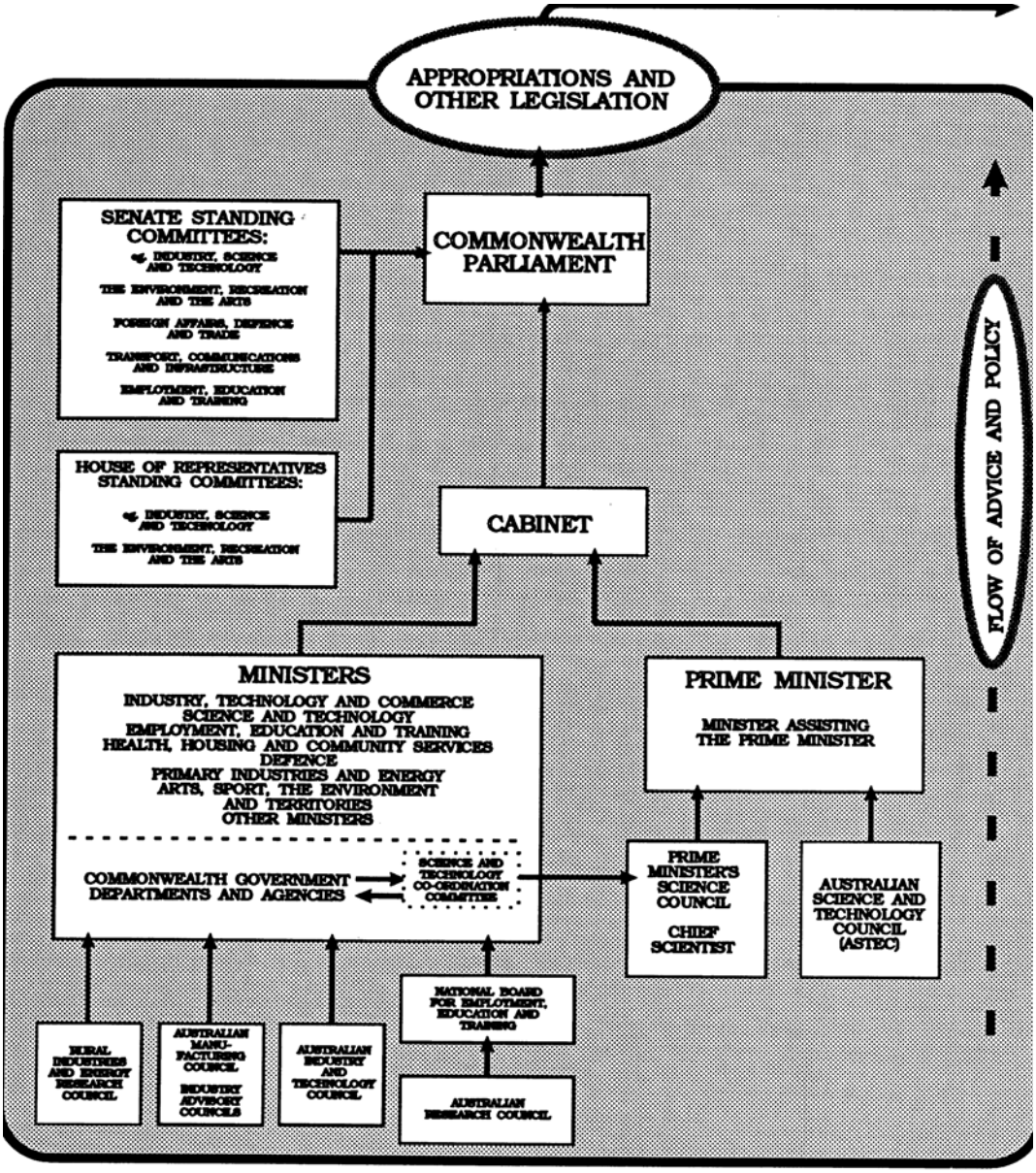
The intention has been to complement the financial discussion with an account of selected outcomes (recent achievements) for the major research agencies and programs. While necessarily selective, these are intended to be illustrative of the discoveries, advances in understanding or technique, or steps in commercialisation which are the end results of the financial support received.

It should be noted that no attempt has been made to present a grand total for 'science and technology' outlays across portfolios. There are a number of difficulties involved in developing such a figure. Not least, judgements have had to be made as to whether particular programs were to be regarded as science and technology for the purposes of this *Statement*. Based on the better-defined area of research and development (R&D), however, data series have been developed in Section 3 and used to present indicative trends for an aggregate described as 'Major Commonwealth Support for Science and Innovation'.

The workings of advisory and funding mechanisms are of interest to many. Figures 1 and 2 are provided as a working guide to the operation of the infrastructure now in place for Commonwealth support of science and technology.

Figure 1

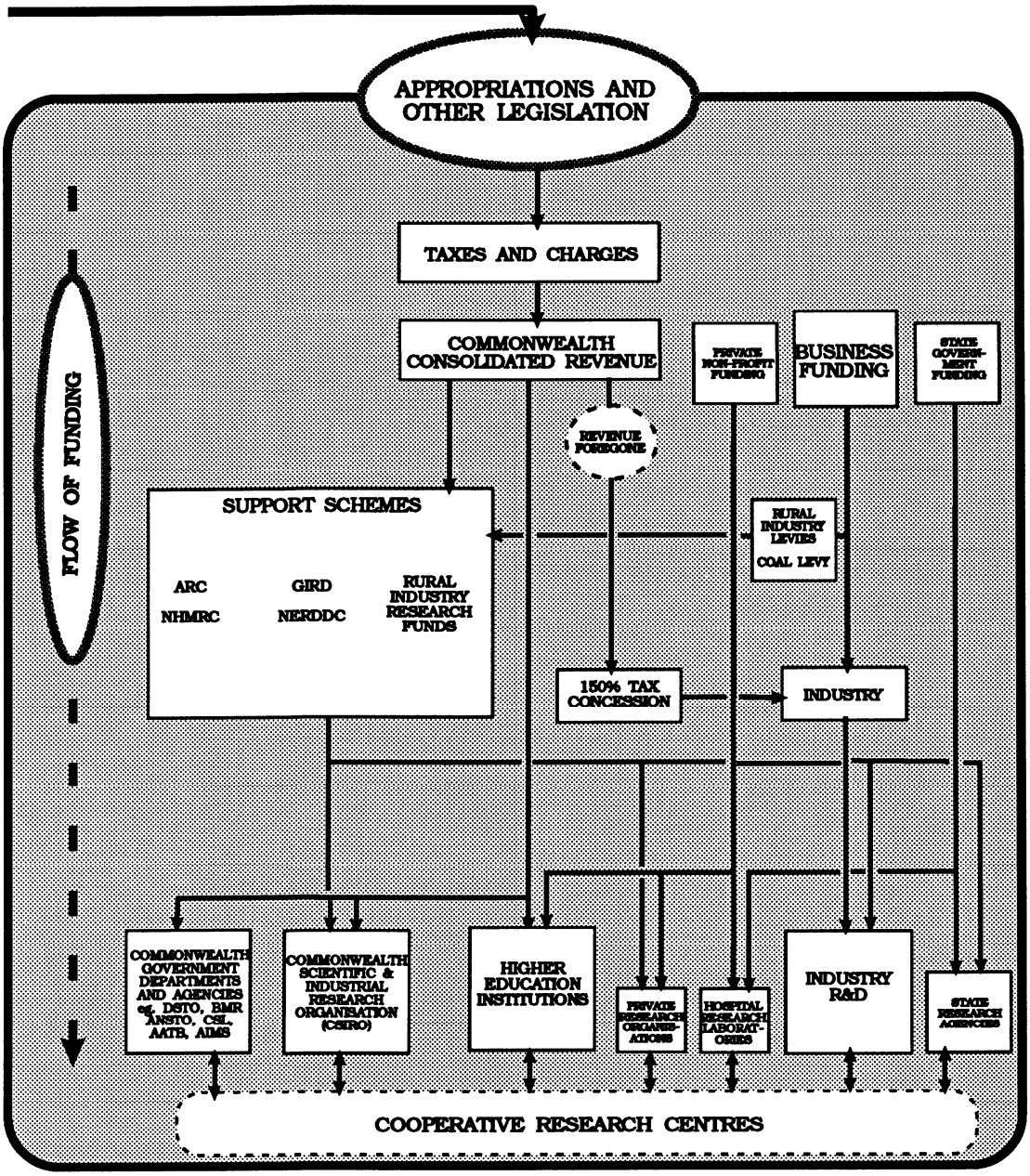
MAIN CHANNELS OF ADVICE
FOR POLICY FORMULATION IN SCIENCE AND TECHNOLOGY



The figure is indicative of major bodies and principal channels for the flow of policy advice leading to Parliamentary and Cabinet decisions on science and technology issues. It does not purport to be other than illustrative. Of course, there are a host of influential forces, including professional organisations and other non-government groups, and there are many cross-links and productive interactions between them.

Figure 2

FLOW OF FUNDING SUPPORT FOR R&D



The figure illustrates the main channels of funding to R&D performers. Funds originate primarily with the taxpayer and private business. The Commonwealth Government Is the major funding source. For simplicity, minor funding flows are omitted.

ADMINISTRATIVE SERVICES

Science and Technology in the Portfolio Budget

The Administrative Services portfolio provides scientific services though four bodies.

The Australian Government Analytical Laboratories operate through the Department of Administrative Services (DAS) Trust Account on a fee for service basis. The Laboratories' projected 1992-93 turnover is $21.0 million, of which $5.5 million is provided through appropriation for public interest activities.

The Ionospheric Prediction Service is budget-funded at $3.4 million in 1992-93.

The Scientific Services Laboratory is part of DAS Project Services, which operates through the DAS Trust Account on a fee for service basis. Its projected income for 1992-93 is $3.5 million.

The DAS Centre for Environmental Management is a separate business unit, also operating through the DAS Trust Account on a fee for service basis. It is funded at $0.3 million in 1992-93 by the DAS Trust Account.

MAJOR RESEARCH ACTIVITIES

Australian Government Analytical Laboratories (AGAL)

Role

To develop analytical methods of suitable precision, accuracy and efficiency to meet demands from the Australian Government for emergency testing services involving the health or safety of the community or threatening Australia's export market for agricultural produce.

Recent Achievements

Superficial fluid extraction

Superficial fluid extraction (SFE) has been shown to be an effective and environmentally friendly alternative to traditional solvent extraction in the analysis of pesticide residues in rice. A batch of 300 rice samples

was tested for low levels of organophosphate pesticides. Organic solvent consumption was 95% less than in the traditional method. The study was one of the first to use SFE on a large scale in residue analysis.

Capillary zone electrophoresis

The application of capillary zone electrophoresis (CZE) in chemical analysis is under investigation. To date the method has been successfully applied to the separation and detection of fourteen sulphonamide residues occurring in meat products. CZE is another environmentally friendly technique in that it uses minimal amounts of reagents compared with other chromatographic procedures.

Ionospheric Prediction Service (IPS)

Role

To provide timely and reliable radio propagation and space environment advice to the Australian community.

Recent Achievements

Modelling ionospheric layers

There is a transient layer of intense ionisation (the "sporadic E" layer), observed in the lower ionosphere, that can have significant impact on high frequency communications systems. Joint work between the IPS and USA researchers has correlated ionospheric observations made from Townsville with atmospheric tides and developed an ionospheric propagation model which can predict the behaviour of sporadic E. Testing of the model has shown it to be reliable.

Solar forecasting

The long lifetimes of large scale features on the sun have only recently been recognised. Joint USA-IPS work, developing a solar data set, has highlighted these features and the analysis should lead to improved medium term solar forecasts.

Scientific Services Laboratory (SSL)

Role

To provide the Department of Administrative Services with a research and investigation capability in relation to its technical advice, design and construction operations and to provide a commercial scientific service to external clients in the construction and related industries.

Recent Achievements

Fire protection

Research and development of new test specifications for fire protection products, where no Australian or overseas test standards were available, has been completed. As a result, several high technology products are now being accepted in Australia and overseas, facilitating valuable Australian exports. SSL's research and advice to the regulatory and installation arms of the construction industry, on smoke alarms for domestic and residential premises, has been a major factor in the growing use of these life safety devices in the community.

Surface coatings

Following the investigation of blistering problems with the lining of aviation fuel tanks, SSL identified the causes and has suggested precautions and design changes.

SSL has also evaluated low molecular weight silicone water repellents used on cement based building surfaces to inhibit ingress of water. A range of test procedures has been developed to aid in their identification and quality assurance.

Other achievements

Other achievements include:

- To provide an alternative to expensive imported products, SSL has produced a powder mixture for absorbing mercury spills which is considerably cheaper and as effective as imported equivalents.
- SSL has developed methods for investigating the effects of magnetic fields associated with 50Hz power distribution in buildings, and identified limits for equipment interference.
- In response to the proliferation of the variety of metal claddings and the range of product failures, SSL has developed a product specification which caters for a range much broader than the current Australian Standard (AS2728).

DAS Centre for Environmental Management (DASCEM)

Role

To focus and coordinate the delivery of the environmental services of the Department of Administrative Services, especially by providing solutions to problems of contaminated land, the indoor environment and waste management.

DASCEM is a new business within the Department which commenced in July 1991. It is developing programs on standardised sampling and analysis for contaminated sites, biological remedy of land contamination and the management of halons. It is also examining how food wastes brought into the country by airlines and similar means, can be managed in an environmentally safe way.

ARTS, SPORT, THE ENVIRONMENT AND TERRITORIES

Science and Technology in the Portfolio Budget

There are a number of agencies and programs within the Portfolio that undertake scientific activities.

The Australian Antarctic Division has been given a total budget allocation of $65 million in 1992-93 ($68 million in 1991-92). The Division's activities include the undertaking of and support for scientific research in the Australian Antarctic Territory, the Southern Ocean and sub-Antarctic islands. The Division's research priorities in 1992-93 will include programs contributing to the study of global climatic change and monitoring of Antarctic ecosystems. The overall science program supported by the Division in 1992-93 will involve marine science, including biology, oceanography, sea floor sedimentology and sea ice studies, on board the Australian Research and Supply Vessel RSV *Aurora Australis,* in the Prydz Bay region and in the Southern Ocean. Other research will include a glaciological traverse south from Mawson station, continuation of the ice core drilling inland of Casey station and biological studies at all stations and Heard Island.

The Commonwealth Bureau of Meteorology has been given a total budget allocation of $112 million in 1992-93 ($110 million in 1991-92). The Bureau's activities include meteorological research. The Bureau's research priorities to be pursued in 1992-93 include particular emphasis on climate research including greenhouse studies, numerical weather prediction modelling, tropical meteorology, air pollution monitoring, remote sensing and marine meteorology.

There are a number of other portfolio agencies that engage in research. The Great Barrier Reef Marine Park Authority (GBRMPA) has been given a total budget allocation of $ 11.0 million in 1992-93 ($14.1 million in 1991-92). The Office of the Supervising Scientist has a total budget

allocation of $7.0 million in 1992-93 ($7.4 million in 1991-92). The budget allocation for the Australian National Parks and Wildlife Service (ANPWS) is $55.1 million in 1992-93 ($49.9 million in 1991-92).

The central office of the Department coordinates research into the greenhouse effect. The Government has allocated $5.8 million to this activity in 1992-93 ($5.9 million in 1991-92). $0.6 million of this amount in each year is included in the Bureau of Meteorology's budget allocations identified above. The priorities for the greenhouse research program are the development of the capacity for regional predictions of climate change, climate modelling, monitoring of sea level rise and the assessment of potential regional impacts.

The scientific results of research supported by this program, and closely related work, have given authority to Australia's participation in international discussions leading to signing of the UN Convention on Climate Change. The Convention calls for Parties to contribute, according to their circumstances, to reduction of remaining uncertainties about climate change and to exchange of relevant scientific and other information. Australian research now stands to make a unique contribution to the better understanding of climate change in the southern hemisphere.

Within the Environment Program, the central office of the Department is responsible for environmental information gathering and the contracting of minor research tasks for the preparation of World Heritage nominations. In 1992-93, research will continue into the possible World Heritage values of the Nullarbor Plain and the Scenic Rim area of Southern Queensland. The central office is also responsible for initiating, in conjunction with ANPWS, GBRMPA, the States and the Territories, and as part of the Ocean Rescue 2000 Program, surveys of marine and estuarine habitats in order to select areas for inclusion in a national representative system of marine protected areas.

The Australian Film Commission and the Australian Sports Commission have some involvement in research activities. The Australian Film Commission has provided assistance for research and development of a series of advanced technologies which promise significant benefits for both cinema and scientific applications. The Australian Sports Commission has various research projects to identify methods to assist in improving the performance of elite athletes in several sports.

The National Science and Technology Centre, which has been allocated $2.9 million in 1992-93 ($4.6 million in 1991-92), has a role in promoting confidence, understanding and a positive attitude to science and technology.

MAJOR RESEARCH ACTIVITIES

Australian Antarctic Division

Role

To contribute to knowledge of the global environment through research in the Antarctic region, provide scientific knowledge for the effective management of human impacts on the Antarctic environment, and increase Australia's influence in Antarctic matters by participating in international scientific programs and by contributing to international scientific forums.

The Antarctic Division conducts research in glaciology, terrestrial and marine biology, oceanography, upper atmosphere physics, cosmic ray physics and medicine. The Division is responsible for the coordination and support of Australian Antarctic scientific research programs, including provision of science support facilities for external agencies. It also administers research grants under the Antarctic Science Advisory Committee research grants scheme, which provides for research by scientists in universities and other non-government organisations.

Recent Achievements

Southern ocean environmental studies

In collaboration with the CSIRO Division of Oceanography, and in support of the international World Ocean Circulation Experiment (WOCE), the first detailed transect of the Southern Ocean from Tasmania to Antarctica was conducted last year. This was the first stage of a six year study. Advanced technology aboard the RSV *Aurora Australis* was successfully deployed to measure temperature, salinity, gas composition, nutrients and chlorofluorocarbons (CFCs) as indicators of the extent of heat and gas exchange between the ocean and the atmosphere. Initial results have provided invaluable information on the extent that the Southern Ocean influences the global climate by the absorption of greenhouse gases and the redistribution of heat between other major ocean basins.

Krill research

Further advances in the research on the abundance and distribution of krill, a vital link in the Antarctic food chain, were made by surveys in the Prydz Bay region by using advanced hydroacoustic survey techniques. These surveys, plus research on live krill in the Antarctic Division aquarium, revealed previously unknown factors in krill distribution and growth rates that will influence the determination of sustainable harvesting levels.

Ice core analysis

Further understanding of past climatic conditions, including atmospheric composition, was made possible by the extraction of ice cores to a depth of 552 metres by Antarctic Division scientists at Law Dome, inland from Casey Station, in the 1991-92 summer season. The cores provide data on climatic conditions for the past 800 years. Initial analysis of chemical and particulate composition has revealed previously undetected activities such as past volcanic eruptions.

Fish surveys

Important information on the viability of commercial fishing in the vicinity of Heard Island was obtained from the second stage of a three year research program on the distribution and abundance offish stocks and zooplankton conducted around Heard Island last year. Initial findings revealed the region would be unlikely to sustain large fishery operations, and may be valuable as an unexploited marine ecosystem in providing unique opportunities for studies in marine population dynamics.

Bureau of Meteorology

Role

To observe and understand Australian weather and climate and provide meteorological, hydrological, and oceanographic information, forecast, warning and advisory services in support of Australia's national needs and international obligations.

Most research within the Bureau is conducted by the Bureau of Meteorology Research Centre (BMRC) in the general areas of short and medium range prediction, climate, tropical meteorology, severe weather, satellite meteorology and greenhouse modelling.

Some research into atmospheric constituents (eg, carbon dioxide, methane, ozone) is also conducted using data from the Bureau’s Ozone Network and its Baseline Air Pollution Station at Cape Grim (Tasmania). Much of this research is undertaken in collaboration with the CSIRO Division of Atmospheric Research.

Recent Achievements

Remote sensing

BMRC's Satellite Group continued to develop a satellite cloud drift wind system. This will augment the data fed into the operational numerical models and help improve forcasts. Satellite measurements of ozone and cloud heights continued to be developed and improvements were made

in the determination of rainfall estimates from satellite data.

Greenhouse modelling

A major achievement has been the completion of a double carbon dioxide calculation with the BMRC global atmospheric model. This model predicts an increase in the equilibrium global surface temperature which compares well with other global models. Further work has been taking place on a coupled atmosphere ocean-ice model.

Baseline Air Pollution Studies

A fifteen year record compiled from measurements at the Cape Grim Baseline Air Pollution Station shows a steady ongoing rise in the atmospheric concentrations of the greenhouse gases, including carbon dioxide and methane. The data also show that the increase of chlorofluorocarbons (CFCs) is declining. Emission reduction targets of CFCs may be achieved about three years ahead of the schedule set by the Montreal Protocol.

Great Barrier Reef Marine Park Authority (GBRMPA)

Role

The GBRMPA is the principal advisor to the Commonwealth Government on the care and development of the Great Barrier Reef Marine Park. The Authority's research monitoring program aims to achieve competence and fairness in the care and development of the Marine Park through the conduct of research, and the deliberate acquisition, use and dissemination of relevant information from research and other sources.

The Authority's research program is focused on a number of issues of critical importance to the conservation and sustained use of the Marine Park. These include water quality, effects of fishing, the crown-of-thorns starfish and the Torres Strait Baseline Study.

Recent Developments

Land-based activities, especially agriculture and urban activities, are releasing chemicals, sewage and sediment that appear to be reducing water quality and affecting inshore corals in some areas. A multi-disciplinary program involving 40 projects has begun.

The effects of trawl and line fishing on the Marine Park environment are believed to be significant, but are poorly understood. An experimental research program involving the Marine Park Authority, CSIRO and the Queensland Department of Primary Industries, has commenced. It includes a major $2 million experiment to determine the environmental effects of prawn trawling.

The causes and effects of population outbreaks of the crown-of-thorns starfish on the Great Barrier Reef have been a controversial issue for more than 30 years. A research program to monitor starfish numbers, measure impacts on reefs, determine the life cycle of the starfish and determine possible causes of the outbreaks is underway. It involves 27 projects.

The Torres Strait Baseline Study is a four year program established to address concerns of Torres Strait Islanders, commercial fishermen and scientists, about the possible effects of mining operations in the Fly River catchment area of Papua New Guinea on the marine environment of the Torres Strait. The program will determine levels of contamination and possible sources,and define baseline conditions against which to assess the results of future monitoring.

Recent Achievements

Crown-of-thorns starfish

The recommendations of an independent scientific review of the program have been implemented. This involves the development of a contingency research program that can respond to new outbreaks of starfish.

Torres Strait Baseline Study

A pilot sample collection study has been completed and preliminary findings published. This will be the basis for the major sample collection program to be undertaken in 1992-93.

Office of the Supervising Scientist - Alligator Rivers Region Research Institute (ARRRI)

Role

To provide a scientific basis for developing standards and measures for the protection and restoration of the environment and for assessing the actual and potential short and long term effects of mining operations in the Alligator Rivers Region of the Northern Territory.

Recent Achievements

Toxicity testing of waste waters

The operation of many industries, including mining, requires the discharge of waste waters into surface streams and rivers. Conventionally, such discharges are controlled by the use of chemical water quality standards to protect aquatic ecosystems. The ARRRI has,

however, recommended the use of a biological control regime and has developed a number of biological toxicity tests which can be used to test the whole effluent prior to release. The tests use local species from different trophic levels and phyla and examine sensitive endpoints such as reproduction and hatchability as well as survival. Four of these tests have now been registered by the National Association of Testing Authorities; the ARRRI is the first laboratory in Australia to be registered for biological toxicity testing.

Modelling of the atmospheric dispersion of radon

Radioactive gas radon is released from uranium mines at levels substantially above normal background rates and can lead to enhanced radiation exposure to the public. The ARRRI has developed new methods for estimating this radiation exposure. However, these measurement techniques alone are not adequate because it is necessary to estimate future radiation exposure arising from different proposed mine management schemes. To achieve this latter capability, the Institute has, in collaboration with Australian Nuclear Science and Technology Organisation, developed and validated a site-specific atmospheric dispersion model for radon and has used it to make estimates of exposure at sites where measurement has not been possible.

Identification of the origin of radium in groundwater

Records of increasing concentrations of sulphate in bores near the Ranger tailings dam have enabled the identification of the movement of a seepage plume from the dam. There has, however, been an associated increase in the concentration of radium, a radioactive product of uranium. If this increase has been due to movement of radium from the dam, the observations would imply that absorption of radium in rocks and soils surrounding the dam is much less significant than expected. A study carried out by the ARRRI, which examined the relative concentrations of a number of radium isotopes, has shown that the observed increases in radium concentrations has not been caused by direct dispersion of radium from the dam. Rather, it has arisen as a result of indirect soil-solute interactions during the passage of major ions in the seepage plume.

Australian National Parks and Wildlife Service (ANPWS)

Role

The ANPWS sponsors scientific research, survey and monitoring as part of its role of enhancing the protection, conservation and management of the Australian natural environment and native Australian flora and fauna.

The ANPWS is the principal nature conservation agency of the Commonwealth Government.

Recent Achievements

Australian Biological Resources Study (ABRS)

The ABRS documents the plants and animals which occur in Australia and where they occur. It promotes the description and classification, and the recording of distribution of Australia's biodiversity both as a natural heritage and as a fundamental database for resources and conservation management. This is achieved through a participatory program which provides grants for research and through a publications program which produces high quality reference works. During 1991-92:

- *Rainforest Animals Atlas of Vertebrates endemic to Australia's Wet Tropics* was published in the *Kowari* series, and
- two volumes, *Non-Marine Mollusca* and *Coleoptera-Scarabaeoidea* were published in the *Zoological Catalogue of Australia* series.

Endangered Species Program (ESP)

The ESP aims to prevent the extinction of native species, to prevent further species from becoming endangered, and to return endangered species to a secure status in the wild. It does this by funding research and management projects aimed at species recovery and threat abatement, and by increasing public education and awareness of endangered species issues. Achievements during 1991-92 included the following:

- Fox control in selected reserves in WA has resulted in a dramatic recovery in numbers of threatened native mammals, including the endangered numbat and brush-tailed bettong, and the vulnerable black-footed rock-wallaby. ESP is funding several aspects of this fox control program in WA, including research into optimum baiting regimes and fox ecology and social behaviour that will ensure future effective fox control.
- Using newly developed cryogenic techniques, germplasm of an endangered native plant has been successfully stored and revived for the first time at Kings Park and Botanic Garden in Perth. This breakthrough is of international significance in the preservation of threatened species.
- Eleven captive-bred orange-bellied parrots were released at Melaleuca in south-west Tasmania as part of a continuing recovery program for an endangered species that also uses coastal habitats in South Australia and Victoria.

New publications included:

- Leigh J H and Briggs J D (eds.) (1992). *Threatened Australian Plants: Overview and Case Studies*,
- Garnett S (1992). *The Action Plan for Australian Birds*, and

- Humphries S E, Groves RH & Michell D S (1992). 'Plant Invasions of Australian Ecosystems: a Status Review and Management Directions'. *Kowarl* 2: 1-134.

Environmental Resources Information Network (ERIN)

In 1991-92, ERIN has made significant advances in implementing a wide area network of graphical environmental information systems. Users within the Australian Heritage Commission, the Australian National Botanic Gardens, the ANPWS and DASET now have facilities to access spatial and tabular environmental information through a graphical user interface.

A database containing over 60,000 biological records has been developed through collaborative arrangements with Australian herbaria, museums and research institutions. Techniques have been developed to validate these specimen data. Satellite imagery at 1 km resolution over the entire continent is now available on the ERIN Network for every month since April 1991.

States Cooperative Assistance Program (SCAP)

SCAP involves the Service in cooperative nature conservation projects of national and international significance related to wildlife, and to national parks and reserves in the States and Territories. In 1991 -92, the ANPWS provided funds to State and Territory agencies for 40 projects.

Funding provided under the SCAP has assisted the Western Australian Department of Conservation and Land Management (CALM) and Curtin University of Technology in preparing DNA profiles of parrots. As a result of this genetic fingerprinting work, CALM has successfully prosecuted a number of aviculturalists for illegal possession of cockatoos, by proving that young birds claimed to have been captive-bred were not the progeny of the alleged parent birds.

National Rainforest Conservation Program

Role

To ensure that the special values of Australia's rainforest are identified, protected and conserved for future generations by supplementing activities undertaken by State and Territory governments.

In June 1986, the Commonwealth Government allocated $22.3 million for a National Rainforest Conservation Program, to be planned and carried out in cooperation with the States. The Program concluded at the end of the 1991-92 financial year, after funding 245 projects.

Recent Achievements

Ecological surveys and studies

Some 75 ecological surveys and studies of rainforests have been carried out in the participating States and Territories (NSW, TAS, QLD, NT and WA), with the majority having been completed. Some studies are long-term monitoring projects. The information obtained increases the knowledge and understanding of the country's rainforest ecosystems, and will be valuable in formulating management plans for conservation of rainforest areas throughout Australia.

National Forest Inventory (NFI)

Role

To provide factual information on Australia's forests to assist Governments in making policy and management decisions on the conservation and utilisation of Australia's forested lands.

The NFI is a cooperative project between the Commonwealth and all State and Territory governments. At the Commonwealth level, the NFI is the joint responsibility of the Department of the Arts, Sport, the Environment and Territories, and the Department of Primary Industries and Energy.

When established in 1988, the NFI was allocated $2.9 million by the Commonwealth Government for an initial 3 year set-up phase. In December 1991, a further $1.0 million was allocated.

Recent Achievements

First release of Continental Forest Overview

The NFI released its Continental Forest Overview during 1991. This is the first comprehensive overview of Australia's forest cover and involved standardisation of forest information across all states and territories. Forests cover about 40 million hectares of land or 5 per cent of the continent.

The overview provides a basis for strategic planning by forest land management agencies, government and industry. It is also a framework for designing and interpreting the more detailed regional inventories being developed.

DEFENCE

Science and Technology in the Portfolio Budget

The Budget allocation for the Defence Science and Technology Organisation (DSTO) will be $209.9 million in 1992-93 ($218.3 million actual outcome in 1991-92). The Defence Industry Development Program is to receive $12.5 million in 1992-93 ($9.8 million in 1991-92).

MAJOR RESEARCH ACTIVITIES

Defence Science and Technology Organisation

Role

To enhance the security of Australia through the application of science and technology.

Recent Achievements

Structural integrity of naval platforms

Significant benefits can be derived from the ability to enhance and predict the life characteristics of naval hulls and superstructures. Achievements in 1991-92 were as follows:

- support was provided to the Navy and contractors concerning the construction of the hull for the Collins Class submarine; DSTO used its expertise in welding and fracture control technology to achieve a considerable advance in materials with expected savings to the Navy of at least $200 million,
- a hydrodynamic load trial was conducted on HMAS Swan to provide improved predictions of the structural integrity and fatigue life of RAN ships, and
- large carbon fibre patches were used to reinforce the critical areas experiencing fatigue cracking on the FFG-7 superstructure; this was developed further and will be the subject of sea trials in 1992-93.

Reducing susceptibility to detection

The vulnerability of ships and submarines can be substantially reduced by lowering their susceptibility to detection by radar or sonar. Some particular achievements in this area included the following:

- The development of materials specifications and experimental techniques for the production of anechoic tiles, for fitting to submarine hulls, was successfully completed and their application demonstrated through pilot production studies with local industry.
- Expertise in radar absorbing materials and paints was further developed and construction of a small radar materials testing range was completed.

Environmental science

DSTO undertook research programs which were of direct benefit to the environment and the continued health and safety of Navy personnel. These included:

- monitoring air quality standards in submarines and investigating the means to maintain air purity at an acceptable level,
- devising antifouling systems for use in submarine seawater systems, and
- identifying the causes of toxic gas generation in the oily water wastes that accumulate in bilges and recommending solutions to this hazard.

Protection for armoured vehicles

DSTO provided the Army with a range of information on lightweight armour for the protection of armoured vehicles. Achievements included:

- establishing protection ranges for the M113 armoured vehicle against a range of threat weapons,
- determining impact fracture characteristics of selected advanced ceramics, and
- investigating the cracking of welded high hardness armour steel; these last results will be applied to develop crack repair procedures.

Support to the Laser Airborne Depth Sounder

The Laser Airborne Depth Sounder (LADS), a concept originally developed by DSTO, has been designed to provide a cost-effective and rapid means of charting shallow coastal areas. The RAN aims to introduce an operational LADS system into service, and has let contracts to BHP Engineering Pty Ltd and Vision Systems Ltd. In 1991-92, DSTO continued to provide research and development support to the Navy project manager and LADS contractors. More than 40 air trials sorties, in a specially configured aircraft, were completed. LADS also received international recognition at the 14th International Hydrographic Conference in Monaco in May 1992.

Infrared sensors

Cadmium Mercury Telluride (CMT) sensors are a critical element in long wavelength infrared surveillance systems. DSTO continued to support CMTEK Pty Ltd, a joint venture with BHP and Innovation Management

Pty Ltd, In the development of real-time growth control of CMT sensor wafers. The growth control process is expected to provide a major increase in the quality of CMT wafers and have significant commercial potential with both defence and civilian applications. With improved methods being developed by CMTEK, these sensors will also be used in the mid-infrared wavelength bands.

Aircraft and helicopters

DSTO activities have continued to improve air safety and reduce the cost of ownership of aircraft and helicopters. Achievements included the following:

- A new dynamical method for detecting and isolating faults in gas turbine engines was trialled on two F/A-18 engines. The method has the potential to contribute to reduced through-life costs by the development of improved methods of assessing condition, increasing the certainty of engine diagnosis, enhancing availability and reducing maintenance costs.
- The F-111C automatic hydraulic test system was licensed to Rosebank Engineering for commercial exploitation and substantial transfer of technology was achieved.
- A contribution to problems of corrosion experienced by P-3C aircraft was made by the development of environmental sensors to determine the nature of the corrosive atmosphere in service. The sensors are to be mounted in P-3C aircraft and the results obtained should lead to a reduced cost of ownership of the aircraft.
- The joint venture company, Defence Technologies Australia, was formed to exploit a DSTO developed low smoke modification to the P-3C engine and arrangements were made to fully test an engine at the US manufacturer's facility.
- An algorithm was developed and successfully tested on a Black Hawk helicopter to inform pilots when control systems limits are being approached.
- A portable vibration analysis fault detection system was developed for the main rotor gearbox in the S70A-9 Black Hawk.

DSTO support to Australian initiatives on international disarmament

Australia has continued to be active in seeking practical means for chemical disarmament. Scientific advice has been given to the drafting by Australia of a complete text for the Chemical Weapons Convention, to serve as an example of what a final text would be like and thus act as a means of accelerating the negotiations on the Convention. Advice was provided to the policy areas of Defence and to Foreign Affairs on the strengthening of the Biological Weapons and Toxins Treaty, on the occasion of the Third Review Conference in September 1991 and its subsequent recommendations. A DSTO scientist was seconded to the South Pacific Forum as part of a team that conducted a survey of the Johnston Atoll Chemical Agent Disposal Facility in late 1991.

EMPLOYMENT, EDUCATION AND TRAINING

Science and Technology in the Portfolio Budget

The Department of Employment, Education and Training supports research and research training at higher education institutions throughout Australia. A major part of the portfolio's total support for research, approximately $870 million in 1992-93, is provided through the operating grants of higher education institutions to cover the cost of training postgraduate research students, research infrastructure costs, and internal research funding. In 1992, institutions have been notionally allocated $266 million on the basis of their postgraduate research student weighted load and $217 million as the research component for staff research activity unrelated to research training. These funds are provided to institutions as part of their one-line operating grants with the institutions themselves deciding on how these funds are allocated. In addition, the Department provides direct research funding of about $ 115 million for five of the six research schools of the Institute of Advanced Studies at the Australian National University (the John Curtin School of Medical Research is now funded through the Department of Health, Housing and Community Services).

For other higher education institutions, direct research funds are provided through research grants, special research centres, key centres of teaching and research and infrastructure grants. These are allocated on the advice of the Australian Research Council (ARC). Also provided are Australian Postgraduate Research Awards (APRAs), Australian Postgraduate Course Awards (APCAs) and Research Fellowships. Funds provided on the advice of the ARC are for research in all fields (other than medicine and dentistry), including the humanities and social sciences. Funding for APRAs, APRAs (Industry) and APCAs is estimated at $59.1 million in 1992-93.

In 1992-93, $258.0 million (over and above the operating grants components) will be distributed on the advice of the ARC. Of this, $103.0 million will be provided in research grants through a number of programs. Special Research Centres and Key Centres of Teaching and Research will receive a total of $20.3 million. $ 18.7 million will be provided in Research Fellowships and $52.1 million in infrastructure funding. Grants to the learned academies will amount to $ 1.4 million in 1992-93.

The Department also provides funding for Overseas Postgraduate Research Scholarships (OPRSs), estimated at $11.6 million in 1992-93.

The *Research Infrastructure Program* supports high quality research by remedying deficiencies in current research infrastructure, enhancing

support for areas of research strength and ensuring that areas of research potential are able to obtain the support necessary for development. The program supplies block grants, development grants to former advanced education institutions and supports co-operative research between higher education institutions.

The *Targeted Institutional Links (TIL) Program* aims at stimulating academic and research co-operation between Australian higher education institutions and their counterparts in Asia. The program provides seed funding to Australian institutions to support collaborative research links which foster internationally competitive research in Australia's national priority areas. Postgraduate scholarships are also awarded to scholars from Korea and Taiwan, whose field of study directly enhances the research links between institutions.

Funds are also provided to the Anglo-Australian Telescope Board (AATB) to support its operations. In 1992-93, the AATB is to receive almost $3.1 million.

In 1990, the Department devised a relative funding model in response to the Government's commitment to develop a method of funding based on what institutions do rather than historical precedent and arbitrary classification. The model identifies a research component of institutional operating grants and allocates it in two ways: funds for activities relating to postgraduate research training are allocated on the basis of weighted student load, while funds for research activities other than those related to postgraduate teaching are allocated according to institutions' success in obtaining funds through Commonwealth competitive research grants schemes (the 'Commonwealth competitive grants index').

In recognition of the fact that an index based on Commonwealth competitive grants only is not a completely satisfactory method of allocating resources for research, a composite index is being developed which gives appropriate consideration to research funds obtained from industry and other non-Commonwealth sources. As a result of the application of the relative funding model, adjustments to operating grants are being implemented. These adjustments will put funding for higher education institutions on a comparable basis for similar activities. The process of adjustment was accelerated as far as possible in 1992 and will be complete for most institutions by 1993.

The Australian Research Council (ARC)

Role

The Council's mission is to provide advice on research funding and research policy, and to promote the conduct of research and research training of the highest quality for the benefit of the Australian community. The Council has a special responsibility for research in the higher education sector, basic research and research training.

The ARC is one of the five Councils of the National Board of Employment, Education and Training. The principal functions of the Council are:

- to make recommendations to the relevant Minister on the distribution of resources provided under research support schemes for which it is responsible; and
- to inquire into, and provide information and advice to the National Board of Employment, Education and Training on matters referred to the Council by the Minister or the Board.

The ARC has responsibility for advising the Minister on the allocation of funds through the Research Grants Programs, Grants for Special Research Centres and Key Centres of Teaching and Research, Australian Postgraduate Research Awards, Research Fellowships Scheme, Research Infrastructure Funding, the Large Equipment Program, and Grants to the Learned Academies and ANZAAS.

Recent Developments

Collaborative Research Grants

The ARC and the Department are giving more emphasis in some of their research support programs to enhancing collaborative links between higher education and industry. The most recent program encouraging such links is the Collaborative Research Grants Program.

Funding through the Collaborative Research Grants Program is provided on a dollar for dollar matching basis with industry. Industry support may be in cash or in kind. Funding is provided for research projects undertaken by researchers in eligible higher education institutions. Collaborative Research Grants are available for work in all areas of the natural sciences and engineering as well as the social sciences and humanities. Grants are awarded for up to three years.

In the first round of grants, which took place in the first half of 1992, the Minister approved the allocation of $2.4 million for forty-one projects. A further $0.3 million was approved for the infrastructure loading. The budget for the Program is to rise to $6.7 million in 1993.

Evaluation of research support programs

The Department and the ARC have established a program of evaluation of research support programs. The budget for evaluation activities for 1992-93 is $0.6 million. The activities include evaluations of particular programs, such as the Special Research Centres and Key Centres, and evaluations of selected disciplines, with the aim of determining the appropriateness and value of the outcomes.

Discipline reviews, which cover research funding over the most recent five year period, are also designed to assist in determining priorities for future research funding. Each evaluation is undertaken by three eminent researchers, whose expertise covers the relevant field, but who did not seek Council support during the period concerned and were not involved in the allocation of grants.

During 1991-92, reviews of funding support were completed in economics, British and European history, Australian history, igneous and metamorphic petrology and geochemistry, and genetics and evolution. Further reviews have been commissioned, and should be completed during 1992, in condensed matter physics, material and chemical engineering, ecology, mathematics and other fields.

International links

An agreement has been reached between the Council and the Alexander von Humboldt Foundation in Germany which will extend the present arrangements and allow up to five reciprocal research awards to be made each year. These will enable researchers in both Germany and Australia to spend between four and twelve months working on a specific project in the other country. In addition to this program, arrangements have been concluded with the French Ministry of Education for up to five reciprocal research fellowships for young researchers across all fields. A similar arrangement has been entered into with the Korean Science and Engineering Foundation.

Research Grants Program

Role

The research grants program including the ARC Research Grants Scheme, the Small Grants Scheme and the Collaborative Research Grants Program support high quality research by individuals or research teams throughout Australia.

The grants are allocated for specific research projects on a competitive basis. Collaborative Research Grants support, on a dollar for dollar matching basis, high quality research involving collaboration between a higher education institution and an industry partner.

Recent Achievements

Evolutionary genetics of Tammar wallabies

The development of the Tammar wallaby has been examined in a number of related projects at Macquarie University, as an indicative system to study the genetics and phylogeny of marsupials. A significant result of the research was the development, by means of wide crosses, of the Tammar wallaby as a model species for genetic mapping. This should result in a marsupial genome map, and facilitate other genetic studies.

Insecticide resistance

Research at the University of Melbourne involved an analysis of the genetic basis of insecticide resistance as a model for micro-evolutionary adaptation. Notable results include the observation that populations in nature tend to evolve single gene resistance, while laboratory experiments normally result in a polygenic response. The analysis of effects on development is leading towards a molecular genetic explanation of the response to selection for insecticide resistance.

Proving Einstein's predictions

This project, undertaken at the University of Western Australia, was part of efforts by a world-wide network of laboratories to detect gravitational radiation, which was predicted by Einstein but had not been observed. The research will not only lead to the development of gravitational radiation astronomy but also to greatly improved devices relevant to other areas. For example, one of the spin-offs from the project was a sapphire loaded cavity oscillator of unprecedented stability with great potential for applications requiring highly accurate timing, which is now being commercialised by a Western Australian company.

Oceanographic features and fish populations

The purpose of this research at the University of Sydney was to discover the reason the size of commercial fish populations varies. The project studied oceanographic features, such as fronts and plumes of estuaries, to determine how many small fish survive early life in the plankton and grow to join the adult populations. Fronts and plumes influence the amount of food available to small fish. Pollutants also accumulate in fronts and affect survival offish. The research has yielded results which will be of benefit to the nation's fishing industry.

Special Centres Program

Role

To support research concentrations on the basis of excellence and their potential to contribute to the economic, social and cultural development of Australia.

The Special Centres Program supports two types of Centres, the Special Research Centres and the Key Centres of Teaching and Research. Special Research Centres are currently funded at a rate of between $0.4 million and $0.9 million per year, depending on the Centre.

The Key Centres of Teaching and Research are designed to give equal weight to teaching and research in institutions. They are based on existing departments in higher education institutions and aim at boosting expertise in areas relevant to national development and promoting co-operation between higher education and industry. Key Centres are funded at a rate of around $0.2 million per year. Though this level of funding may be considered modest, a large proportion of the Key Centres obtain considerable additional funds from other sources, such as industry.

Recent Achievements

Laser systems

There has been continued demand at the Lasers and Applications Centre at Macquarie University for development of specialised high-power gas laser systems. The development of semiconductor diode-pumped and tunable solid-state lasers has advanced substantially to provide the impetus of major industrially-related developments. The Centre has made significant progress in the application of a range of sophisicated laser techniques including non-linear optical techniques, to industrial measurement and to medical diagnostics and therapy.

Australian Postgraduate Research Awards and Overseas Postgraduate Research Awards

Role

Australian Postgraduate Research Awards (APRAs) provide competitive awards for Australian students undertaking research leading to a Masters degree or PhD. Australian Postgraduate Research Awards (Industry) promote joint industry-higher education research opportunities. Postgraduate Course Awards are provided to assist students undertaking

Masters degrees by coursework. Overseas Postgraduate Research Scholarships aim to assist overseas students to undertake research degrees at Australian universities.

Recent Achievements

The bird cherry-oat aphid

An Award holder at the University of Adelaide has recently completed a study of the bird cherry-oat aphid. This aphid has never before been studied in Australia despite its ability to cause economic reductions in the yield of wheat crops. It was shown that the aphid survives over summer in irrigated grass pastures from which it migrates in autumn to infest newly sown wheat crops. The number of aphids migrating from these pastures is dependent upon the frequency of days on which temperatures exceed 35°C. The timing of migration was shown to be closely linked to day length, aphid numbers and host plant age. The research program has led to the use of these various parameters as a means of predicting the likely risk of infestation of wheat crops in autumn.

Metamorphic core complexes

An Award holder at Monash University has undertaken research revealing that the westward propagation of the Woodlark spreading centre has torn apart the continental crust of Papua New Guinea, so that deeply burled metamorphic and igneous rocks have been dragged eighty kilometres to the surface and have been exposed as giant gneiss domes in the D'Entrecasteaux Islands. The work has been acclaimed by both academia and the Australian mining industry, which awarded the researcher a medal in recognition of her work.

Economic and environmental improvements in paper production

An Award holder at the University of Tasmania has investigated the combined use of two polymers, polyethylene oxide and phenolformaldehyde resin, to investigate fibre retention performance in pulp suspension in the paper production process. The project has proposed a mechanism for operation of the retention aid system and suggests influential factors which may be of value in identifying optimum conditions under which the system can be implemented. These improvements are likely to lead to paper production under improved economic and environmental conditions.

Research Fellowships Schemes

Role

Fellowships provide support for individuals to undertake research at postdoctoral level and above.

There are four types of Fellowship: Australian Postdoctoral Research Fellowships (for researchers normally with less than 3 years postdoctoral experience), Australian Research Fellowship (for researchers normally with at least 3 years postdoctoral experience), Queen Elizabeth II Fellowships (for outstanding researchers who would normally have no more than six years postdoctoral experience), Senior Research Fellowships and Australian Research Fellowships (Industry) (ARFI) (for research with an industrial company).

Recent Achievements

Improved understanding of mantle mineral phases at elevated pressure and temperature

This study provides an important first step in resolution of the issue of chemical stratification in the Earth's mantle. A Fellow at the Australian National University has provided the first data on pressure dependence of elastic wave velocities of two spinal structured polymorphs of magnesium silicate, the high pressure forms of olivine, to 30,000 atmospheres. Olivine comprises about 60 per cent of the uppermost mantle and its high pressure forms are believed to constitute about 40 to 60 per cent of the so-called transition zone between 400 and 650 km depth.

Nutrition and proteins in wheat

This project, conducted at the University of Adelaide, undertook the molecular cloning and characterization of triticin (a special group of wheat seed storage globulins), and studied their possible role in the improvement of grain quality. The research also involved the study of the relationship between overall seed protein composition and bread-making quality. It was established that triticin has a much superior nutritional quality than gliadin and glutenin, which are the major storage proteins of wheat.

The Institute of Advanced Studies, The Australian National University

Role

The Institute carries out research and postgraduate training in the physical, biological and social sciences.

Its budget of approximately $ 130 million ($115 million of which is provided through the Department of Employment, Education and Training) and the full-time commitment of its staff to research permit it to concentrate on fields of research and large scale endeavours which take advantage of its particular range of facilities and expertise. It has a

special responsibility to carry out research of national importance and to combine a search for fundamental understanding with a concern for the use of the research results. It aims at being a research resource for other Australian universities and also maintains strong contacts with universities and research institutions in other countries.

Recent Achievements

The physiology of photosynthesis

More than a decade of leadership by the Plant Environmental Biology Research Group in the physiology of photosynthesis has been recognised by the award of the 1991 CSIRO Research Medal. Building upon fundamental research with exotic succulent plants, the Group uncovered a universal relationship between plant discrimination against naturally occurring, non-radioactive isotopes of carbon, and the efficiency of water use by plants. These insights have led to large national and international programs designed to select and breed wheat, peanut, cowpea and other plants which use water more efficiently. In Australia, an improvement of one per cent in water use efficiency of wheat could be worth more than $20 million in one year.

Large scale motions in the universe

Researchers at the Mount Stromlo and Siding Springs Observatories have recently completed a large survey of 1500 spiral galaxies. They have used this survey to investigate large scale motions within a volume of the Universe some 500 million light years across, and have discovered that within the whole of this volume, the galaxies have a general streaming motion of 600 km per second with respect to the Cosmic Microwave Background. This result calls into question a fundamental cosmological assumption, namely that this Microwave Background acts as a fixed frame of reference for the matter content of the Universe.

The Anglo-Australian Telescope (AAT)

Role

Operating under an agreement between the Governments of the United Kingdom and Australia, the Anglo-Australian Telescope Board maintains facilities which enable British and Australian astronomers to undertake research for the advancement of scientific knowledge.

These facilities include the Anglo-Australian Telescope and the UK Schmidt Telescope at Siding Spring Mountain outside Coonabarabran, and a laboratory in the Sydney suburb of Epping.

Recent Achievements

Clues to the formation of our galaxy

The large congregations of stars that astronomers call globular clusters were among the very first objects to form out of the diffuse cloud of gas that became our Galaxy. For many years a popular view has been that these globular clusters formed at the same time. Over the last few years, improved techniques for determining the ages of globular clusters have been developed. Observations made by two different groups using the Anglo-Australian Telescope have revealed ages differing by as much as several billion years between otherwise similar globular clusters. This research has led to a reappraisal of the theories of galaxy formation, and an alternative explanation allowing protracted development of these clusters, is now favoured.

The atmosphere of Venus

It is often stated that the surface and lower atmosphere of the planet Venus cannot be studied from the Earth because of the opaque clouds that pervade the atmosphere. As a result, most studies of the planet have been made by spacecraft. However, at certain infrared wavelengths the clouds and atmosphere become relatively transparent, allowing observations from the surface of the Earth.

Recent infrared observations made with the Anglo-Australian Telescope have shown that the highlands of Venus can be directly recorded. This discovery defines the limits on the range of minerals present, as well as improving our knowledge of the lowest few kilometres of the atmosphere, including the water vapour content. An understanding of the Venus atmosphere, which exhibits an extreme greenhouse effect, is germane to descriptions of the terrestrial atmosphere.

At the same time, the observations revealed unexpectedly bright and variable regions of airglow, somewhat resembling aurorae on earth. The air glow, which forms about 90 km above the surface of Venus, monitors another important region of the atmosphere where a global circulation of gas is driven by upwelling about mid-day and subsequent sinking near local midnight. Observations of the airglow, which is associated with oxygen atoms recombining to form molecules, allows constraints to be placed on both the physical and chemical behaviour of the upper atmosphere of Venus.

HEALTH, HOUSING AND COMMUNITY SERVICES

Science and Technology in the Portfolio Budget

This portfolio includes several agencies dealing with research and scientific services. These are the National Health and Medical Research Council (NHMRC), the Australian Institute of Health and Welfare (AIHW), and CSL Limited. AIDS research and health research programs are also funded through the portfolio.

Medical and public health funding through the NHMRC will increase to $108.7 million in 1992-93 ($103.3 million in 1991-92). The AIDS research program will decrease to $10.4 million ($10.8 million in 1991-92). AIDS research is also funded through NHMRC. Health research funding through Health, Housing and Community Services Research and Development Grants will remain at $1.8 million in 1992-93 ($1.8 million in 1991-92).

CSL Limited will receive $1.2 million to fund the World Health Organisation (WHO) Influenza Reference Centre.

During 1991-92, legislation expanded the function of the former Australian Institute of Health to include welfare-related activities. The Institute is now known as the Australian Institute of Health and Welfare, and there is a significant increase in its appropriation for 1992-93 to $6.5 million ($4.2 million in 1991-92). This reflects its expanded role encompassing the collection, analysis and publication of data from social welfare, community services and housing assistance programs, with the objective of developing national data sets.

Capital works funding for research in medical research institutes for 1992-93 totals $10.0 million. Institutes were assessed by an expert team. Those being funded demonstrate the greatest capacity to contribute to the advancement of medical science.

MAJOR RESEARCH ACTIVITIES

National Health and Medical Research Council (NH&MRC)

Role

The objective of the National Health and Medical Research Council is to advise the Australian community on the achievement and maintenance of the highest practicable standards of individual and public health and to foster research in the interest of improving these standards.

The Council is currently funding 1131 research projects, as well as providing block funding for several major research centres and institutes.

Recent Achievements

Leukaemia

Researchers at Sydney's Children's Medical Research Foundation have developed a model to identify events that happen during leukaemia development. It reflects the various events involved in the initiation and progressive phases of cancer, particularly cancer of the blood cells or leukaemia. Use of the model may pave the way for a cure and possibly even the means to prevent the disease. Tracing the chain of events in the cancer process can provide an insight into the properties the cells possess at each stage of development. It is the analysis of these properties which is the key to developing treatment for the disease.

Early detection of kidney disease

A common hereditary and potentially fatal kidney disease can now be detected in the unborn child and researchers are continuing work to isolate the single gene that carries it. Polycystic kidney disease (PKDI), the single most common cause of kidney failure in adults, can be diagnosed as early as 11 to 12 weeks of pregnancy, despite the fact the symptoms don't normally appear until adulthood. This improved diagnosis of PKDI has occurred through the identification of DNA markers which indicate that the disease is present in a person's genes. These new markers have been isolated as a result of work undertaken by researchers at the Adelaide Children's Hospital Department of Cytogenetics and Molecular Genetics.

Composite bionic ear/speech processor

Researchers at the Australian Bionic Ear and Hearing Aid Research Institute have developed a new and improved bionic ear. The Institute is world renowned for developing the cochlear implant (also known as the bionic ear), for which it holds 90 per cent of the world market. Researchers have now developed a composite bionic ear and speech processor, a single device which removes the need for separate pieces of equipment. This device has significant potential for world wide marketing and stands to benefit hearing impaired people throughout the world.

Blood pressure drug - a danger to the unborn child

Researchers at the University of New South Wales have concluded that a type of drug used to treat high blood pressure can cause acute renal failure in the fetus if given to a woman in the last three months of pregnancy. Drugs used to treat hypertension, generally known as 'converting enzyme inhibitors', can prevent amniotic fluid from forming and surrounding the baby in the womb. This leads to an inability of the baby to produce urine, and the associated risk of renal failure.

Health, Housing and Community Services Research and Development Grants

Role

To improve through research and evaluation, the techniques and practice of administration, planning and delivery of health, housing and community services in Australia and also to provide information which will assist the development of policy.

Recent Achievements

Improved well-being for the ageing

Coinciding with the tenth anniversary of the United Nations' Action Plan on Ageing, a research program directed specifically at the promotion of well-being in the ageing process was carried out. It consisted of a number of contributing projects which provided useful information on the effectiveness of home-based rehabilitation for older people with disabilities, social and environmental influences in the health and independence of the elderly and key factors in decisions about how, when and why people retire.

Commonwealth AIDS Research Grants Program (CARG)

Role

To develop means of preventing infection with Human Immunodeficiency Virus (HIV), to develop better methods of diagnosis and treatment of HIV and complicating conditions, to define factors which place people at risk of infection and to establish means of reducing them. Also to monitor the personal and social impact of HIV infection and its spread within the community.

Recent Achievements

Patents

CARG contributions to a CSIRO program in Melbourne have led to the development and patenting of a number of compounds with high antiviral activity. Four patents have arisen from research funded at the National Centre in HIV Virology relating to agents inhibiting HIV infection or replication.

HIV and injecting drug use

Data from the Australian National AIDS and Injecting Drug Use Study have been published throughout 1991 and 1992. This study of over 2,000 injecting drug users around Australia provided important information on infection rates, risk behaviours and other aspects of injecting drug use in Australia.

Australian Institute of Health and Welfare (AIHW)

Role

In collaboration with relevant Commonwealth, State and Territory agencies, and non-government organisations, to undertake analyses and compile statistics on the health of Australians, and the provision, use and cost-effectiveness of health services and health technologies in Australia.

Recent Achievements

Health expectancies in Australia

In late 1991, AIHW published a report on health expectancies in Australia. This provided national estimates of expectation of life free from disability, handicap and severe handicap in 1981 and 1988.

It also examined the question of whether the proportion of life spent with disability or handicap is increasing in Australia.

Economics of health promotion and illness prevention

The Institute has developed a model for analysis of the economics of health promotion and illness prevention. The model has been used in a study of the economic impact of diet and alcohol related disease. Work is proceeding on the health economics of smoking, exercise, obesity, injury, osteoporosis, cholesterol, hypertension and various cancers.

Early warning on the implications of new technologies

The Institute has developed a process for providing early warning on the implications for health care of new technologies to Commonwealth and State Health Authorities. From August 1991 to June 1992, ten briefs covering a range of new technologies were circulated.

CSL Limited (CSL)

Role

To be Australia's leading manufacturer of biological Pharmaceuticals and to meet both the medical and veterinary markets' needs for such products. Also to identify new and improved products and processes and to market and implement them to enhance the overall profitability of the business.

Recent Achievements

CSL-World Health Organisation (WHO) Influenza Reference Centre

In recognition of its expertise and reputation, a CSL Centre was recently designated as a WHO Collaborating Centre for Influenza joining the National Institute for Medical Research in London and the Centres of Disease Control, USA, as the key Centres in the influenza network. The worldwide WHO network was established in 1947 to act as an early warning system for the emergence of new influenza strains and to provide data for the yearly recommendations for the composition of influenza vaccines. The CSL Centre now operates on an international basis and participates in the annual WHO consultation on vaccine formulation. Its function is to monitor influenza activity and undertake detailed analysis of influenza virus isolates received from laboratories in the Western Pacific Region. Regional information is collated for use by WHO and the Australian Influenza Vaccine Committee in their annual consultation on influenza vaccine formulation.

INDUSTRY, TECHNOLOGY AND COMMERCE

Science and Technology in the Portfolio Budget

There are three major scientific research organisations in the portfolio: the Australian Institute of Marine Science (AIMS), the Australian Nuclear Science and Technology Organisation (ANSTO), and the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

There are also a number of agencies and programs supporting technological development in industry through the provision of grants, concessions and services. The Industry Research and Development (IR&D) Board, which includes both industry and government representatives, is concerned with promoting the development, and improving the efficiency and international competitiveness of Australian industry by encouraging research and development activities. The IR&D Board has responsibility for administration of the tax concession, the Discretionary Grants Scheme, the Generic Technology Grants Scheme and the National Procurement Development Program.

The Australian Technology Group (ATG), currently under development will act as a small commercially focussed company to help identify research with commercial potential, particularly but not limited to, research from the public sector. The Group will also market research output and seek to further develop an export industry in intellectual property.

Grants or incentives to industry include the following:

- *The tax concession* for industrial research and development.
- *Pooled Development Funds*, concessionally taxed investment companies, provide patient equity capital for small and medium size firms.
- *Generic Technology Grants* provide support for research and development in nominated areas of technology which are important for the international competitiveness of Australian industry into the 1990s. These are:
  - *Biotechnology Grants*
  - *New Materials Technology Grants*
  - *Information Technology Grants*
  - *Communications Technology Grants*
  - *Waste and Environmental Management Technology Grants*

- *Advanced Manufacturing Technology Grants (AMTG)* provide support to companies to research and develop, or trial and demonstrate advanced manufacturing products, services or systems in collaboration with a user company.
- *Discretionary Grants* provide support to companies which have insufficient taxation liability to obtain adequate benefit from the tax concession for research and development but have the potential to fully exploit the results of their research and development projects.
- *National Procurement Development Program (NPDP)* provides financial assistance to support joint projects to trial and demonstrate and/or research and develop new products, services and systems, including prototypes, which link into forward procurement requirements of government departments and agencies.
- *Motor Vehicles Components Developments Grants Scheme (MVCDGS)* provides funding for Australian research and design of components and vehicles.
- *The computer bounty* provides assistance for the production of computer hardware, certain assemblies, electronic microcircuits, printer circuit boards, modems and multiplexors, and certain operating software.
- *The Factor (f) Pharmaceutical Industry Development Program* provides higher prices for some products, in return for a commitment by individual manufacturers to undertake increased activity in Australia, including new investment, production, research and development.
- Australian *Building Research Grants Scheme (ABRGS)* provides funds to encourage building and construction research of long term benefit to the building industry.
- *The National Teaching Company Scheme* aims at creating links between public sector research institutions and companies in the manufacturing and services sectors. It does this by supporting suitably qualified graduates to work on industry-based projects jointly supervised by participating institutions and companies.

Services to industry and community include the following:

- *The National Industry Extension Service (NIES)* is a joint Commonwealth/State program which provides extension services to firms in the traded goods and services sectors to increase internal efficiency and international competitiveness.
- *The Patent, Trade Marks and* Designs *Offices* provides industrial property rights services. The offices operate on full cost recovery.
- *The International Science and Technology Program* aims to stimulate Australian involvement in international research collaboration and generate awareness of Australian S&T capabilities. A longer term aim is to build commercial opportunities through collaborative research.

Program or agency		Budget expenditure 1991-92 $m	Budget estimate 1992-93 $m
AIMS		14.2	14.0
ANSTO		64.3	66.9
Nuclear Safety Bureau		0.8	0.8
CSIRO		446.3	456.3
Kraft Pulp Mill Study		1.9	1.9
Industry Innovation Program (including GIRD)		39.9	45.8
Australian Technology Group		-	30.0
Motor Vehicle & Component Development Grants		2.3	0.1
Computer Bounty		74.5	71.0
Factor (f) Pharmaceutical Industry Development Program		26.3	65.1
ABRGS		0.3	0.3
NIES	-Commonwealth	5.5	5.3
	-States	10.8	11.2
VQS		1.2	1.3
National Space Program		5.7	7.0
Science and Technology Awareness		0.7	1.7
MVJV		9.4	-
International Science and Technology Program		5.1	5.3
TOTAL		709.2	784.0
PORTFOLIO TOTAL		1543.0	1501.0

- *Policy advice* for the establishment and delivery of Government services In science and technology is provided through the Science and Technology Policy Branch (Innovation Division), the Policy and Projects Division, the Bureau of Industry Economics and other Divisions of the Department of Industry, Technology and Commerce.
- The *Vendor Qualification Scheme (VQS)* provides assistance to export oriented firms in the Information Technology sector seeking accreditation to internationally recognised quality and regulatory standards.
- The *National Space Program* promotes the growth of commercially viable industries based on space technologies and encourages greater involvement by industry in space R&D.
- The *Marine Science and Technology Program* aims to align marine R&D more closely with industry requirements and to play a key role in international co-operation in marine science and technology. Closer links between the marine industry, government and research agencies are being developed through the Consultative Group on Marine Industries Science and Technology (C-MIST) and the Oceans Australia conference series.
- *The Science and Technology Awareness Program* aims to increase awareness and understanding of the central role which science and technology play in Australia's economic and social wellbeing.
- *The Malaria Vaccine Joint Venture (MVJV)* was a consortium involved in developing a malaria vaccine. The operation concluded during 1991-92.

Budget support for these programs is shown in the table above. It should be noted that the Patent, Trade Marks and Designs Offices are not included in the above figures as they operate on full cost recovery.

MAJOR RESEARCH ACTIVITIES

The Australian Institute of Marine Science (AIMS)

Role

To advance the development of national knowledge of the marine environment; to communicate this knowledge so that it can be applied to the development, conservation and management of marine resources; to create opportunities for technological and commercial development and to foster cooperation between researchers with similar interests.

AIMS is receiving additional funds of $ 1.3 million over the three year period from 1991 to 1994 to extend its crown-of-thorns starfish monitoring program to a detailed investigation of factors affecting the health of the Great Barrier Reef, monitoring nutrients, trace elements, fish stocks and hydrodynamics.

This type of monitoring program is now recognised as essential for understanding natural variation and, therefore, to provide the baseline information on which to advise decision makers and developers with respect to the impact of human activities in these areas of high ecological and economic value.

Recent Achievements

Hydrodynamic modelling

The structural complexity of the coral reef and tropical shelf systems of northern Australia and Papua New Guinea precludes direct, synoptic measurements of water motions and mixing, on both local and regional scales. To develop an understanding of the complex circulation patterns within these sytems, and the implications of that circulation for biological and chemical processes, oceanographers at AIMS have developed special numerical hydrodynamic models.

Within the last year, the Coastal Oceanography group has implemented and refined three dimensional models to simulate the dynamics of circulation in specific systems where vertical water movements are now known to be important.

A three dimensional circulation model has been developed for the Gulf of Papua and has shown that circulation in the Gulf of Papua is influenced by currents in the eastern Torres Strait and by the Coral Sea coastal current, as well as by local wind conditions and fresh water inputs from the extensive river systems bordering the Gulf.

Mangrove forestry

Several species of mangrove show potential for use as cabinet timbers. Two of the many species available in North Queensland are being used for a silvicultural trial. One in the Hull River area, North Queensland, which began in July 1990, is now showing a survival rate of 70 per cent of seedlings planted.

The early results of these and other trial plantings indicate the importance of adequate drainage particularly during the stage of seedling establishment when the young trees are developing their root systems. The project is providing data to investigate the potential of a mangrove forestry industry.

Inter-annual variability in reef fish

Monitoring since 1980, has revealed large variations from year to year in the abundance of young fish in the Great Barrier Reef region. This monitoring has delivered several unexpected bonuses, such as illustrating how fish populations respond to catastrophic disturbances of their habitat by events such as cyclones and outbreaks of the crown-of-thorns starfish. Results dispel the notion that fish abundance is regulated by the "carrying capacity" of reef habitats.

The study has also shown that some small reef fish may live as long as 20 years. One implication of this unsuspected longevity is the possibility that stocks of reef fish may take up to a decade to recover from any disturbance that seriously lowers their abundance. The work obviously has significant implications to both the tourist industry and to management agencies such as the Great Barrier Reef Marine Park Authority.

The Australian Nuclear Science and Technology Organisation (ANSTO)

Role

Undertake research and development in nuclear science and associated technologies to contribute to Australia's industrial innovation and development, and environmental and health management. Maintain a core of essential nuclear expertise and nuclear facilities, and further Australia's non-proliferation, nuclear safeguards and wider nuclear technology policies.

Recent Achievements

Recovery of rare earths

A process has been developed to recover rare earths from Ashton Mining's Mt. Weld deposit at Laverton, Western Australia. The unique process developed on the basis of laboratory-scale studies, was successfully demonstrated in a pilot plant at ANSTO where six tonnes of concentrates were processed from March to June 1992.

Pollutant migration

New powerful computer modelling techniques have been developed to predict pollutant generation and migration in pyritic mine wastes. The computer model has been successfully applied commercially to waste heaps at the AITIK mine site in Sweden, and forms the basis of ANSTO's rehabilitation strategy for the site.

Shellfish as pollutant monitors

A new technique has been developed using shellfish as archival monitors of water pollution. Using a state-of-the-art secondary ion mass spectrometer, variations in the heavy metal content in the daily micro-laminations of shells can be detected. The results on shellfish from the Hawkesbury-Nepean River System indicate that it is possible to detect exposure to evaluated levels of pollutants for periods as short as two days. The technique can be used to accurately date short term pollution incidents that occurred up to twenty years ago.

Nucleonic Equipment

Two pieces of equipment have been developed which are entering the commercial area. These include the following:

- An in-pipeline radiation monitor which is an engineered device designed to detect the position of leaks in underground pipelines by monitoring the location of radioactive tracer, forced under pressure through leaks into the surrounding earth. The equipment has been developed for Tracerco Australasia and has been fully field tested by ANSTO and Tracerco on an industrial pipeline. As a result of this development, Tracerco has been able to tender on major projects in this area.
- 'Point to point' and 'scanning' transmission gauges have been developed in conjunction with the ANSTO Computer Centre for Tracerco and Alcoa. Alcoa will develop the full industrial prototype. Tracerco has already been commissioned to undertake a commercial job for Alcoa using the laboratory prototype. Alcoa have suggested that there may be a global market for the gauges.

Synroc

In March 1992, ANSTO signed a memorandum of understanding with the China National Nuclear Corporation that will involve cooperation on research and development of Synroc.

Plasma immersion ion implantation

ANSTO, in collaboration with CSIRO Division of Applied Physics, the University of Adelaide and MM Metals, has successfully completed a three year project on plasma immersion ion implantation, supported by the Industrial Research and Development Board through a New Materials Generic Technology Grant. The technique significantly increases the surface hardness of a range of steels, resulting in enhanced wear resistance.

The Australian Space Office

Role

The aim of the Australian Space Office is to encourage greater local industry involvement in space R&D and promote the development of commercially viable industries based on space technologies.

Recent Achievements

Atmospheric Pressure Sensor (APS)

The APS is a passive remote sensing instrument for measuring atmospheric pressure at the earth's surface from an orbiting satellite. It is expected to improve significantly the accuracy and extend the range of meteorological forecasting. CSIRO has developed a laboratory model which was successfully flight tested in a research aircraft. The Office subsequently awarded a contract to an Australian company to carry out a phase A concept study on the scientific and engineering feasibility of a spaceborne APS.

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Role

CSIRO's main role is the conduct of strategic research to:

- *develop technologies for all sectors of Australian industry;*
- *improve the management of its natural resources;*
- *protect Australia's unique environment; and*
- *promote the well-being of the Australian people.*

CSIRO is recognised nationally and internationally for its contributions to science and Australia's development. CSIRO will build on this reputation through close collaboration with industry, government, and other research institutions to ensure the nation derives the greatest benefit from its research.

Objectives

CSIRO's objectives are to:

- enhance export and import replacement performance of Australia's primary and manufacturing industries,
- reduce the trade deficit of the information and communications industries.

- develop ecologically sound management principles and practices for the use and conservation of Australia's natural resources,
- achieve sustainable development in production systems and develop technologies to minimise environmental damage from economic development, and
- enhance productivity and effectiveness in provision of infrastructure and services, particularly public health and construction.

Structure and Organisation

CSIRO is governed by a Board comprising up to ten members, one of whom is the Organisation's Chief Executive. The research carried out by CSIRO's 7000 staff is undertaken in six research institutes which have the following objectives:

Institute of Animal Production and Processing

- To enhance the global competitiveness of Australia's animal based and food industries, the health and well-being of its people and the wise long term use of its resources for these purposes.

Institute of Industrial Technologies

- increase the international competitiveness, efficiency and scope of Australia's manufacturing industries, and be a leader in strategic research for those industries.

Institute of Information Science and Engineering

- be a leader in strategic research on information and communications technologies and the integration of systems based on these technologies for the benefit of Australia,
- help increase the international competitiveness and export orientation of the Australian information and telecommunications industries, and
- assist other industry sectors to improve their competitiveness through the use of advanced computer and communications systems.

Institute of Minerals, Energy and Construction

- play a major contributing role in the development of sustainable and competitive minerals, energy and construction industries in Australia and in the creation of a better living and working environment for all Australians.

Institute of Natural Resources and Environment

- provide the scientific knowledge required for the effective management and conservation of Australia's natural resources and environment, particularly in relation to the conservation and protection of natural heritage and sustainable use by dependent industries.

Institute of Plant Production and Processing

- benefit Australia's plant-based industries through research that improves Australia's international competitiveness and market access, and maintains the resource base.

While CSIRO is funded primarily by direct appropriations from the Commonwealth, an increasing proportion of the Organisation's funds come from external sources. These include collaborative ventures with industry, granting schemes funded by both industry and government, and earned revenue.

Planning and Reporting

CSIRO uses the Australian Bureau of Statistics' interim Australian Standard Research Classification socioeconomic objectives as the basis for strategic planning and reporting outcomes of the Organisation's research. This classification provides a framework for describing the purpose for undertaking research in terms of economic and social benefits. The following achievements are reported on this basis.

Plant Production and Primary Products

Recent Achievements

A new test for the lupinosis toxin

Australia is the world's leading producer of lupin seed, and exports of this highly nutritious grain legume earn over $ 120 million annually. Lupins also enrich the soil by adding nitrogen, making it an ideal crop for growing in rotation with cereals. However, seed and stubble can become contaminated with fungal toxins which are hazardous to animals. Australian food regulations place a maximum acceptable level of 5 parts per billion of these toxins in products designed for human use. CSIRO's Division of Animal Health has developed a test for detecting these toxins in lupin seed which will help guarantee the quality of lupin products such as bran, that are being increasingly recognised as competitive alternatives to some other grains.

Controlling the rate of flowering

Researchers in CSIRO's Division of Plant Industry have achieved a breakthrough in understanding the mechanics of vernalisation - the prolonged chilling of wet seed in order to accelerate flowering. Results indicate that the requirement for vernalisation is methylation of the regulatory regions of genes critical to flowering. The potential to be able to control the rate of flowering of some major crops has wide industry application.

CSIRO Sap Meter goes commercial

Overseas orders are being received for the Australian-designed "Greenspan Technology Sapflow Sensor". The Sapflow Sensor, which provides measurements of water use and growth in plants and trees, has taken expensive and sophisticated elements of high technology and made them available to orchardists, horticulturists and tree farmers at a reasonable price.

New mandarin variety

With the Australian citrus industry changing its emphasis towards fresh fruit production and greater varietal range, joint research by the CSIRO Division of Horticulture and the Victorian Department of Food and Agriculture has led to the development of a new mandarin variety. Sunset Mandarin, the first citrus variety to be granted protection under Australia's Plant Variety Rights Legislation, is an early-to-mid season variety that will be released to industry during 1992-93.

Animal Production and Primary Products

Recent Achievements

Buffalo fly trap

Buffalo flies cause extreme irritation of cattle and other livestock in Northern Australia resulting in considerable production losses. CSIRO's Division of Entomology has developed an environmentally safe and labor-efficient fly trap which comprises a plastic covered tunnel built over a cattle race. Flies are brushed off cattle passing through the trap by weighted curtains hung inside the tunnel; they then make their way upwards, attracted by the natural light to be killed by the heat generated inside the plastic covering. The traps can be located at strategic points such as the entry to a dairy or water source.

Fututech commercialisation contracts signed

Fututech is a revolutionary, highly automatic technology for the slaughter and dressing of beef cattle which removes much of the heavy manual tasks associated with animal processing and improves the efficiency, hygiene and work environment for the processing of live animals to meat. CSIRO, the Meat Research Corporation, and the Kilcoy Pastoral Company have signed agreements for the construction of a Fututech plant to be built at the Kilcoy abattoirs. BHP has been contracted to do the re-engineering and management of the construction project which will operate in parallel to the traditional abbatoir, to enable comparative trials and modifications to be conducted in a competitive commercial environment.

New genes to alter biochemistry of animals

CSIRO has now produced transgenic mice, which provide the first known demonstration that animal biochemistry can be effectively altered through genetic engineering. The technique has utilised a new gene which encodes the information necessary for animals to synthesise the essential amino acid cysteine. The gene, prepared by linking two bacterial genes to pieces of sheep regulatory DNA has been inserted into the genomes of laboratory mice, and the resultant transgenic animals have been shown to synthesise this amino acid when they are supplied with sodium sulphide in their diet. Current experiments are in progress to transfer the new gene to sheep in order to increase the efficiency of wool growth.

New grazing legume released

Pasture improvement has the potential to substantially increase livestock production over a large area of readily improvable land in Northern Queensland. In the past, anthracnose disease has proved a devastating setback for many improved pasture legumes in the north. CSIRO's Division of Tropical Pastures has in collaboration with the University of Queensland and the Queensland Department of Primary Industries, developed a suite of legumes belonging to the *Stylo* genus which are resistant to anthracnose. Recently, Siran, a shrubby *Stylo* with broad-based resistance to anthracnose was released commercially.

AUSPIG - improvements in pig management and productivity

AUSPIG, a computer software package to improve the management and productivity of pig producers was commercially released in Australia in July 1990. AUSPIG has increased the profitability of pig enterprises in Australia and the Netherlands by up to 30%. The 26 users currently licenced, include BP Nutrition (with whom the technology transfer phase is now complete), farmers, State agricultural departments and universities. BP Nutrition is using the software extensively in the USA and Europe where it has had a major impact on new feeds that they have designed. They are now conducting an extensive survey in the USA to identify specific markets and products.

Merino sheep with resistance to worms

It has been estimated that internal parasites cost the Australian sheep industry $350 million per year through lost production and the direct costs of control. CSIRO, in collaboration with the University of New England, has developed a Merino flock with outstanding resistance to worms. Simulation studies suggest that animals from this flock should require little or no anthelmic treatment, thereby reducing the costs of parasitism and the reliance on chemical control.

New test for genetic disorder of cattle

In collaboration with the Queensland Department of Primary Industries, CSIRO's Division of Tropical Animal Production has developed a DNA-based test which, if applied systematically would

eliminate Pompe's Disease, a fatal genetic disorder of cattle. By isolating the gene responsible for the disease, the test enables carriers to be identified, and culled from breeding.

Phosphorous nutrition

An investigation of phosphorous nutrition in the context of managing tropical legume-based pastures, taking account of past rainfall and temperature data, has been completed by CSIRO's Division of Tropical Crops and Pastures. Economic phosphorous management options based upon using fertilisers or supplements, have been developed for graziers according to location, soil phosphorous status and pasture legume type.

Rural Based Manufacturing

Recent Achievements

Clearing yarn

"Siroclear", a new device from the CSIRO Division of Wool Technology enables rust stains, dirty fibres, black fibres, vegetable contamination and packing material residue to be removed from yarn before it is woven into fabric. Siroclear has been incorporated into a Swiss computer operated yarn clearing device, which monitors and classifies yarn problems as it removes contamination while wool is wound from a bobbin to a cone at speeds up to 100 km/hr. Since Siroclear removes these impurities from wool, darning fabric defects is now becoming a thing of the past.

Eliminating "problem milk"

Every autumn, cheeses made in south east Australia are likely to contain excess moisture and decrease in quality during maturation. CSIRO's Dairy Research Laboratory is collaborating with the Milking Research Centre (Victorian Department of Food and Agriculture) to define the causes of seasonal changes in the suitability of milk for cheesemaking. It was found that nutrition is a key factor, and it is possible to produce a good cheese by providing cattle with quality feed during the problem period.

Recent achievements in Sensory Research Centre project in Japan

CSIRO's Division of Food Processing has completed the sensory evaluation of 100 Australian food products in Japan. The evaluation has yielded unexpected findings about both the differences and similarities between Japanese and Australians in their liking for, and sensitivity to various tastes. The results are being applied to the development of products specifically tailored for the Japanese market, and planning is underway to extend the Project to other important food markets in the Asia-Pacific region.

Wood adhesives

Australia uses over 50,000 tonnes of adhesives to produce more than one million cubic metres of wood-based panel products annually. In collaboration with Chemplex Australia Ltd, the CSIRO Division of Forest Products has developed fast-curing adhesive systems that produce plywood and panels with uniform bond strength from pine species, in about half the curing time required for conventional formulations at a comparable cost. This commercialised CSIRO system is already expanding its market share among forest product companies.

Wool's new "money spinner"

A CSIRO innovation called "Sirospun" which reduces the cost of spinning wool was developed and commercialised by a consortium comprising the Australian engineering company, Warren Brown and Staff, the International Wool Secretariat (IWS) and CSIRO. Sirospun, has also been supported by the Wool Research and Development Corporation throughout its development. Yarns made using the Sirospun process are particularly suited to the spinning of fine wools, and the process has assisted the IWS "Cool Wool" promotion campaign for lightweight wool apparel.

A study by the Australian Bureau of Agriculture and Resource Economics (ABARE) has shown the CSIRO's Sirospun process to have returned over 100 times its research and development cost. The ABARE study suggests that Sirospun has the potential to increase returns to Australian woolgrowers by up to $36 million dollars a year by the turn of the century. The estimated return to woolgrowers at present values is over $900 million.

Minerals Industry

Recent Achievements

Ferrous smelting - HISMELT

There is extensive opportunity for adding value to Australian iron ores by further processing, but a key impediment is the massive investment required to establish a new plant on a sufficiently large scale to be competitive. In collaboration with CRA and a US based company, Midrex, CSIRO's Division of Mineral and Process Engineering is developing the HISMELT direct iron making process which enables economic operation at a smaller scale than the traditional blast furnace route to iron. A large scale research and development facility is being constructed with a budget of $100 million at Kwinana to demonstrate operation of the HISMELT process on a semi-commercial scale and to obtain operating data for the design of the first generation operating plants.

Industrial refractories - QMAG

Queensland Magnesia Pty Ltd. (QMAG), a joint venture between Queensland Metals Corporation, Pancontinental Mining and Radex Austria AD, has established a plant at Rockhampton using technology developed by CSIRO's Division of Mineral Products. The technology produces dead burnt and electro-fused magnesia which is used to produce a range of refractories. The export market is estimated to be $100 million per annum. The Division advised on the establishment of the laboratory and associated equipment and trained staff and, where necessary, developed new sophisticated methods of analysis.

Nickel exploration research

Mineral exploration methods depend largely on ore genesis models of how mineral deposits form in host rocks. A new model developed by CSIRO's Division of Exploration Geoscience enabled Australian Consolidated Minerals Ltd to find five new deposits in the Mt. Keith area, which has already been covered by 20 years continuous exploration using the old methods. The Mt. Keith region is now expected to supply 4.5 per cent of the world nickel metal market.

SIROSMELT technology

There is growing world wide acceptance of SIROSMELT bath smelting technology. CSIRO has licenced two companies to use the technology - MIM Holdings Ltd, and Ausmelt Pty Ltd. At Mt Isa Mines Ltd, a $65 million, 60,000 tonnes per annum (tpa) lead smelter (ISASMELT) has been constructed, and construction has begun on a 180,000 tpa copper plant to replace the existing reverberatory furnaces. Other recent developments involving MIM Holdings Ltd include the use of the technology in a copper/nickel smelter at Radio Hill in Western Australia and a copper smelter in the United States. Ausmelt have licensed a tin smelter in the Netherlands and a nickel/PGM (platinum group metals) smelter in Zimbabwe and announced contracts for a number of zinc-fumer, slag cleaning furnaces in Korea.

Titanium diboride production

Incorporation of the ceramic material titanium diboride into cathodes used in aluminium smelting cells gives a significant saving in electrical consumption. In collaboration with Comalco, CSIRO's Division of Mineral Products has developed a novel process route from the laboratory to technical scale to produce a high-grade pure titanium diboride product.

Upgrading mineral sands

Australia produces 50-60 per cent of the world supply of zircon, ilmenite and rutile. Reserves of rutile, primarily used as a feedstock for the production of paint pigments, are declining. CSIRO's Division of Mineral Products has carried out research on the conversion of ilmenite to synthetic rutile for AMC Mineral Sands Ltd. This research has contributed significantly to the Company's decision to develop the

Eneabba West deposit to provide feedstock to its new plant in Geraldton, WA.

Energy Resources and Supply Industries

Recent Achievements

Process control in coal preparation

In collaboration with BHP Engineering, CSIRO's Division of Mineral and Process Engineering has commercialised COALTROL, an advanced process control system for coal preparation plants. COALTROL uses another CSIRO developed on-line analysis system to:

- make adjustments to the relative density set points of the heavy media cyclones in the preparation plant,
- ensure that it meets the specified tonnage weighted ash over the production batch, and
- minimise short-term variations in product coal ash content.

A modified COALTROL package developed to control specific energy rather than ash has been installed in Illinois, USA.

Assistance with oil exploration

Even in highly promising areas, oil exploration companies may drill many holes that are dry or contain only traces of oil. When faced with these, should a company continue drilling in the same area, or move on to fresh fields? This is a difficult choice, but with drill holes costing $6 million each, it is a key one in oil and gas exploration. A new technique called Appatite Fission Track Analysis (AFTA), developed during collaboration between CSIRO and the University of Melbourne, provides help in making this decision by giving a direct indication of whether the temperature regime in a drilling area has been favourable or unfavourable for oil generation. AFTA is already in commercial use enhancing productivity in oil exploration.

Technology for lead acid battery production

Research by CSIRO's Division of Mineral Products has shown that the curing step used in the production of lead acid battery plates can be shortened dramatically. "Cureless paste" batteries have undergone extensive performance and life testing in vehicles and compare well with the conventional product.

Measuring the coking potential of coal

In collaboration with the Joint Coal Board, CSIRO has developed the Proton Magnetic Resonance Thermal Analyser (PMRTA) to meet the coking industry's need to know the coking potential of specific coals so

that they can be blended to provide strong coke. By measuring the mobility of carbon and hydrogen atoms in the molecular structure of coals as the sample is heated from 300° C to 660°C, the PMRTA determines the different temperatures and temperature ranges at which the coal will soften, become most mobile or "plastic" and become solid as a semi-coke. The PMRTA system has been sold to the British Coal Research Laboratories. Research bodies in Japan and the USA are also interested in purchasing an instrument.

Assessing the potential of petroleum source rocks

With the gradual decline of the giant Bass Strait oilfields, the North West Shelf is becoming the most important petroleum province in Australia. However, because of the costs of drilling offshore, exploration companies must be confident that their target source rocks have been sufficiently heated to enable hydrocarbons to be released from buried organic matter. Traditional tools for thermal maturity determination are unreliable due to the widespread occurrence of vitrinite (a type of organic matter with considerable petroleum generating potential) which contains an unusually high concentration of hydrogen. CSIRO scientists are using a laser Raman microprobe to determine the fluorescent properties of vitrinite to obtain an accurate measure of thermal maturity and hence, petroleum generation. A dozen Australian exploration companies are supporting pilot studies on North West Shelf wells.

Manufacturing Industries

Recent Achievements

From Gene Shears to Mini-Shears

Researchers from CSIRO's Division of Biomolecular Engineering have modified the design of the Gene Shears molecule to create a smaller, tougher version dubbed "Mini-Shears" which they hope will function when introduced as a "drug" rather than when manufactured within the living cell. Mini-Shears is a prototype for a range of molecules that could form the basis of novel Pharmaceuticals for treating viral diseases and cancer, and researchers are now making further modifications to enhance the delivery and effectiveness of the molecules.

High voltage cables

Olex Cables, Australia's only producer of extra-high-voltage cables, collaborated with CSIRO's Division of Applied Physics to develop computer models to predict the required temperature distributions within cables during manufacture. As a result, Olex Cables was able to compete successfully with major overseas manufacturers to win the contract to supply and install Victoria's $22 million Richmond - Brunswick 220kV power line.

Toxic waste treatment

In collaboration with Siddons, Ramset and Nufarm Limited, CSIRO's Division of Manufacturing Technology has developed a plasma waste destruction unit which has been commissioned at Nufarm's Laverton North manufacturing plant. The Plascon technology treats waste as it is made during the manufacturing process rather than afterwards, by exposing toxic substances to temperatures of up to 15,000°C, thus breaking down these toxic substances into safer compounds which can be recycled or disposed of safely.

Biomaterials for medical use

In collaboration with the Centre for Biomedical Engineering at the University of New South Wales, CSIRO has developed new polymeric biomaterials for application in medical devices. A biostable and biocompatible polyurethane formulation has been developed which is resistant to *in vivo* stress cracking, presently a major problem with implants. The polyurethanes also displayed extreme oxidative and hydrolytic stability and have potential in other specialised medical applications.

Improved traffic monitoring

Current traffic monitoring systems activate only when sensors or radars are triggered and often require road modifications in order to operate effectively. The SAFE-T-CAM system developed by CSIRO's Division of Manufacturing Technology in collaboration with Telecom and a local software developer, Iconix, is now being used on the Hume highway to monitor heavy vehicle movement. The SAFE-T-CAM technology offers superior road monitoring since it is portable, operates in all road conditions, emits no electromagnetic signals and needs no human maintenance.

Information and Communications Industries

Recent Achievements

Audio processor for cars and homes

This market-driven low cost microchip has been developed by CSIRO from its existing Fast Fourier Transform chip technology. It is aimed at providing sophisticated digital signal processing for the substantial car and home audio market. Engineering samples of the chip are fully operational and the project is entering the next phase of marketing and product development. Projected total chip and system sales over the next five years are some $45 million. The prime market will be car audio systems, and significantly larger markets for suitable derivative chips exist in telecommunications.

Mobile communications - antennas for Mobilesat

The Australian Space Office has approved funding for the commercialisation of a vehicle-mounted electronically-tracking antenna developed by CSIRO for the Land-Mobile-Satellite-Service. This compact antenna is suitable for fitting to cars and trucks to enable mobile voice and data communications. MITEC will be responsible for manufacturing the antennas and Codan for marketing. This CSIRO developed antenna is expected to gain a substantial share of the world-wide market.

Construction

Recent Achievements

A computer package for optimising route alignments

ALIGN 3D, developed by CSIRO's Division of Building, Construction and Engineering is a planning package intended to be used in conjunction with existing packages for constructing a road, railway or other transport facility. ALIGN 3D automatically explores a transport corridor and optimises the alignment of a route by presenting the user with a selection of low cost routes which allows him to select between them on the basis of cost and subjective criteria. The package can produce a set of twenty or more alternatives in a matter of hours, compared to the alternative of within days or weeks from conventional methods. It has been used in the Very Fast Train project, and on ore haulage roads in the Pilbara.

Commercial Services

Recent Achievements

Sewerage treatment

The continuous Racod meter has been developed by CSIRO to meet a need for continuous measurement of the components required for efficient removal of nutrients in sewage treatment plants. The instrument is likely to have broader applications for monitoring the performance of anaerobic digesters and conventional sewage plants. Local and multinational instrument makers are showing strong interest in the concept.

Economic Development, Environmental Aspects

Recent Achievements

Award-winning farm software

To help agencies and farmers optimise the use of water and land in irrigated areas CSIRO has developed a salt-water and groundwater management program. It is a PC based program which shows the consequences of various irrigation practices on groundwater levels, rates of soil salinisation and crop yields. This user friendly package won first prize in the NSW Royal Agricultural Society farm software competition sponsored by *The Australian.* The package is ideal for State extension officers, land managers, soil conservationists, teachers and students.

Interface device for data transfer

A CSIRO device being developed and marketed with MODAC SYSTEMS, can transfer data from remote locations to a personal computer in the home, office or laboratory. Through satellite and landline, the interface device connects directly to the data acquisition equipment currently used by water authorities and environmental agencies worldwide for water quality monitoring, flood warning, gas and oil pipeline monitoring and meteorology. Fifteen companies have registered interest in commercialising the technology.

National Pulp Mills Research Program

Commonwealth, State and industry funds have supported a CSIRO program to undertake research into pulp mill effluent and its impact on the marine environment. Results from projects in Phase 1 were made available in July 1992. They included:

- evaluation of chemical components in mill effluent,
- measurement of chlorinated phenolics and dioxin levels,
- study of how pulping plant processes affect chemical composition of effluent,
- development of methods to minimise organochlorine emissions from pulp mills,
- assessment of how effluent affects Australian algae, fish and molluscs, and
- modelling the mixing of effluent from a point source into Australian coastal waters.

Environmental studies

After preparing the initial study design for a major environmental study of Port Phillip Bay, CSIRO won a $12 million contract from a consortium headed by Melbourne Water, which included the Victorian Environment Protection Authority, the Department of Conservation and Environment, and the Port of Melbourne Authority.

CSIRO expertise in this area was also recognised by the Department of Defence who asked CSIRO to conduct a four year marine environmental study at Jervis Bay, NSW which was completed by 30 June 1992.

Sewer sentinel

A robust portable package for monitoring oxygen level, turbidity, temperature, pH and electrical conductivity in sewage effluent has been developed by CSIRO's Division of Materials Science and Technology. A prototype has undergone extensive and successful testing in collaboration with Melbourne Water, and the package is now being commercialised. The package gives early warning of hazardous discharges into the sewer system enabling preventative action to be taken in time to avoid damage to expensive treatment facilities. The device may also be used to detect illegal trade waste discharges into sewers and provide evidence for prosecuting the offenders.

Environment

Recent Achievements

"Clever clover" as a natural fertilizer

CSIRO researchers have devised a new way of managing the home vegetable garden. The system uses living clover as *a* natural fertiliser and mulch and was developed to help preserve soil in market gardens where too much tilling often causes soil degradation. The release of this story in the mass media has resulted so far in 1900 orders for clever clover kits at $10 each.

New edition of *The Insects of Australia*

In 1991, a two volume second edition *of The Insects of Australia* covering over 85,000 species was published. Produced largely by entomologists working with CSIRO's Australian National Insect Collection, it describes many new insect families and is the most comprehensive work of its nature in the world. It is a valuable reference for students, agriculturists, naturalists and general scientists as well as entomologists.

Weevil released to control *Mimosa*

A Mexican flower-feeding weevil was released in January 1992 to help control the woody weed *Mimosa pigra,* which is one of the worst environmental threats in Northern Australia. *Mimosa* already has a stranglehold over 800 sq kms of wetlands, and is threatening Kakadu National Park. It produces over 9,000 seeds per square metre annually, making it very difficult to control. The weevil is seen by CSIRO scientists as an essential component of a suite of potential biological control agents. The insect is the first to attack the plant's reproductive organs, thus reducing seeding and the rate of spread.

Health

Recent Achievements

Dietary fats and heart function

Research within the CSIRO Division of Human Nutrition has highlighted the cardioprotective effects offish oil fatty acids containing the omega-3 polyunsaturated fatty acids (PUFAs). Studies in animals have suggested a potential for the marine fatty acids in reducing cardiac arrhythmias and increasing the functional efficiency of the heart. These findings have provided the stimulus for studying the therapeutic values of edible oils as well as investigating the molecular basis for this cardiac protection.

Targeting health advice to selective audiences

Cholesterol is found in the blood attached to two main particles - low density lipoproteins (LDL), which promote heart disease, and high density lipoproteins (HDL) which protect against it. Human studies within CSIRO's Division of Human Nutrition have shown important gender differences in people's dietary fat and cholesterol. In cases where blood cholesterol levels rise, the excess cholesterol is carried in women in the "healthier" HDL particles, while in men most of the excess is in the undesirable LDL particles. This research demonstrates the need to focus public health advice on those people with clearly defined risk. This strategy will require precise methods of identification of those at risk.

Advancement of Knowledge

Recent Achievements

A year of achievement in radioastronomy

The Australia Telescope and the University of Sydney's MOST telescope have jointly monitored the emergence of a radio supernova remnant from the exploded star Supernova 1987A. This is the first time the creation of a radio supernova remnant has been observed and adds significantly to our understanding of the supernova process.

In July 1991, the discovery of ten millisecond pulsars (found with CSIRO's Parkes radiotelescope) was announced - on the front page of Nature. These pulsars were all in the one globular cluster 47 Tucanae, which now harbours almost half the known millisecond pulsars and more than a quarter of the known binary pulsars. These millisecond pulsars will provide stringent tests of the theory of general relativity and of stellar evolution.

Industry Research and Development Board

Role

Through the operation of various programs, to facilitate wealth creation by the development of internationally competitive Australian industries through the encouragement of successful innovation and improving Australian firms' awareness of the role of innovation in business growth.

The Industry Research and Development (IR&D) Board has operated under the Industry Research and Development Act of 1986. Under this Act, the Board has responsibility for administering several programs which are the tax concession, the Discretionary Grants Scheme, the Generic Technology Grants Scheme, the Advanced Manufacturing Technology Development Program (AMTDP) and the National Procurement Development Program (NPDP).

Tax concession for industrial R&D

Role

The objective of the tax concession/or industrial research and development is to make Australian companies more innovative and internationally competitive through improving innovative skills in Australian industry by:

- *increasing companies' investment in R&D;*
- *encouraging better use of Australia's existing research infrastructure;*
- *improving conditions for the commercialisation of new process and product technologies developed by Australian companies; and*
- *developing a capacity for adoption of foreign technology.*

The tax concession for industrial research and development is a major program in the Government's package of measures to encourage the performance of R&D in industry.

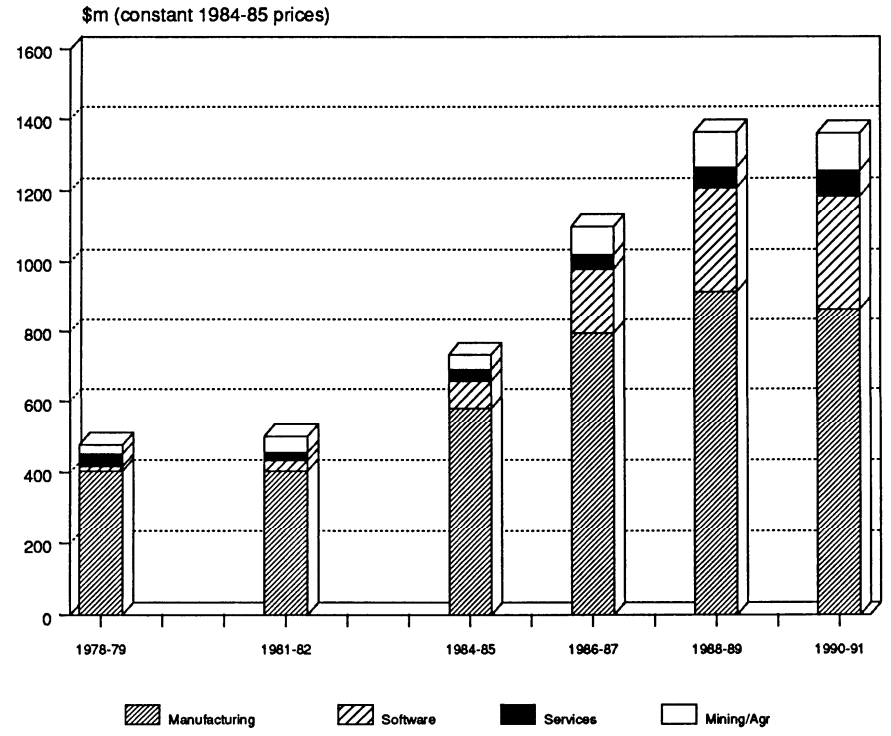
Recent Achievements

Effectiveness

Australian Bureau of Statistics R&D data show that the level of private business expenditure on R&D has increased substantially in real terms over the period since the introduction of the concession (see Figure 3 opposite). Much of the growth may be attributed to the concession. It

Figure 3

BUSINESS EXPENDITURE ON R&D



Source: *Australian Science and Innovation Resources Brief 1992* and ABS 8104.0

provides a considerable incentive to industry, with an estimated $316 million of company tax revenue foregone in 1991-92. It is available to all tax-paying companies conducting eligible R&D in Australia and is used by about 1600 companies each year.

Signalling technology

Signalling Technology Pty Ltd (Sigtec) have established a niche market in microprocessor based signalling products for use in narrow-band voice grade systems. The assistance of the tax concession has enabled Sigtec to develop a device which reduces chatter on taxi driver radios and eliminates radio traffic intended for other parties or groups. Sigtec has secured four long term contracts with multinational companies operating in Japan, North America, the UK and other European countries, for the supply of signalling circuit boards and other products

based on its proprietary signalling chips. The company now exports some 60 per cent of its output to more than forty countries.

Medical equipment

Australian Biomedical Corporation (ABC) is currently manufacturing and marketing sophisticated pathology equipment world-wide through the Leica corporation in Germany. About 98 per cent of the products produced by ABC are exported. The company claims that the tax concession has allowed them to bring products to market ahead of competitors and to mount an on-going product development program to expand their market position.

Discretionary Grants Scheme

Role

To provide support to companies which have insufficient taxation liability to take optimum advantage of the tax concession/or research and development but have the potential to fully exploit the results of research and development.

Recent Achievements

Improved range of cooking appliances

St George Appliances Pty Ltd of Victoria have used a Discretionary Grant project to provide aesthetic improvements, improved insulation, catalytic self-cleaning and enhanced manufacturing efficiency to a range of cooking appliances. The project was very much about bringing a company with 1950s technology into the 1990s. Completed in just over a year, the project has enabled the company to be competitive at the high end of the market with other Australian companies only now following their lead.

Automation in the food processing line

Australian Food Processing Laboratories Pty Ltd (AFPL) in Victoria have developed an overall hardware and software control system which automatically controls the packaging, sealing, sterilisation and cooking of a variety of packaged foods. With a small grant of $70,000 the company completed its project on schedule in six months. The control systems are now commercial and being sold to major food manufacturers. The company has grown from an annual turnover of $376,000 to $800,000 with employment increasing from 6 to 33 persons during the project period. The major part of this growth has been due to the installation, commissioning and start of production on the company's own processing line which is now supplying value-added processed foods to local and export markets. In addition, as part of AFPL's activities, substantial import replacement has been achieved.

Generic Technology Grants Scheme

Role

To provide support and directions for the development of strategic technologies, which are important/or the international competitiveness of Australian industry.

Recent Achievements

Electrowinning zinc at high current density

Increasing the current density in zinc electrowinning increases cell throughput, offering the possibility of lower capital cost through reduction in electrode area. Pasminco Metals Ltd and the CSIRO Division of Mineral Products collaborated on a project to evaluate the feasibility of electrowinning zinc at current densities about ten times the conventional level. Satisfactory performance at high current density was confirmed in laboratory-scale studies, and suitable operating conditions were defined. Several cells based on rotating cathodes were tested and continuous production of zinc strip was shown to be feasible. Careful attention was paid to deposit morphology and energy consumption, and sufficient data were collected to allow a preliminary economic assessment of the method.

High productivity welding processes

The CSIRO Division of Manufacturing Technology, the University of Wollongong Department of Materials Engineering, BHP Steel Slab and Plate Products Division, and Bisalloy Steels are collaborating on a project to improve productivity in the welding of steel plate.

The program of R&D has been directed towards process developments in multiple-wire submerged arc welding, narrow-gap gas-metal arc and submerged arc welding, robotic gas-metal arc welding and buried gas-tungsten arc welding. Significant advances have been made in all of these areas.

A particularly important outcome of the project, completed in June 1992, has been the linking together of CSIRO and University of Wollongong researchers with BHP to form the core partners in a new Co-operative Research Centre (CRC) for Materials Welding and Joining. The CRC will be centred on the research facilities of the partners in the project supported by the Generic Technology grant and involve additional organisations based in Adelaide, Sydney and Wollongong.

Artificial neural network for heart pacemaker

The University of Sydney and Teletronics Pacing Systems have developed new computer designs that allow much faster and more accurate processing than previously possible. These involved artificial neural networks which can be incorporated on a single silicon chip

within a heart pacemaker. This will benefit patients directly in therapeutic treatment, in that it will allow their hearts to work in a more natural fashion. The same techniques will also be used in other medical products.

Combating Influenza

Biota Holdings Ltd announced that one of its anti-viral compounds showing considerable promise will be evaluated by Glaxo for possible use in humans to combat influenza. This product of successful collaboration between Biota, CSIRO and the Victorian College of Pharmacy was designed and synthesised using novel Australian biotechnology developed under the Scheme. Biota have given Glaxo the right to develop and market these unique compounds in return for continued funding of the research program. Glaxo have made a milestone payment to Biota of $1.1 million on acceptance of this new compound into their program.

Advanced Manufacturing Technology Development Program (AMTDP)

Role

The Program provides financial assistance to support joint projects to trial and demonstrate and/or research and develop new products, including prototypes of AMTproducts, services and systems which meet the requirements of end-users and which improve the take up of new technology in industry.

The AMTDP was established in June 1991 following an announcement in the Industry Statement, *Building a Competitive Australia.* An amount of $20 million will be committed to the Program over four years.

The support of a number of key networking organisations, including the Metal Trades Industry Association (Council of Australian Machine Tool and Robotics Manufacturers) and the Automotive Technology Centre, has been enlisted to promote the program to appropriate participants.

National Procurement Development Program (NPDP)

Role

To provide grants for industry and government to collaborate in the research, development, trialling and demonstration of internationally competitive, innovative Australian products.

The NPDP was established in 1987. It was expanded from 1 July 1990 to formally include the participation of State and Territory Governments in providing financial, administration and promotional support.

Overall, 238 projects have been considered and 107 projects funded to a total commitment of $35 million. A recent independent evaluation of the program shows that the NPDP program despite its short period of operation and the long timeframe involved in commercialisation, has performed satisfactorily against its objective of improving the efficiency and international competitiveness of Australian industry.

An important long term objective of the program is to overcome risk aversion by government purchasing agencies in the purchase of Australian products and services. The program is having a positive impact, evidenced by strong interest from both government and industry. Twenty-eight Commonwealth and fifty-two State Government departments and agencies have participated in the program.

Recent Achievements

Airport terminal management system

In partnership with Federal Airports Corporation (FAC), the Preston Group, an innovative systems development company, was supported by a $450,000 NPDP grant to develop and trial a suite of planning, management and control software modules for use by airport operators - the Terminal Management System (TMS). It has used the Sydney Airport installation as a reference site to win orders from Heathrow, Schiphol (Netherlands), Brussels and Manchester airports. Export orders to date total over $3 million.

For the FAC, the trialing of TMS at Sydney Airport has resulted in greater capacity utilisation, achievement of cost savings and provision of a higher standard of passenger service through the increased use of aerobridges. Other benefits to the FAC have included greater staff productivity and a better response from airport management to all scheduling requirements.

Early detection of electric supply faults

A scientific instrument company, CHK Engineering Pty Ltd, entered into a partnership with the South East Queensland Electricity Board (SEQEB) to research, develop and trial a fault indicator to maximise the quick restoration of the electricity supply. The project was awarded a $160,000 NPDP grant. The development of a successful product has meant improved reliability of service for SEQEB customers, reduced costs and greater efficiencies through greater sensitivity to faults, early maintenance and reduced downtimes. For CHK, the program has resulted in access to domestic and North American markets and has changed its business from importer to exporter.

PRIMARY INDUSTRIES AND ENERGY

Science and Technology in the Portfolio Budget

The mission of the Department is to increase the contribution that the agriculture, minerals, energy, fisheries and forestry industries make to the well-being of Australians. Responsibility for achieving research and development objectives falls to different authorities at a number of levels within the portfolio. Three key institutional arrangements influence the strategic and operational aspects of portfolio research objectives and priorities. These are:

- the Primary Industries and Energy Research Council,
- three research bureaux, and
- eighteen Research and Development corporations and councils.

The *Primary Industries and Energy Research Council (PIERC)* was established to provide advice to portfolio Ministers on policies, priorities and strategies for portfolio R&D, and to provide a link to Australia's major science and technology bodies and industry. The Council comprises senior members from research funding bodies, government organisations, community groups, R&D corporations, industry, and the States. PIERC provides strategic directions for the portfolio's research effort, facilitates the networking and consultative processes within and outside the portfolio and advises on opportunities for collaborative research.

The Department's three research bureaux are the *Australian Bureau of Agricultural and Resource Economics (ABARE)*, the *Bureau of Mineral Resources, Geology and Geophysics (BMR)*, and the *Bureau of Rural Resources (BRR)*. Expenditure by these three Bureaux in 1992-93 is expected to be $86.7 million. These three bureaux play a vital role in the conduct of public sector research and provide scientific and economic advice to assist the process of Government. The research undertaken by these bureaux is funded predominantly from consolidated revenue. Their research output is mostly in areas where the external benefits are high and where user-pays funding is not generally cost-effective.

Eighteen *R&D Corporations and Councils* have been established to encourage greater end-user participation in research and to ensure industry research organisations are more active in the commercialisation of research and the realisation of industry opportunities, and more involved in the transfer of technology. Research expenditure undertaken through these bodies in 1992-93 is expected to be $188.7 million, of which approximately 47 per cent will be collected from industry levies.

Fifteen of the R&D Corporations and Councils are industry based:

- Cotton R&D Corporation
- Dairy R&D Corporation
- Fishing Industry R&D Corporation
- Grains R&D Corporation
- Grape and Wine R&D Corporation
- Horticultural R&D Corporation
- Meat Research Corporation
- Pig R&D Corporation
- Sugar R&D Corporation
- Wool R&D Corporation
- Honeybee R&D Council
- Egg Industry R&D Council
- Chicken Meat R&D Council
- Tobacco R&D Council
- Dried Fruits R&D Council

Provision is made for Government funding of these Corporations and Councils on a joint funding basis between industry and government. The Government's contribution is designed to provide an incentive for the primary industry sector to increase its R&D funding and to become more responsible for its own R&D priority setting. Within the portfolio, the R&D Corporations and Councils are the vehicles for decentralised management.

Three R&D Corporations are predominantly funded by Government:

- the Energy R&D Corporation,
- the Land and Water Resources R&D Corporation, and
- the Rural Industries R&D Corporation.

Direct funding of R&D by Government was judged as being appropriate for these Corporations, particularly where the private sector is likely to under-invest in R&D and where substantial benefits would accrue to the community as a whole. These Corporations are, however, able to generate income from royalties and licences for successful R&D they have sponsored, to actively solicit funds to finance worthwhile research proposals, and to accept voluntary contributions from industry.

MAJOR RESEARCH ACTIVITIES

Bureau of Rural Resources (BRR)

Role

BRR's role is to provide a more informed scientific and technical basis for decisions by governments and managers and thereby assist them to improve the economic and environmental sustainability of Australia's rural resources.

In undertaking its role, BRR:

- *provides short term advice and carries out strategic analysis and research to provide timely, authoritative scientific advice as input to rural resources policy and program management,*
- *facilitates and coordinates rural scientific activities including collaborative programs with other agencies, and participates in international scientific and other fora with direct relevance to the Bureau's objectives, and*
- *informs the community and stimulates public debate on rural issues of a scientific and technical nature.*

Recent Achievements

Fisheries resource status reports

In February 1992, BRR released the first set of a series of national fisheries status reports. The status reports were for the southern bluefin tuna, orange roughy, gemfish, northern fish trawl, Torres Strait prawns and Torres Strait rock lobsters. These reports highlighted that southern bluefin tuna and gemfish are currently over-exploited and catches are being controlled accordingly. For similar reasons, the catch of orange roughy will be reduced sharply to achieve this. The other fisheries species are being fished within sustainable limits.

Introduced vertebrates - control or harvest ?

BRR released the results of extensive studies into the distribution and use of introduced vertebrates in Australia. The studies showed the widespread distributions and impacts of feral animals on the Australian landscape, the potential for commercial harvest and the opportunities for Aboriginal communities to assist in managing pest species. A lack of stable markets was identified as the main impediment to commercial use in remote areas.

Bureau of Agricultural and Resource Economics (ABARE)

Role

To efficiently and effectively provide high quality economic information of direct relevance to Australia's primary and energy industries in order to enhance their economic performance and that of Australia as a whole.

Recent Achievements

Model for assessing the benefits of wool textile research

ABARE developed a computer model of the wool industry to enable benefit-cost comparisons to be made between projects in all stages of production, from wool growing to garment manufacture. In cooperation with CSIRO, the International Wool Secretariat and the Australian Wool Corporation, the model has been used to quantify the costs and benefits of CSIRO wool textile research. The economic gains from one particular spinning invention, Sirospun, were shown to be around 100 times the research and development costs.

Model for evaluating aluminium-related projects

A user friendly benefit cost evaluation model was developed to evaluate more than 50 of CSIRO's aluminium-related research projects. This model will assist CSIRO in project selection and the setting of research priorities.

Assessment of alternative royalty regimes

A mine level model developed at ABARE is being used in an Australian New Zealand Minerals and Energy Council review of current royalty regimes. The model is being used in assessing the effects on project viability and government revenues of alternative royalty regimes in the iron ore industry.

Bioeconomic model of the southern shark fishery

ABARE developed a model of the southern shark fishery incorporating the major biological, physical and economic features of the fishery. The model was used to analyse the likely economic and biological impacts of a range of management options for the fishery.

Regional model of Australian beef supply

Liberalisation of North Asian markets could result in a significant increase in demand and further diversity in the types of cattle turned off Australian properties. A regional model of Australian beef supply was developed by ABARE for use in estimating the likely regional impact of changes in activity in the beef sector. The model enables an assessment of the relative profitabilities of grass fed and grain fed beef production at the regional level.

Bureau of Mineral Resources, Geology and Geophysics (BMR)

Role

BMR's role is to contribute to the sustainable and environmentally responsible development of Australia's natural resources and the mitigation of hazards to life and property by:

- *generating publicly accessible information necessary for the exploration and assessment of the nation's petroleum, mineral and groundwater resources,*
- *participating in monitoring and developing an understanding of the natural environment,*
- *participating in global and regional geoscientific programs of importance to Australia, and*
- *providing independent scientific advice to government, industry and the public for the management of Australia's resources, development of multiple land use policies and environmental protection, mitigation of earthquakes and other natural hazards and detection of underground nuclear explosions.*

Recent Achievements

New structural interpretation of the Vulcan Graben, Timor Sea

BMR has enhanced the petroleum prospectivity of the Vulcan Graben in the Timor Sea, by providing a significantly improved understanding of the extemely complex geological structure of the area. The area includes the Jabiru, Challis and Skua oil fields. The research applied innovative techniques in the structural analysis of acromagnetic and seismic data, which enabled the history of oil migration and accumulation to be understood more fully. This will improve exploration efficiency through better targeting of prospects.

Novel environmental monitoring technique

Geochemical equipment aboard BMR's RV *Seismic*, originally designed to detect seepage of petroleum hydrocarbons from sub-seafloor accumulations, recently demonstrated its capability for environmental monitoring in a pilot survey with the Sydney Water Board. The equipment detected high concentrations of light hydrocarbons in sea water, indicating pollution from human sources. The continuous profiling capability of the equipment provides a unique tool with potentially wide application in environmental monitoring and offshore exploration.

Origins of the Great Barrier Reef

BMR was actively involved in the multilateral Ocean Drilling Program off the Great Barrier Reef. Research results dated the initiation of the Great Barrier Reef at less than 1 million years, considerably younger than was previously thought. This has major implications for our understanding of Australia's continental margins and sedimentary processes, which are significant factors affecting the sustainable development of Australia's continental margins. The study also provided explanations for two sediment geometries commonly seen on seismic sections, with direct benefits to hydrocarbon exploration. In addition, there was tantalising evidence of very early human activity in Australia, through the presence of increased amounts of charcoal in sediments. This find challenges currently accepted views of the timing of human settlement in Australia.

Definition of Australia's legal continental shelf

BMR has provided geoscientific advice to a number of government departments on the definition of Australia's legal continental shelf. This is of use in negotiations with neighbouring countries and on the delimitation of seabed boundaries with Indonesia (in the Christmas Island area) and New Zealand. This has been achieved by undertaking bathymetric mapping in areas of concern using the BMR's RV *Seismic*.

Improvements in the speed and accuracy of geological mapping

New image processing technology has been applied to airborne magnetic and radiometric data to produce coloured images which represent changes in the properties of surface and deep geological materials, usually not obvious from ground observations. Interpretation of these images is allowing the production of more reliable geological maps. Exploration interest has been stimulated in several areas, as a result of the sale of these images to industry. The maps also have significant application for land use planners concerned with erosion mitigation.

Dairy Research and Development Corporation

Role

To lead effective change for a profitable and competitive Australian dairy industry through excellence in research and development.

Recent Achievements

Controlling Johne's disease

Victorian researchers have led the world in developing a blood test to identify cattle infected with Johne's disease. The test is very specific and gives good indication of infected animals. When used in

combination with a faecal test, scientists are confident of identifying infected animals which should be slaughtered.

The research on Johne's research has been extended to develop an on-farm control program. The Corporation sent a brochure on controlling the disease to every dairy farmer in Australia.

New breeding techniques for white clover

Victorian researchers have made rapid progress towards breeding highly productive varieties of white clover with resistance to insect pests and viruses. By working with New Zealand scientists, and using techniques in biotechnology, years have been cut off the time it takes to breed new varieties through conventional breeding techniques.

Starter Culture Research Centre

Starter cultures are the live bacteria that begin the progress of turning milk into cheese, yoghurt and other fermented foods.

The Australian Starter Culture Research Centre was established to research and develop starter cultures that would produce superior cheese and other fermented food products. The Centre is a joint venture involving the Corporation and dairy manufacturers including Murray Goulbourn Co-operative, Bonlac Foods, United Milk Tasmania and Dairy Vale Co-operative. These companies have access to research developments, new starter cultures and consultancy services provided by the Starter Centre, which is based at the CSIRO Dairy Research Laboratory at Highett, Victoria.

Dairy Industry Quality Centre

In response to an industry initiative, the Corporation has established the Dairy Industry Quality Centre to focus on industry needs for research and information on ways to improve dairy product quality and thus improve export potential.

Located at the NSW Dairy Corporation Laboratories in Sydney, the Quality Centre's key roles are to:

- provide a quality information service on ways to improve dairy product quality,
- develop and co-ordinate the Corporation's quality research program, and
- conduct research on quality issues.

Grains Research and Development Corporation (GRDC)

Role

The activities of the Corporation focus on research and development aimed at enhancing the profitability, international competitiveness and sustainability of the Australian grains industry by developing grain products for markets, improving grain production efficiency and optimising the use of the natural resource base.

Recent Achievements

New conservation farming tool

A project supported by GRDC has resulted in the commercial release of a new planting boot which applies nitrogenous fertiliser safely during sowing. The availability of this technology will result in more efficient use of nitrogenous fertiliser in Queensland and northern New South Wales. The new tool reduces the risk of fertiliser being wasted between application and planting and increases the use of conservation cropping techniques.

Meat Research Corporation

Role

To manage the research and development needs of the meat and livestock industry.

Recent Achievements

Software package for Asian beef markets

A research project conducted by all the State departments of agriculture has resulted in the development of a farm software program, which will help southern graziers determine which north Asian market offers the best prospects.

Grape and Wine Research and Development Corporation

Role

To improve competitiveness and returns in domestic and international markets, and to ensure sustainable, commercial, environmental, marketing and social outcomes for the long term welfare of the Australian wine industry.

The Corporation's objectives are:

- *improved efficiency of grape and wine production,*
- *improved capacity to manage grape and wine style,*
- *development and adoption of sustainable, environmentally acceptable production techniques,*
- *balanced production of grapes in relation to size and nature of market demands, and*
- *high level of communication and accountability to the Australian wine industry*

Recent Achievements

Objective quality measurements

Measurement of grape quality is difficult to achieve, particularly as processing into wine can induce many changes in flavour and composition. Research undertaken at the University of Adelaide and the Australian Wine Research Institute has identified an indicator of potential wine quality that can be applied to fresh grapes. A testing process has been developed and is the subject of a patent application. The new test will allow rapid and precise allocation of grape inputs to particular market destinations.

Biological control of grapevine mites

Mites, very small invertebrate animals, have the potential to reduce grapevine performance. Work conducted by the NSW Department of Agriculture has identified natural predators of these mites and has verified their presence in parts of NSW, Victoria and South Australia. Strategies to encourage the activities of predators, and even the rearing of predator populations have been developed and Australian grape growers are now being encouraged to adopt these strategies.

Sugar Research and Development Corporation (SRDC)

Role

To foster an internationally competitive and sustainable Australian sugar industry through directed investment to meet the strategic R&D needs of the industry.

Recent Achievements

Transgenic sugarcane plants

A simple and efficient system has been developed for the production of transgenic sugarcane plants. This work, by researchers at the University of Queensland, Department of Botany, supported by SRDC, is a world first which opens the way for the application of genetic engineering techniques for sugarcane improvement.

Cane loss monitor

During the harvest of sugar cane, losses can be significant particularly when green cane harvesting is practiced. These losses have been of concern to the industry for a number of years. A joint project between BSES and Agridry Rimik Pty Ltd, using SRDC funds, has led to the development of an instrument for monitoring cane losses from the harvester. The instrument monitors several other harvester functions in addition to cane loss and provides the machine operator with the information needed to reduce cane losses. Commercial versions of the monitor are being used during the 1992 harvest.

Wool Research and Development Corporation (WRDC)

Role

To plan and recommend a research and development program that will maximise the net returns to Australian woolgrowers and to the economy in an environmentally and economically sustainable way.

The objectives of the Corporation are:

- *wool enhancement,*
- *fibre and product specification,*
- *cost reduction in production and processing, and*
- *environmental sustainability.*

Recent Achievements

Measuring faults in wool tops

A new technology developed by Centexbel in Belgium for measuring faults (neps, vegetable matter and dark fibres) in wool tops was released to industry. The Optalyser, an instrument developed with support from WRDC, uses the application of advanced optics and image analysis to quickly and consistently assess tops for faults. At present, these faults are determined by a very expensive, slow and relatively inaccurate manual inspection of top webs spread over a lighted area.

New wallaby grass cultivars for pasture use

Two cultivars of native wallaby grass (*Danthonia* species) developed through the National Pasture Plant Improvement Program have been licensed for release. Wallaby grass tolerates drought and grows naturally in low fertility soils. It will be useful in establishing low-cost grazing systems in higher rainfall areas and on the margins of the rangelands.

Honeybee Research and Development Council

Role

To direct, administer, examine and evaluate research and development needs, and to fund projects aimed at improving the productivity and profitability of the honeybee industry.

Recent Achievements

Control of American Brood disease

American Brood disease is a bacterial disease of honeybees that causes significant economic losses to the beekeeping industry. A laboratory test has been developed by the New South Wales Department of Agriculture, which for the first time in bee disease control, facilitates an effective trace back system to diseased hives. This test provides the means to determine more accurately the true incidence and prevalence of American Brood Disease. It also provides the basis for the development of more effective disease control strategies for American Brood disease both in Australia and overseas. Most States are already using it as a diagnostic tool.

Impact of commercially managed honeybees on native flora and fauna

A study proceeding in Ngarkat Park, South Australia, demonstrated the ability of beekeepers and ecologists to work hand in hand to access the impact of honeybees on native flora and fauna. The study to date

indicates that honeybees do not have a negative impact in the circumstances studied, and indeed may have a beneficial impact on the seed set of native plants.

Egg Industry Research and Development Council

Role

To develop and implement a plan for research and development for the Australian egg industry. The Council aims to improve the economic, environmental and social conditions facing producers and those involved in the processing and marketing of eggs and egg products.

Recent Achievements

Recommendations for the control of external parasites of poultry

Following a two year study which concluded during 1990-91, the Council is in the process of printing a booklet aimed at egg producers which will demonstrate how mites can be controlled in sheds. The mites, northern fowl mite and poultry red mite, damage the host by sucking blood and causing irritation. This leads to decreased egg production and/or increased food consumption. Very heavy infestations may kill hens.

The publication will include a simple one page question and answer guideline for each mite species. It will nominate those registered pesticides capable of controlling mites, how the pesticide can be applied, how long the treatment lasts and other management measures that can be taken to prevent reinfestation.

Tobacco Research and Development Council

Role

To support a research and development program to reduce significantly the cost of producing tobacco leaf and improve overall leaf quality.

Recent Achievements

Mechanical harvester

Early successful trials of a prototype mechanical harvester aroused great interest in the industry. After further modification and successful extensive trials in 1992-93, the machine could move quickly towards commercialisation.

Energy Research and Development Corporation (ERDC)

Role

To stimulate and facilitate investment in effective energy research/or Australia in order to:

- *increase the efficiency use of energy use,*
- *increase the development of competitive Australian Industries,*
- *increase the diversity of energy supply,*
- *reduce adverse environmental impacts,*
- *reduce energy requirements, and*
- *reduce energy costs.*

Recent Achievements

Advanced generation options for the Australian electricity supply industry and their impact on greenhouse emissions

This extensive study, by Ewbank Preece Sinclair Knight, was 50 per cent funded by the Electricity Supply Association of Australia. The objective of the study was to assess the likely future relevance to Australia of advanced methods of large-scale electricity generation which are now being developed around the world. A particular aim was to assess the capability of emerging technologies to contain or reduce the rates of greenhouse gas emissions to the atmosphere from electricity generation. The study has provided a valuable contribution to knowledge and options for the industry and has now been published.

Mass flow rates of oil, water and gas in pipelines

The Petroleum Division of the Australian Minerals Industry Research Association and CSIRO Division of Coal and Energy Technology have developed and successfully proven techniques for the on-line determination of mass flow rates of oil, water, and gas in pipelines, using dual energy gamma ray transmission, and microwave techniques. The laboratory accuracy of these techniques, compared to conventional mass flow rate measurements, has proved to be better than within 5 per cent. Field measurements on the Western Mining Company's (WMC) offshore oil platform Vicksburg in Western Australia are proving to be very successful. A combination of the microwave and gamma ray transmission techniques has also proved to be successful in the laboratory and equipment design is in progress.

Spark ignition natural gas engine

In October 1991, Ford Motor Company commenced a demonstration of a natural gas vehicle in their truck fleet operating between the Geelong and Broadmeadows plants in Victoria. Ford Australia and GAFCOR, in

conjunction with Cummins Diesel Australia and supported by a research investment by ERDC, have developed a Ford truck fitted with a Cummins engine which has been converted by GAFCORto run solely on natural gas. The demonstration phase of the project has seen the truck travel approximately 800 km per day between the Ford Geelong and Broadmeadows plants in Victoria. At an average fuel cost of 15 cents per kilometre, this represents a saving of over 45 per cent compared to the diesel trucks in the fleet.

Gas assisted solar water heater

During May 1992, Solarhart, a unit of James Hardie Industries Limited, released its gas assisted solar water heater to the Australian market. This event marked the culmination of a short development program for which the ERDC provided 50 per cent funding. The solar water heater market in Australia is dominated by electric boosted units. Gas boosting promises reduced primary energy usage and emissions. The gas assisted system is expected to appeal to new markets and initial forecasts suggest an additional turnover of between 1000 to 2000 units.

International standards for solar water heaters

The University of New South Wales provided technical support to Standards Australia for their input to the International Standards Association program on solar water heater testing. A standard has been approved for submission and it is anticipated that it will be adopted as an International Standard. This will allow exporters of solar water heaters to test their products in Australia, and have the results recognised in countries that accept international standards. This will considerably reduce the time and cost of establishing new export markets for Australian solar water heater products.

Land and Water Research and Development Corporation

Role

To improve the long term productive capacity, sustainable use, management and conservation of Australia's land, water and vegetation resources through a directed, integrated and focussed research and development effort

Recent Achievements

Environmental effects of pesticides

The long term effects on Australia's river ecosystems of the intensive use of pesticides in Australian agriculture is an area of particular concern. The Corporation, in collaboration with the Cotton Research

and Development Corporation and the Murray Darling Basin Commission, recognised the need for a coordinated research effort to assess the impact of pesticides on the Riverina environment, using the cotton industry as a model. A study was conducted to review the current state of knowledge and to identify gaps for future research. The resultant R&D priorities will be the focus of a jointly funded commissioned program to commence in early in 1993.

Rural Industries Research and Development Corporation (RIRDC)

Role

To enhance the sustained economic contribution of agricultural industries to the national economy. To achieve this, it organises and funds research and development to support small, emerging and new rural industries. RIRDC also addresses broader issues of interest to those in the agricultural sector such as agroforestry, climate change and pest and disease control. The Corporation also provides services for the semi-independent research and development councils.

Recent Achievements

Release of first Australian grown aromatic rice

RIRDC has been working with the New South Wales rice industry and the New South Wales Department of Agriculture's rice breeders based at Yanco, to develop Australian varieties of aromatic rice. These varieties attract premium prices on the domestic and international markets. This year saw the release onto the domestic market of the first Australian grown aromatic rice, which was developed as a result of RIRDC funding to the New South Wales Department of Agriculture rice breeders program. This product is achieving good domestic market share and will be marketed internationally in the coming year.

Release of foods imports study

ACIL Australia Pty Ltd undertook a study of food imports into Australia on behalf of the Corporation, the results of which were released this year. The study found that, while there is considerable anxiety in parts of rural Australia about what appears to be a trend of rapidly rising food imports, the rate of increase in food imports has actually slowed appreciably.

PRIME MINISTER AND CABINET

Science and Technology in the Portfolio Budget

Expenditure on science and technology policy through the independent, high level advisory body ASTEC is expected to be $2.0 million in 1992-93 ($1.7 million in 1991-92).

Expenditure on science and technology policy and programs through the Office of the Chief Scientist is expected to rise to $55.7 million in 1992-93 ($19.5 million in 1991-92). This amount incorporates $54.5 million for the Cooperative Research Centres (CRC) Program (of which $1.2 million is a carry over from 1991-92).

Funds for the Resources Assessment Commission are $5.5 million ($5.3 million in 1991-92) to undertake resource assessment activities.

MAJOR POLICY ACTIVITIES

Prime Minister's Science Council

Role

To provide a major forum for consideration of issues of national significance in science and technology, and to keep the Prime Minister and senior Ministers abreast of key issues and thereby enhance the understanding of matters affecting Government policies.

The Science Council is chaired by the Prime Minister and includes Ministers with primary responsibility for science and technology matters. Additional members are drawn from the scientific and technological community and from industry to allow the Council the benefit of the best expertise available in Australia.

The Government policy statement, *Developing Australian Ideas*, has announced the Government's decisions to:

- change the name of the Council to the Prime Minister's Science and Engineering Council;
- have the Treasurer join the Council;
- invite the current President of the Institution of Engineers, Australia, to join the Council; and

- provide the Council with the following terms of reference, to:
  - address important issues in science, technology, engineering and relevant aspects of education and training,
  - examine the contribution of science, technology and engineering to the economic and social development to Australia,
  - to enhance awareness in community of the importance of science, technology and engineering for Australia's economic and social development,
  - examine Australia's science and engineering resources and effectiveness of their organisation and utilisation, and
  - examine Australia's science and engineering infrastructure and the effectiveness with which it achieves the application of science and technology in the economic and social development of Australia.

Recent Achievements

The Science Council held meetings in December 1991 and May 1992. Preparations for these meetings were organised through independent working groups in each of the topics to be discussed. These working groups undertook wide consultation with Government Departments, industry and the research community through meetings and seminars. (The topics discussed are listed in Section 1.)

Coordination Committee on Science and Technology

Role

To facilitate the sharing of information on science and technology issues and assist the coordination of programs and policies concerned with science and technology.

The Coordination Committee brings together senior officers from all Commonwealth Departments with an interest in science and technology as well as the heads of major research funding and performing agencies.

Recent Achievements

There were four meetings of the Coordination Committee during the year and a major undertaking was the preparation of a report on *Costing and Pricing of Public Sector Research.* Subcommittees of the Coordination Committee have also examined issues relating to databases and the formulation of a Commonwealth response to the recommendations relating to Environmentally Sustainable Development (ESD) Research, Development and Demonstration

contained in the reports of the ESD working groups

The Coordination Committee also reviewed four theme papers for the White Paper on Science and Technology which were then discused at the December meeting of the Prime Minister's Science Council.

Office of the Chief Scientist

Role

The Office of the Chief Scientist provides policy advice, briefing and support directly and through the Chief Scientist to the Prime Minister and Minister Assisting. It also provides advice, information and administrative support for specific programs in order to maintain and enhance a world class Australian science and engineering infrastructure, and to achieve the effective application of science and technology for the economic and social development of Australia.

The Office of the Chief Scientist:

- provides secretariat services to the Prime Minister's Science Council and to the Coordination Committee on Science and Technology, including coordination of the preparation of papers for consideration by the Prime Minister's Science Council;
- provides support for the Cooperative Research Centres Committee in its development of recommendations to the Minister Assisting in advice on the selection of the Cooperative Research Centres and, implements and administers the Program;
- provides advice on issues in science and technology, directly and through the Chief Scientist, to the Prime Minister and the Minister Assisting;
- obtains information about current and emerging developments and issues in science and technology policy;
- maintains close liaison with the Prime Minister's Office and consults with relevant Departments and agencies, to keep informed of significant developments and to facilitate cross-portfolio policy coordination;
- consults broadly with people outside Government, including with research, business, academic communities and the union movement, in order to bring a wide range of views and experience to bear on the development of policy advice;
- advises on the coordination of the work of the Structural Adjustment Committee of Cabinet and other Committees, as appropriate; and
- initiates and develops new policy proposals where appropriate, in cooperation with other Departments.

During the year, major activities of the Office of the Chief Scientist included the organisation of two meetings of the Science Council in December 1991 and May 1992, the organisation of four meetings of the Coordination Committee, the preparation and coordination of the major Government policy statement *Developing Australian Ideas* and the establishment of an additional nineteen Cooperative Research Centres.

Recent Achievements and Future Directions

The Cooperative Research Centres Program

The Cooperative Research Centres Program was launched in May 1990. Under the Program, new Government funding, rising to $100 million annually (1990 dollars) by 1995, will be provided to support up to fifty Centres.

The objectives of the Program are:

- to support long term and high quality scientific and technological research which contributes to national objectives, including economic and social development, the maintenance of a strong capability in basic research, and the development of internationally competitive industry sectors;
- to capture the benefits of research, and to strengthen the links between research and its commercial and other applications, by the active involvement of the users of research in the work of the Centres;
- to build centres of research concentration by promoting cooperative research, and through it a more efficient use of resources in the national research effort; and
- to stimulate education and training, particularly in graduate programs, through the active involvement of researchers from outside the higher education system in educational activities, and of graduate students in major research programs.

The Cooperative Research Centres Committee, which is appointed by the Prime Minister and chaired by the Chief Scientist, provides advice on the Program. The Committee is assisted by two expert advisory panels, with expertise in a wide range of scientific and engineering disciplines. During the selection process, the panels also draw on the expertise of a range of other Australian and overseas assessors.

Selection of Centres

The second round of the selection process for the Program was completed in December 1991. Twenty Cooperative Research Centres were selected, but the offer of funding was subsequently withdrawn from one of the applicants. The following nineteen Cooperative Research Centres (CRCs) have been established:

- Australian Maritime Engineering
- Materials Welding and Joining
- Polymer Blends

- Australian Photonics
- Sensor Signal and Information Processing
- Distributed Systems Technology
- Molecular Engineering and Technology
- Cardiac Technology
- Cochlear Implant, Speech and Hearing Research
- Biopharmaceutical Research
- Tropical Plant Pathology
- Industrial Plant Biopolymers
- Viticulture
- Hardwood Fibre and Paper Science
- Legumes in Mediterranean Agriculture
- Australian Mineral Exploration Technologies
- Hydrometallurgy
- Catchment Hydrology
- Biological Control of Vertebrate Pest Populations

A third and last selection round for Centres under the Program is currently underway, following the receipt of seventy-three applications by the 1 July 1992 deadline.

Australian Science and Technology Council (ASTEC)

Role

To provide independent advice to the Government on science and technology policy matters, including:

- *the advancement of scientific knowledge*
- *applying science and technology to the national well-being*
- *the adequacy, effectiveness and balance of science and technology in Australia*
- *identification and support of new ideas in science and technology likely to be of value to Australia*
- *practical development and application of scientific discoveries*
- *the fostering of innovation in industry*
- *improving efficiency in the use of resources by the application of science and technology.*

Recent Achievements

Research and Technology: Future Directions

During 1991, a very substantial part of ASTEC's resources were devoted to the preparation of *Research and Technology: Future Directions*, which was tabled in September 1991. This report was commissioned by the Prime Minister, following from the recommendations in ASTEC's earlier report Setting Directions for Australian Research, in order to prepare the way for a Government policy statement *Developing Australian Ideas*. Several of ASTEC's current studies arose out of *Research and Technology: Future Directions* (see Section 1 for further details).

Major national research facilities

In April 1991, ASTEC was commissioned to conduct a study of major national research facilities, defined as those costing over $5 million each. The study was concerned with facilities which are likely to require Government decisions on their funding over the next 5-10 years.

The study produced two reports, *Major National Research Facilities: Expressions of Interest* (1991) and *Major National Research Facilities: A National Program* (1992). The latter report received significant press coverage and has been well received by the science and technology community.

Other activities

Other ASTEC activities included the following:

- ASTEC's report *Setting Directions for Australian Research* was tabled in Parliament in mid September 1990. A joint ASTEC/ARC seminar was held in October 1990 to launch the report and to look forward to its possible implementation. The proceedings of the seminar were published in July 1991.
- ASTEC and the Federalism Research Centre (Australian National University) jointly sponsored the workshop *Science, Technology and Australian Federalism: Getting the Best from the System*, at the Australian National University in April 1991. The proceedings were published in September 1991.
- ASTEC, the Centre for Research Policy, University of Wollongong and the Department of State Development, NSW jointly sponsored a workshop on research data in November 1991. The proceedings of the workshop were published in May 1992.
- ASTEC held a Forum on National and International Developments in Big Science in May 1992. The Forum had two presentations on recent international meetings, a presentation on the *Major National Facilities: a National Program* report and three case studies of major national research facilities.

TRANSPORT AND COMMUNICATIONS

Science and Technology in the Portfolio Budget

There are two organisations in this portfolio dealing with scientific services and supported from the budget outlays. They are the Australian Road Research Board (ARRB) and the Federal Office of Road Safety (FORS).

The budget outlay for the ARRB during 1992-93 is expected to remain at $2.2 million. The Budget outlay for FORS will be $140.6 million (which incorporates $130 million for the Federal "Black Spots" Program).

A large number of Government Business Enterprises (GBEs) in this portfolio deal with scientific services and conduct research. Their activities do not appear in the Budget. These include the Australian and Overseas Telecommunications Corporation, Australia Post, QANTAS, Australian Airlines, the Federal Airports Corporation, the Civil Aviation Authority and a number of other organisations.

MAJOR RESEARCH ACTIVITIES

Federal Office of Road Safety (FORS)

Role

To minimise deaths, injuries and crashes on the roads and their social and economic consequences, to promote safety in road travel, to administer and coordinate national road user and vehicle safety programs in a cost effective manner. Collection and analysis of statistical data and a well focused re search program are central to this role.

Recent Achievements

Fatigue in the road transport industry

An extensive program of fact finding on Australian and overseas data included a survey of road transport operators and over 860 truck drivers. The first stage of this study reported on current fatigue management practices within the industry, and in similar industries, both in Australia and overseas. Results indicated a broad consensus

between drivers and industry on the extent of the problem and a range of strategies to tackle it.

Drink driving

Two reports have been released on the effect of the reduction of the legal blood alcohol concentration for driving in the ACT from 0.08 to 0.05. This work has shown that introduction of the lower limit greatly reduced the incidence of drink driving at very high blood alcohol levels, as well as in the 0.05 to 0.08 range. This was instrumental in achieving support for the introduction of the 0.05 blood alcohol limit in Western Australia.

Passenger car occupant protection

A major research project was undertaken to find cost effective ways of improving passenger car occupant protection. This included field surveys to relate injuries to crash severity together with a barrier crash test program of Australian cars to assess the improvements possible when utilising a range of new safety technology. As a result, a new Australian Design Rule for frontal impact protection has been issued for public comment. This research is expected to lead to major improvements in Australian passenger car safety including the installation of driver side airbags in most new models by 1995.

Improving bus safety

A package of Australian Design Rules aimed at providing bus occupants with a high level of protection has now been put into place. These include revised emergency exit provisions, stronger seats and anchorages, requirements for rollover strength and fitting of seat belts to all seating positions in long distance coaches.

The research program supporting this work included dynamic and static tests of existing and prototype bus seats and the design and construction of a prototype bus structure to meet the rollover strength requirements. A code of practice based on the prototype and computer simulation has been prepared to assist industry to meet the requirements.

Research has also been done in the areas of crash avoidance which encompasses mandating speed limiters, improving braking performance and research on driving hours and graduated licences.

Drugs and driving

The first year of a three year research initiative on drugs and driving has established the feasibility of using small saliva samples to research legal and illegal drug use in the general driving population. This overcomes severe limitations associated with the use of blood samples for the same purpose.

Support for the Australian Road Research Board (ARRB)

Role

To undertake relevant and timely research and associated services to help the road transport sector in Australia provide safe, sustainable, efficient and effective transport services.

Recent Achievements

Accelerated Loading Facility

ARRB's activities included the use of the Accelerated Loading Facility at Brewarrina (NSW) to test the durability of low cost pavements subject to intermittent flooding. The pavement treatments developed as a result of this trial will result in substantial cost savings in the construction of all weather roads.

Camera Data Acquisition System

ARRB has developed and recently released a Camera Data Acquisition System (CAMDAS). CAMDAS processes video traffic information in real time to perform speed counts and monitor traffic movements, headway and driver behaviour. This avoids the need to install physical detectors or to perform manual vehicle counts in dangerous or complex traffic situations.

SECTION 3:

TRENDS IN COMMONWEALTH SUPPORT FOR SCIENCE AND INNOVATION

Summary Data

Commonwealth support for major science and innovation programs has risen from $2708 million in 1991-92 to an estimated $2857 million in 1992-93, a real increase of 2.2 per cent. Broadly, there have been significant increases over the whole period since 1981-82, with the tax concession schemes providing particular stimulus from about 1985. Omitting those concessions, the rise in total Commonwealth support results from increased R&D overall in the higher education sector coupled with a steady rise in amounts disbursed through the various granting schemes.

Figure 4 and Table 1 present a summary of Commonwealth support for science and innovation at constant price values. They provide a four-way breakdown of the data as follows :

- higher education research
- R&D in Commonwealth agencies
- special purpose or directed research grant schemes
- industrial incentives through tax concessions.

Higher Education Research

Support for research in the higher education sector (excluding support from special purpose grant schemes) is estimated to increase to $1143 million in 1992-93 from $1084 million in 1991-92, representing a real increase of 2.1 per cent.

The higher education sector receives support through general or nondirected research funds (actually the research component of funds which are provided for both teaching and research purposes), funds provided specifically for research, and research funds under the control of the Australian Research Council (ARC). Only funds provided specifically for higher education are considered here. (A significant proportion of the funds provided under special purpose grant schemes also flow to higher education).

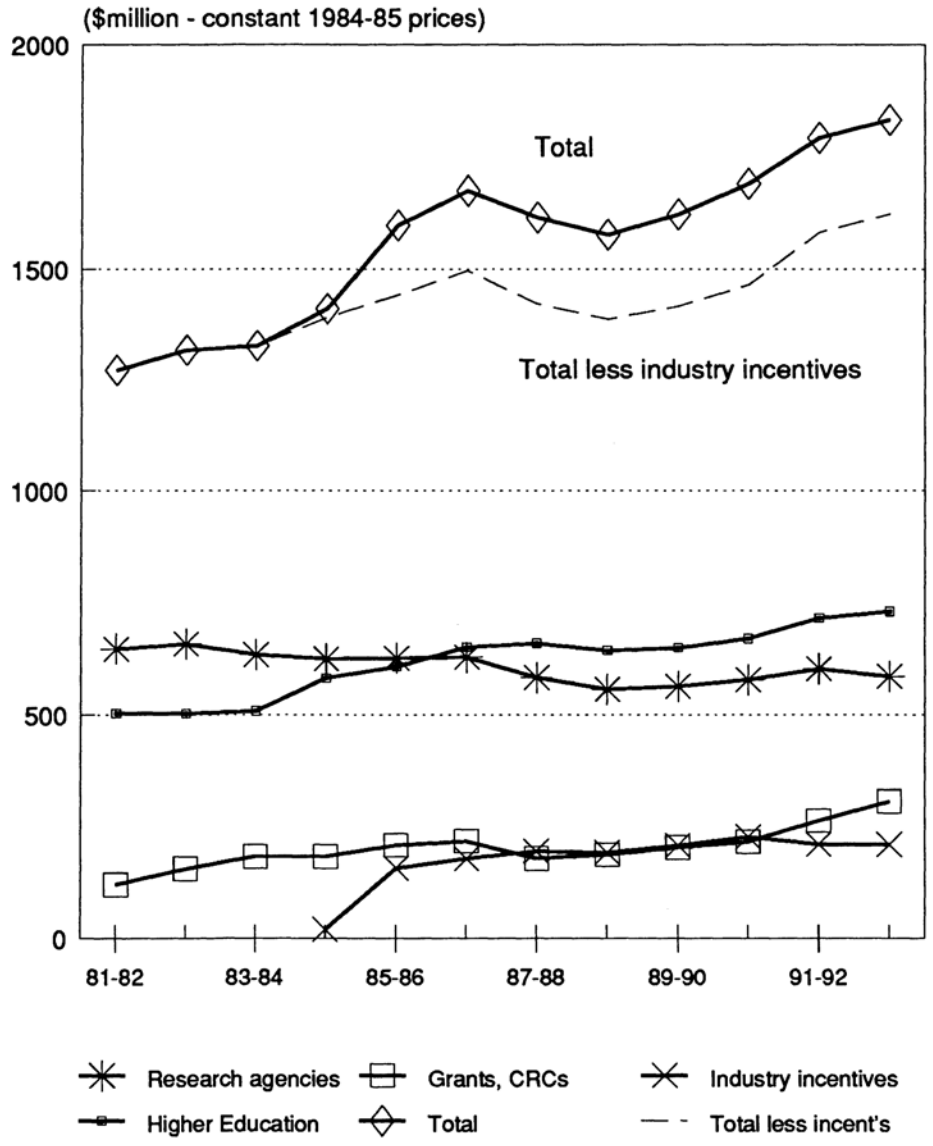
TABLE 1 Constant Price Summary of Major Commonwealth Support for Science and Innovation, Through the Budget and Other Measures ($m at constant 198435 prices)

	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	(est) 1992-93
MAJOR SCIENTIFIC RESEARCH AGENCIES												
• Defence	158.5	157.2	155.3	158.4	154.9	159.2	151.4	156.0	157.6	152.9	153.7	141.2
• Civil	489.7	502.1	480.1	467.3	472.2	470.2	432.5	401.1	406.3	425.8	449.5	444.8
SUB-TOTAL	648.2	659.3	635.4	625.7	627.1	629.4	583.9	557.1	563.9	578.7	603.2	586.0
SCIENCE AND INNOVATION GRANTS												
• Health and Medical	36.0	39.3	47.9	52.0	52.6	55.8	56.5	57.2	62.8	72.9	83.2	83.8
• Industry and space	34.5	64.1	75.1	69.2	93.7	90.7	66.1	64.0	67.4	67.7	87.3	98.6
• Cooperative Research Centres	-	-	-	-	-	-	-	-	-	-	12.1	34.9
• Rural	30.8	31.1	36.9	41.4	44.8	55.4	44.0	54.3	57.4	55.3	62.5	70.7
• Energy and environment	14.5	17.0	18.6	16.7	13.5	12.4	9.1	8.7	12.9	17.3	15.4	15.2
• Transport	3.4	2.8	3.6	2.8	2.4	1.7	1.6	1.5	1.4	1.5	1.5	1.4
SUB-TOTAL	119.2	154.3	182.1	182.2	207.0	216.0	177.3	185.6	201.9	214.7	261.9	304.7
COSTS OF IR&D & RELATED INCENTIVES	-	-	-	20.0	155.9	177.1	193.5	190.3	206.4	225.4	209.1	208.3
HIGHER EDUCATION RESEARCH												
• ARC and related grant schemes	39.9	45.6	49.1	52.8	54.4	56.5	58.3	62.9	87.0	122.8	161.7	174.7
• Specific R&D support	106.8	106.5	110.2	112.0	110.2	109.4	108.5	105.6	105.0	104.3	105.9	105.8
• Est. general research support	356.8	351.1	349.6	418.0	443.5	486.1	493.9	475.8	458.4	444.1	450.0	451.9
SUB-TOTAL	503.5	503.2	508.8	582.8	608.1	652.0	660.8	644.3	650.4	671.3	717.6	732.4
TOTAL COMMONWEALTH SUPPORT AT ESTIMATED 84-85 PRICES	**1271**	**1317**	**1326**	**1411**	**1598**	**1675**	**1615**	**1577**	**1623**	**1690**	**1792**	**1831**
EST. REAL % INCREASE/DECREASE		3.6	0.7	6.4	13.3	4.8	-3.5	-2.4	2.9	4.2	6.0	2.2

SOURCE: Based on data in Table 2 and using GDP non-farm deflators.

Figure 4

MAJOR COMMONWEALTH SUPPORT FOR SCIENCE AND INNOVATION



Source: *See Table l*

Research in Commonwealth Agencies

The largest Commonwealth research agencies are CSIRO, DSTO, ANSTO, BMR, Antarctic Division and AIMS. Support through Budget appropriations to these agencies, and some smaller ones, is expected to be $914 million in 1992-93, compared with $912 million in 1991-92 (a real decrease of 2.9 per cent).

It is important to note that the research agencies receive funds in addition to those appropriated directly and that these sums are not included in the amounts referred to above. Such external funding has increased significantly in recent years. For example, CSIRO receives business funding, funds from earned revenue (from licencing fees, disposal of assets etc.) and additional Commonwealth support won competitively via the special purpose grant schemes. To encourage improved links with industry, the Government has set a target for external earnings (ie, funds from other than its direct Budget appropriations) of 30 per cent of total funding. Direct appropriations to CSIRO for 1992-93 are expected to amount to $456 million (with a further $8 million through DPIE and DITAC, see Table 3) , but the total budget of the Organisation is expected to be in the region of $685 million.

Special Purpose Research Grant Schemes

Support for R&D through the special purpose research grant schemes is estimated to increase to $475 million in 1992-93 from $396 million in 1991-92, representing a real increase of 13.5 per cent.

The Commonwealth has established a number of research grant schemes which are directed to special areas of interest - health and medical research (NH&MRC), rural research (RIRFs and other rural), industrial R&D (GIRD and its predecessors), energy R&D, and some smaller ones. The new Cooperative Research Centres, established for the purpose of promoting linkages, are also included in this category.

Tax Incentive Scheme - Industrial R&D and Innovation

Estimated support for R&D and innovation in the business sector through the industrial R&D tax concession will be $325 million in 1992-93 ($316 million in 1991-92), at about the same level in real terms.

If the tax concession scheme is included with the industrial component of the special purpose grants, total support for industrial R&D and innovation is expected to be $479 million in 1992-93, rising from $448 million in 1991-92, a increase of 3.5 per cent.

Changes in the Balance of Funding

Figure 5, expressed as a percentage of GDP, provides an alternative view to Figure 4. In addition, funding of both civil and defence research agencies is shown and higher education funding is split between specific R&D funding and general university funding of R&D (GUF) which is the estimated research component of support for teaching and research.

Looking at the broad changes apparent in Figures 4 and 5, Budget funding for the research agencies has remained approximately static in real terms over the period since 1981-82. The slight fall is due to the conclusion of some substantial capital expenditures and recent policy changes to shift the balance towards non-Budget competitive funding. Over the same period, the special purpose schemes have increased significantly. This increase is even more substantial if the industry incentive schemes are included. When this is done support for industrial R&D is seen to have received the largest increases. Support for health and medical research and for rural research has also risen significantly.

The increases in funding for industrial R&D have followed policy changes which recognise its important role in innovation and competitiveness. Australian business R&D has been shown to be at comparatively low levels in relation to other OECD nations (see Section 5) and there has been little effective interaction between industry researchers and those in government agencies and universities.

In the higher education sector there has also been a significant increase in funding since 1981-82. Within the sector, there has been a substantial shift so that the proportion of funds controlled by the ARC is now much higher. Total funds have increased overall and there has been a substantial change in the funding mechanisms.

The 1988-89 dip in total funding levels is traceable mainly to a real fall in the level of Budget funding for Commonwealth research agencies, since offset by increases in external funding. Such non-Commonwealth funding is not shown in Figures 4 and 5.

Detailed Data

Table 2 is the current price summary corresponding to Table 1. It summarises the data from Tables 3, 4 and 5.

For the most part, the data series in Tables 3 and 4 are comprised of well-defined expenditures which can be readily identified from the Budget Papers. However, Table 5 presents a less clear-cut situation for the two largest items. The first of these is the estimated research component of the general Commonwealth funding for universities. This includes support for teaching activities as well as for research and the research component can only be estimated on the basis of the ABS R&D surveys. Since there were no ABS surveys in some earlier years, and survey results will not be available for some time in relation to the latest years shown, the effect of adding this series to others, as in Table 2, is to blur the assessment of overall trends. See the footnotes to Table 5.

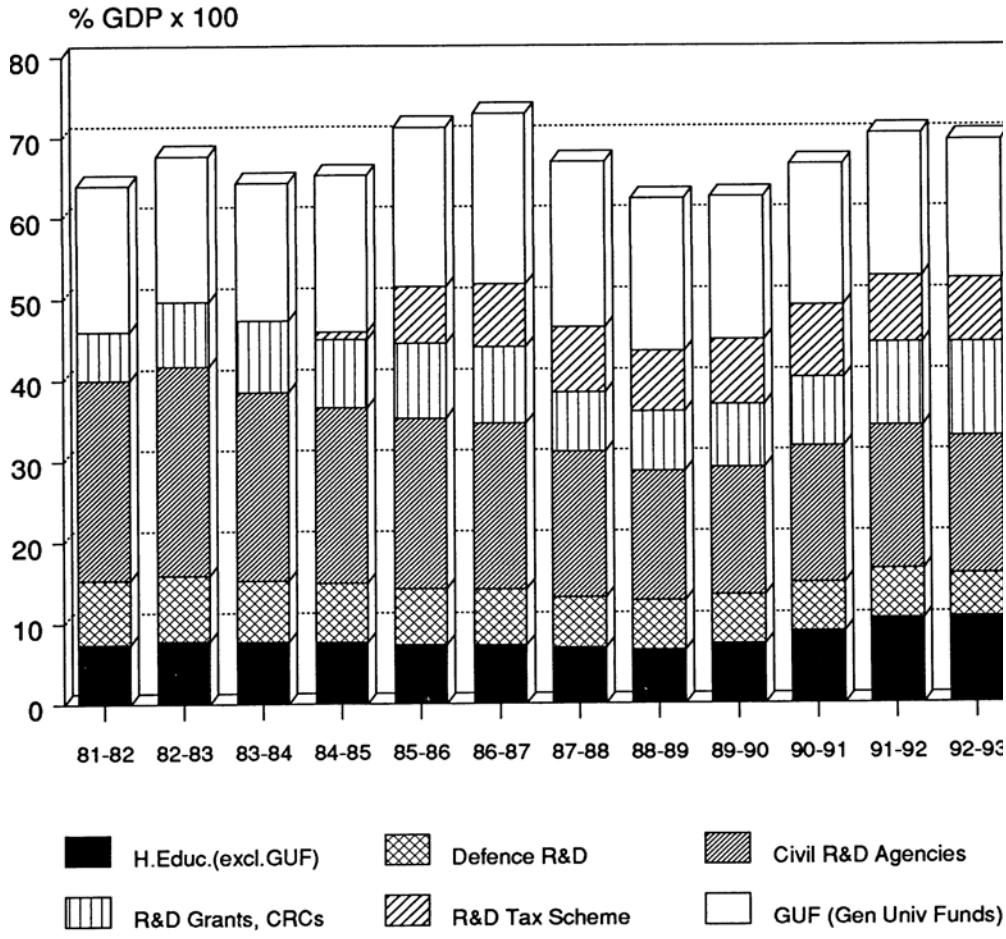
TABLE 2 Summary of Major Commonwealth Support for Science and Innovation, through the Budget and Other Measures ($m)

	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93 (est)
MAJOR SCIENTIFIC RESEARCH AGENCIES												
• Defence	126.1	138.8	146.6	158.4	165.9	183.4	187.0	209.8	225.2	227.2	232.3	220.3
• Civil	389.8	443.3	453.2	467.3	505.8	541.7	534.1	539.5	580.6	632.7	679.2	693.9
• SUB-TOTAL	515.9	582.2	599.8	625.7	671.7	725.1	721.1	749.3	805.8	859.9	911.5	914.1
SCIENCE AND INNOVATION GRANTS												
• Health and Medical	28.6	34.7	45.3	52.0	56.3	64.3	69.7	76.9	89.7	108.4	125.7	130.7
• Industry and space	27.5	56.6	70.9	69.2	100.3	104.4	81.7	86.0	96.4	100.5	131.9	153.9
• Cooperative Research Centres	-	-	-	-	-	-	-	-	-	-	18.2	54.5
• Rural	24.5	27.5	34.9	41.4	47.9	63.8	54.3	73.0	82.0	82.1	94.4	110.3
• Energy and environment	11.5	15.0	17.5	16.7	14.4	14.3	11.3	11.7	18.5	25.8	23.3	23.7
• Transport	2.7	2.5	3.4	2.8	2.6	2.0	2.0	2.0	2.0	2.2	2.2	2.2
SUB-TOTAL	94.9	136.3	171.9	182.2	221.6	248.9	219.0	249.6	288.6	319.0	395.7	475.3
COSTS OF IR&D & RELATED INCENTIVES	-	-	-	20	167	204	239	256	295	335	316	325
HIGHER EDUCATION RESEARCH												
• ARC and related grant schemes	31.8	40.3	46.3	52.8	58.3	65.0	72.0	84.5	124.4	182.5	244.3	272.5
• Specific R&D support	85.0	94.0	104.0	112.0	118.0	126.0	134.0	142.0	150.0	155.0	160	165
• Est. general research support	284.0	310.0	330.0	418.0	475.0	560.0	610.0	640.0	655.0	660.0	680	705
SUB-TOTAL	400.8	444.3	480.3	582.8	651.3	751.0	816.0	866.5	929.4	997.5	1084.3	1142.5
TOTAL COMMONWEALTH SUPPORT	**1012**	**1163**	**1252**	**1411**	**1712**	**1929**	**1995**	**2121**	**2319**	**2511**	**2708**	**2857**
% GDP	0.640	0.677	0.643	0.653	0.712	0.729	0.669	0.623	0.625	0.666	0.704	0.696
TOTAL COMMONWEALTH SUPPORT AT ESTIMATED 1984-85 PRICES	**1271**	**1317**	**1326**	**1411**	**1598**	**1675**	**1615**	**1577**	**1623**	**1690**	**1792**	**1831**
EST. REAL % INCREASE/DECREASE		3.6	0.7	6.4	13.3	4.8	-3.5-	-2.4	2.9	4.2	6.0	2.2

SOURCE: See Tables 3, 4 and 5

Figure 5

MAJOR COMMONWEALTH SUPPORT FOR
SCIENCE AND INNOVATION AS A PERCENTAGE OF GDP



Source: *See Table 2 and ABS 5206.0*

TABLE 3 Major Commonwealth Research Agencies - Budget Outlays ($m)

	Outlays											(est.)
	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
ARTS. SPORT, THE ENVIRONMENT, TOURISM & TERRITORIES												
Antarctic Division	21.6	32.0	35.2	37.4	42.2	47.4	49.2	46.3	57.7	62.8	67.3	65.4
Bureau of Meteorology Research Centre (BMRC)[1]	1.2	1.7	1.7	1.8	1.8	2.3	2.5	2.2	2.4	2.8	3.3	3.1
Supervising Scientist Alligator Rivers Research Inst	4.0	6.0	4.5	4.7	5.5	6.1	5.9	6.6	7.5	6.7	7.5	7.0
DEFENCE												
Defence Science and Technology Organisation	126.1	138.8	146.6	158.4	165.9	183.4	187.0	209.8	225.2	227.2	232.3	220.3
EMPLOYMENT, EDUCATION & TRAINING												
Anglo-Aust Telescope	1.7	1.9	1.8	1.8	1.9	2.0	2.4	2.5	2.7	2.9	3.0	3.1
HEALTH, HOUSING & COMMUNITY SERVICES												
Australian Inst, of Health (excl. grants)	3.0	3.4	4.0	4.6	5.1	5.2	3.4	4.2	4.4	4.2	5.0	6.4
CSL Ltd (Budget component)	4.9	6.3	6.6	8.8	12.8	15.8	17.3	16.6	9.4	3.0	5.9	10.7
INDUSTRY, TECHNOLOGY & COMMERCE												
Aust Nuclear Science & Technology Organisation[2]	37.8	36.4	38.8	41.9	45.4	45.2	50.8	54.3	57.5	62.6	65.1	67.7
Australian Institute of Marine Science	5.7	6.4	6.9	7.4	7.6	8.2	9.5	11.0	11.4	13.6	14.2	14.0
CSIRO[2]	290.9	328.2	331.6	324.9	344.3	367.8	347.8	348.1	375.2	414.4	446.3	456.2
Kraft Pulp Mill study (CSIRO)	-	-	-	-	-	-	-	-	0.5	1.4	1.9	1.9
PRIMARY INDUSTRIES & ENERGY												
Contribution to CSIRO for Aust Animal Health Labs				3.9	4.1	4.4	4.7	4.7	4.9	5.3	5.5	6.0
Bureau of Mineral Resources[3]	18.9	21.1	22.0	30.1	35.2	37.4	40.6	42.9	47.0	52.9	54.2	52.3
TOTAL	**515.9**	**582.2**	**599.8**	**625.7**	**671.7**	**725.1**	**721.1**	**749.3**	**805.8**	**859.9**	**911.5**	**914.1**

(1) BMRC was established on 1 January 1985. Prior data are estimated R&D expenditures by the Bureau of Meteorology.
(2) CSIRO and ANSTO figures for 1980-81 were adjusted to include superannuation on the same basis as in subsequent years.
(3) From 1989-90, property operating expenses (principally rent) of about $3m per annum are deducted to reflect expenditure on the same basis over the series.

TABLE 4 Major R&D Granting Programs and other Support for Science and Innovation through the Budget ($m)

	Outlays											(est.)
	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
ARTS, SPORT, THE ENVIRONMENT, TOURISM & TERRITORIES												
Aust Biological Resources Study	0.8	1.0	1.1	1.2	1.2	1.0	1.1	1.3	1.6	1.2	1.8	2.0
Greenhouse research	-	-	-	-	-	-	-	0.8	5.7	8.7	9.6	10.0
EMPLOYMENT, EDUCATION & TRAINING												
Research evaluation and Academies	-	-	-	-	-	-	-	-	-	1.6	2.0	2.0
ARGS & ARC grants/fellowships (including marine R&D grants)[1]	20.7	22.7	25.5	30.8	34.6	39.8	42.7	50.7	35.6	1.2	-	-
Post-graduate Awards[1]	8.8	11.5	15.1	16.3	17.8	19.3	20.3	21.7	11.3	-	-	-
Education R&D Grants	0.8	0.2	-	-	-	-	-	-	-	-	-	-
Targetted Institutional Links Program	-	-	-	-	-	-	-	-	0.2	1.0	2.0	1.1
HEALTH, HOUSING & COMMUNITY SERVICES												
AIDS Research	-	-	-	-	0.8	1.5	3.0	3.5	5.0	7.1	10.8	10.4
Health and Community Services Research Grants	1.4	1.5	3.2	1.6	1.6	1.8	1.1	1.4	1.7	1.6	1.6	1.6
NH&MRC Research Grants	25.6	30.0	38.5	44.2	51.2	59.4	65.6	72.0	83.0	94.7	103.3	108.7
Capital Works for Medical Institutes	1.6	3.2	3.5	6.3	2.6	1.6	-	-	-	5.0	10.0	10.0
INDUSTRY, TECHNOLOGY & COMMERCE												
IR&D Incentives Act 1976												
. Commencement grants	9.7	13.1	14.6	16.3	14.3	16.9	3.1	0.1	-	-	-	-
. Project grants	12.1	34.8	43.2	38.1	37.7	17.9	6.4	2.8	0.3	-	-	-
. Public interest projects	2.4	4.9	8.1	9.8	6.3	3.5	1.0	0.3	-	-	-	-
IR&D Act 1986 (GIRD)	-	-	-	-	-	10.8	25.6	31.8	32.0	29.6	32.2	-
. Biotechnology grants	-	-	0.7	2.2	4.3	-	-	-	-	-	-	-
Advanced Manufacturing Tech Program	-	-	-	-	-	-	-	-	-	-	0.1	-
National Procurement Development Program (NPDP)	-	-	-	-	-	-	0.7	3.9	5.6	4.2	4.4	-
Technology Development Program	-	0.2	0.7	0.9	0.8	1.2	1.4	1.1	1.9	3.0	3.2	-
Industry Innovation Programs	-	-	-	-	-	-	-	-	-	-	-	45.8
InterScan support	2.1	2.2	2.5	-	-	-	-	-	-	-	-	-

TABLE 4 Major R&D Granting Programs and other Support for Science and Innovation through the Budget ($m) — *continued*

	Outlays											(est)
	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
National Space Program	-	-	-	-	3.0	5.0	3.2	5.4	2.4	5.5	5.7	7.0
Malaria Vaccine Joint Venture	-	-	-	-	0.3	0.4	0.8	1.2	0.8	2.3	9.4	-
Research associations[2]	1.2	1.3	1.7	1.9	1.9	2.0	2.0	-	-	-	-	-
Motor Vehicle R&D	-	-	-	-	20.6	22.9	11.6	8.4	8.3	4.7	2.3	0.1
Assistance under the Bounty[3]												
(Computers) Act 1984	-	-	-	1.5	13.2	19.4	25.7	31.1	45.0	51.3	74.5	71.0
Australia Technology Group												30.0
PRIMARY INDUSTRIES & ENERGY[4]												
Wool Research	7.9	8.6	10.0	11.7	13.0	14.4	12.1	21.7	20.8	11.7	13.8	15.5
Meat Research	4.0	4.6	5.4	4.0	5.5	8.4	8.6	11.9	13.8	13.6	20.8	22.8
Fishing Industry Research	1.5	2.5	3.1	4.3	5.0	6.2	6.2	5.4	8.1	8.4	6.6	8.8
Grains	7.5	6.8	10.8	14.1	15.2	17.9	11.2	11.1	13.3	14.4	14.8	15.7
Horticulture Research	-	-	-	-	-	-	-	0.6	1.2	3.1	4.4	6.5
Energy research	10.7	14.0	16.4	15.5	13.2	13.3	10.2	9.6	11.2	15.9	11.8	11.7
Land & Water research	0.7	1.2	0.7	1.5	1.8	4.9	7.8	10.4	9.9	13.3	13.3	15.5
Special Rural Research Fund	0.2	0.2	0.1	0.3	0.4	1.5	3.0	4.0	5.0	6.0	8.4	10.5
Other rural research	2.8	3.6	4.6	5.4	7.0	10.6	5.5	8.0	10.1	11.7	12.3	15.0
PRIME MINISTER & CABINET												
Cooperative Research Centre Grants	-	-	-	-	-	-	-	-	-	-	18.2	54.5
TRANSPORT & COMMUNICATIONS												
Payments to Australian Road												
Research Board	1.9	2.0	3.0	2.3	2.0	2.0	2.0	2.0	2.0	2.2	2.2	2.2
Railway R&D Organisation	0.8	0.5	0.4	0.5	0.6	-	-	-	-	-	-	-
TOTAL	**125.9**	**170.6**	**212.5**	**229.4**	**274.0**	**307.9**	**282.0**	**322.1**	**335.6**	**322.9**	**399.7**	**478.4**

FOOTNOTES TO TABLE 4

(1) From 1989-90 most ARC funding has been appropriated through the *Higher Education Funding Act* rather than the Budget. See Table 5. ARC funding now includes post-graduate awards and the grants and fellowships formerly administered under the Australian Research Grants Scheme (ARGS)

FOOTNOTES TO TABLE 4 - *continued*

(2) Prior to 1981-82, Commonwealth support for Research Associations was provided through CSIRO. Since 1988-89 the Associations are fully funded by industry.
(3) Assistance is provided for local manufacturers of computer hardware, systems software and electronic microcircuits. It covers design and development costs.
(4) For consistency, the expenditure figures for Wool, Meat, Other Rural Research, Fish, Horticulture and Grains exclude that component of Commonwealth outlays funded from industry levies. The component of outlays provided by way of industry levy or contribution is given in the following table .

INDUSTRY CONTRIBUTION
(estimated proportion of levies attributable to research purposes - $m)

	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93 est
Wool	8.77	8.83	9.30	12.32	11.88	15.25	18.31	14.21	19.63	17.11	14.05	15.46
Meat	3.02	4.16	3.61	4.61	5.55[a]	7.68[a]	8.65[a]	11.58[a]	13.30[a]	15.17[a]	25.60[a]	22.80[a]
Grains												
- Grain[b]	0.77	0.52	1.33	1.30	2.16	2.07	2.35	2.53	3.99	4.27[b]	5.31[b]	7.48[b]
-Wheat	1.97	4.65	4.65	5.40	5.48	6.40	5.16	8.35	9.84	8.45	12.92	16.84
Coal[c]	5.16	4.28	2.14	4.17	3.28	4.82	7.07	15.02	17.05	14.95	13.88	8.90
Special Rural	-	-	-	-	-	-	-	-	0.20	0.30	0.15	1.03
Fish	-	-	-	-	-	-	-	-	-	0.50	1.12	2.95
Horticulture	-	-	-	-	-	-	-	-	-	0.92	1.54	2.58
Other Rural												
- Chicken Meat	0.22	0.24	0.23	0.24	0.29	0.38	0.40	0.38	0.46	0.55	0.78	0.60
- Cotton	0.20	0.25	0.67	1.00	0.89	1.04	0.86	1.55	1.87	2.66	3.87	3.53
- Dairying	0.42	0.54	0.57	0.60	0.67	1.26	1.64	1.57	2.94	4.82	5.21	5.00
- Dried Fruit	0.12	0.12	0.09	0.12	0.16	0.32	0.26	0.29	0.39	0.45	0.78	0.86
- Grape & Wine	0.28	0.37	0.38	0.49	0.52	0.67	0.82	0.94	1.28	1.25	0.96	1.47
- Honey	0.06	0.05	0.05	0.05	0.08	0.09	0.11	0.10	0.12	0.14	0.07	0.13
- Pig Industry	0.42	0.40	0.42	0.60	0.78	1.00	1.43	1.37	1.95	2.58	2.68	2.68
- Egg Industry	0.15	0.15	0.15	0.16	0.22	0.31	0.28	0.37	0.30	0.45	0.57	0.60
- Sugar	-	-	-	-	-	-	1.28	1.40	1.37	1.48	1.28	3.52
- Tobacco	0.41	0.47	0.55	0.67	0.66	0.69	0.64	0.94	0.77	0.59	0.59	0.70
Total	22.83	22.29	23.71	30.61	32.61	41.98	49.25	60.62	75.47	76.66	91.36	97.12

(a) Industry contributions for meat R&D to the Australian Meat Research Corporation.
(b) From 1990-91 barley, grain legumes, and oilseeds are covered by a single outlay to the Grains R&D Corporation.
(c) Coal research is funded entirely through industry levies. As there is no Commonwealth contribution it is omitted from Table 4.

TABLE 5 Estimated Costs of Programs and Incentives providing support for Research and Innovation outside the Budget ($m)

	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93 (est)
EMPLOYMENT, EDUCATION & TRAINING*												
Higher Education Funding Act: special research assistance [1]	1.5	5.9	5.7	5.6	5.9	6.0	9.0	12.1	77.3	178.7	240.3	269.4
Identifiable research support for universities[2,4]	85.0	94.0	104.0	112.0	118.0	126.0	134.0	142.0	150.0	155.0	160.0	165.0
Estimated research component of general university funding for both teaching and research[3,4]	284	310	330	418	475	560	610	640	655	660	680	705
INDUSTRY, TECHNOLOGY & COMMERCE												
Tax Concession[5] for industrial R&D	-	-	-	-	147	184	219	249	276	301	316	325
Tax Deduction for equity subscriptions in Management Investment Companies (MICs)[6]	-	-	-	20	20	20	20	7	19	34	-	-
TOTAL	**371**	**410**	**440**	**556**	**766**	**896**	**992**	**1050**	**1177**	**1329**	**1396**	**1464**

* These data are estimates of funding provided for higher education research through the *Higher Education Funding Act* and predecessor legislation.

(1) Includes funding for ARC Research Grants, Postgraduate Awards, Fellowships, Overseas Postgraduate Research Scholarships, Special Centres and Infrastructure but excludes funding through Budget sources.

(2) Indicative estimates. The three most recent items are projections based on 1987 identifiable research expenditure data collected by DEET from pre-1986 universities and include funds earmarked for research purposes. They do not include funds spent on research from the operating grants of former advanced education institutions.

(3) The data since 1988-89 are projections based on the 1988 ABS R&D Survey. They should be regarded as indicative only, especially given the magnitude of changes in the higher education sector over recent years, including amalgamations and the redirection of funds from university operating grants to the ARC. They include an estimate of the research component of teaching and research expenditure from the operating grants of the pre-1986 universities. They do not include funds spent on research from the operating grants of former advanced education institutions. Estimates for 1978-79, 1981-82, 1984-85, 1986-88 and 1988-89 are based on ABS R&D Survey data. Estimates for other years are indicative only.

(4) As far as possible, the estimates provided are on a basis consistent with the regular ABS surveys of R&D. The following data, of interest for other purposes, are derived using the Relative Funding Model (see Section 2).

	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93 est
ANU Institute of Advanced Studies (estimate) [a]	71	76	81	87	93	97	100	108	122	134	141	144
Estimated research and research training component of higher education operating grants [b]	202	229	252	271	293	315	334	366	397	429	475	494

(a) This is an estimate of funds provided for research and research training to the Institute of Advanced Studies through the operating grant of The Australian National University

(b) This is an estimate of the research and research training funds within the operating grants of all higher education institutions. The relevant methodology, developed for the Relative Funding Model applied to the operating grants of institutions in 1990, estimates a component of the operating grant associated with research training and another associated with non-training research.

(5) A 150% company tax deduction for eligible industrial R&D expenditure has applied from 1 July 1985. The data series comprise estimates based both on information provided in registrations for the concession and analysis by the Australian Taxation Office (ATO). They do not account for any recoupments arising from the dividend imputation system. The focus of the Table is on the effect of Government actions in the wider community. Hence the series given shows the estimated cost to revenue attributable to business R&D activity in particular years. Because the payment of tax is lagged behind the concessional R&D activity, a separate series estimates the revenue foregone in each year. From 1985-86 to 1991-92 this series is nil, $105m, $145m, $190m, $245m, $270m, $290m and $305m.

(6) Licensed Management and Investment Companies invest in approved high technology/growth activities. The equity subscription in these companies attracted a 100% income tax deduction in the year that subscriptions were made. The scheme concluded in June 1991.

A further blurring results from the inclusion of the estimated costs of Commonwealth revenue foregone through the taxation concession scheme for industrial R&D. As already indicated, the amounts shown are estimates. (See footnote (4) to Table 5.) However data presented in Table 5 this year incorporates some improvements to the estimates published previously.

Budget-based Science and Innovation Data and ABS R&D

Over the past three decades there has been considerable international effort to reach agreed definitions of R&D . The resulting definitions have been applied with some rigour in periodic surveys conducted within most OECD countries. This so-called "Frascati" methodology has been applied in Australia since 1969 when the national R&D surveys, now conducted regularly by the Australian Bureau of Statistics (ABS), were introduced.

The results from the R&D surveys have been essential in establishing benchmarks and time series in various expenditure and workforce indicators related to the Australian research effort.

At the same time, commentators have frequently sought to use data taken from the Budget papers to formulate views on the adequacy of Commonwealth support for research and the implications of this for science and technology policy. The data series presented in this Section has been developed to meet that need. For this reason, data presented here will not exactly match the R&D aggregates reported in ABS surveys. The practice followed here of listing whole agencies and programs as defined for administrative and financial purposes inevitably leads to the partial inclusion of non-R&D activities. In addition, there is a significant amount of R&D funded through agencies and programs not listed. Nevertheless, there are broad similarities between trends in what is described here as "science and innovation" and R&D expenditures as reported by ABS.

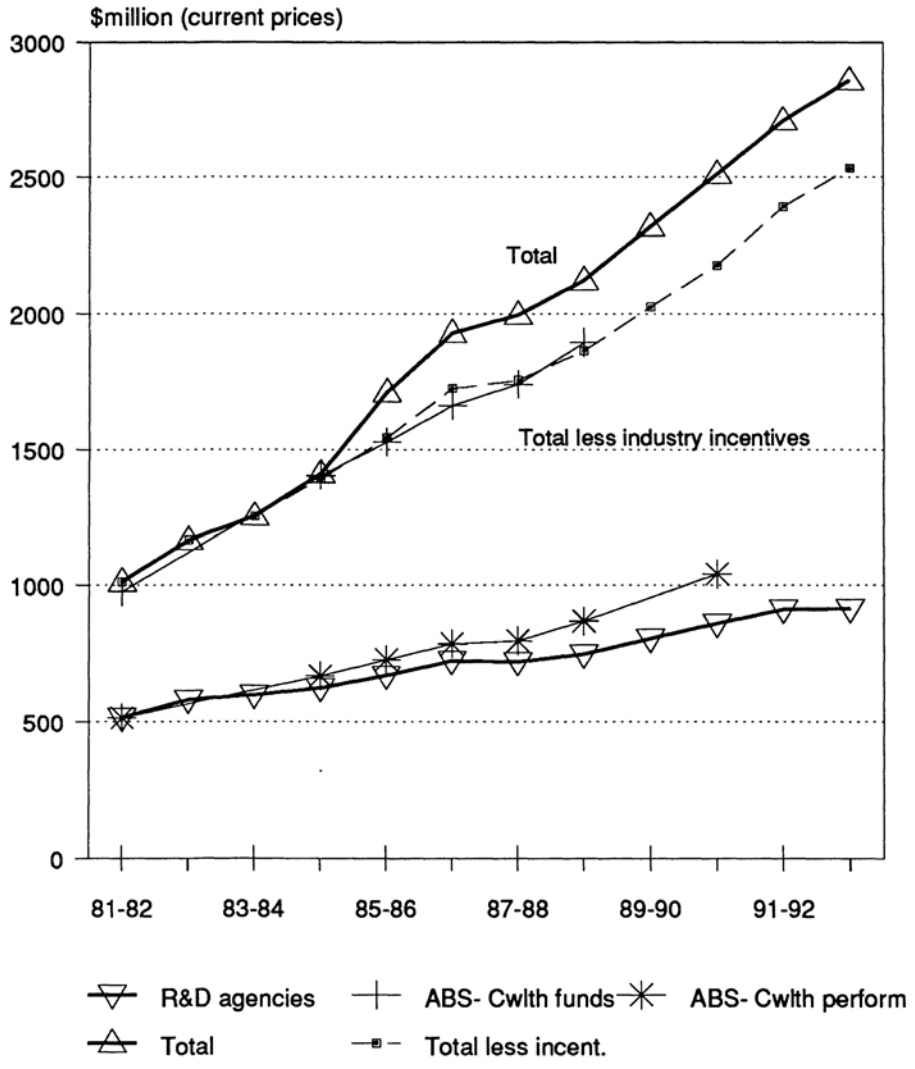
Figure 6 shows the comparison between the "science and innovation" series presented in this Section and ABS (Frascati) R&D. The total budgets of the research agencies show little deviation from ABS R&D performance data. The discrepancy which does occur can be explained largely in terms of CSIRO's external income. (ABS R&D performance data for the agencies includes expenditure from all sources of funds. The series here shows only directly appropriated Commonwealth funding.)

Commonwealth Support in a National Perspective

Figure 7 provides a schematic picture of the Commonwealth's activity in the national R&D context and its relative size and interactions compared with other elements of the overall R&D system. The Commonwealth is the dominant funder of R&D in Australia and Commonwealth agencies are also significant performers of R&D.

Figure 6

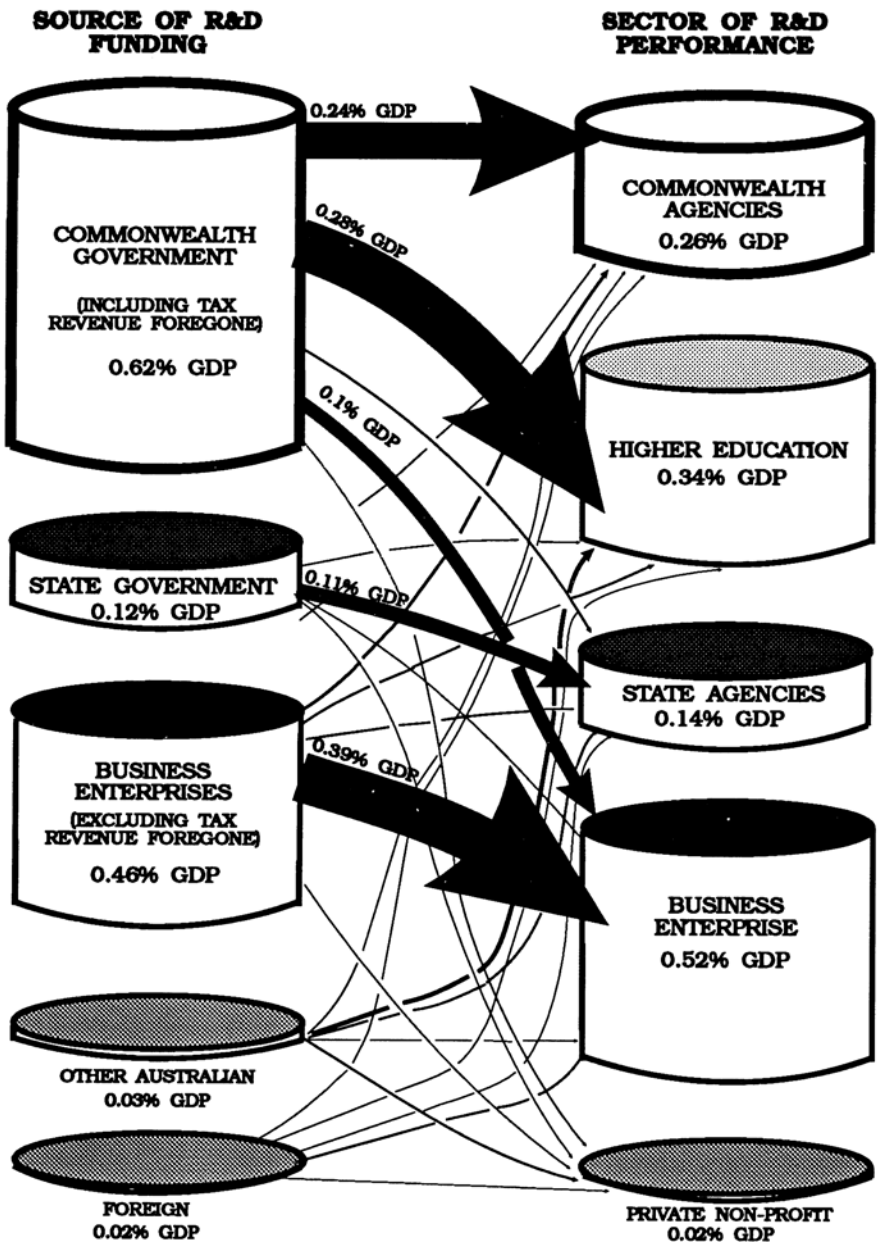
BUDGET- BASED DATA AND ABS R&D



Source: *See Table 2, Australian Science and Innovation Resources Brief 1992 and ABS 8109.0*

Figure 7

COMMONWEALTH R&D SUPPORT IN A NATIONAL PERSPECTIVE



The figure illustrates major flows of funding support between sectors, based on 1987-88 data. It places Commonwealth funding of R&D in a national perspective.

SECTION 4:

INTERNATIONAL CONTEXT

International Comparisons of R&D Levels

R&D levels in OECD nations are commonly compared by considering the ratio of gross domestic expenditure on R&D (GERD) to gross domestic product (GDP). This ratio of GERD/GDP is the most often quoted R&D indicator and provides a standardised method of comparison between different countries. The major advantage of this ratio is that it removes any need for consideration of exchange rates or inflation. GERD is, however, made up of components from R&D performed in quite different sectors (principally, the business sector, government agencies and universities). Different countries vary widely in the relative contribution of these sectors to total GERD and policy issues are usually focussed primarily at the sectoral level, thus there is advantage in considering them separately. For the same reasons, and because there are flows of funds between all sectors, it is also important to consider separately the major sources of funds for R&D (business and government).

A complication, however, is that institutional structures in the government and academic sectors vary widely between countries. The type of research typically conducted in government agencies in one country may be conducted in universities in another. The reverse also applies. Thus it can also be useful to make comparisons with these two sectors combined.

The upper part of Table 6 provides comparisons of the latest available OECD R&D data dissected both by source of funds and sector of performance. In addition, the funding data from the Table are shown in Figure 8. Sectoral data of this kind can provide useful insights. Table 6 shows that Australia has a relatively low GERD/GDP ratio and that this is due primarily to a relatively low R&D effort by the business sector.

For any country, GERD/GDP and its component ratios can also be compared between different years. Data on Australian trends over recent years are shown in the lower part of Table 6.

International comparisons of R&D/GDP are often made with the implication that the national share of GDP allocated to R&D should change. In that case, inter alia, consideration should also be given to how rapidly change might be effected. These issues require dynamic comparisons (ie, of growth rates) as well as static comparisons of the kind presented in Table 6.

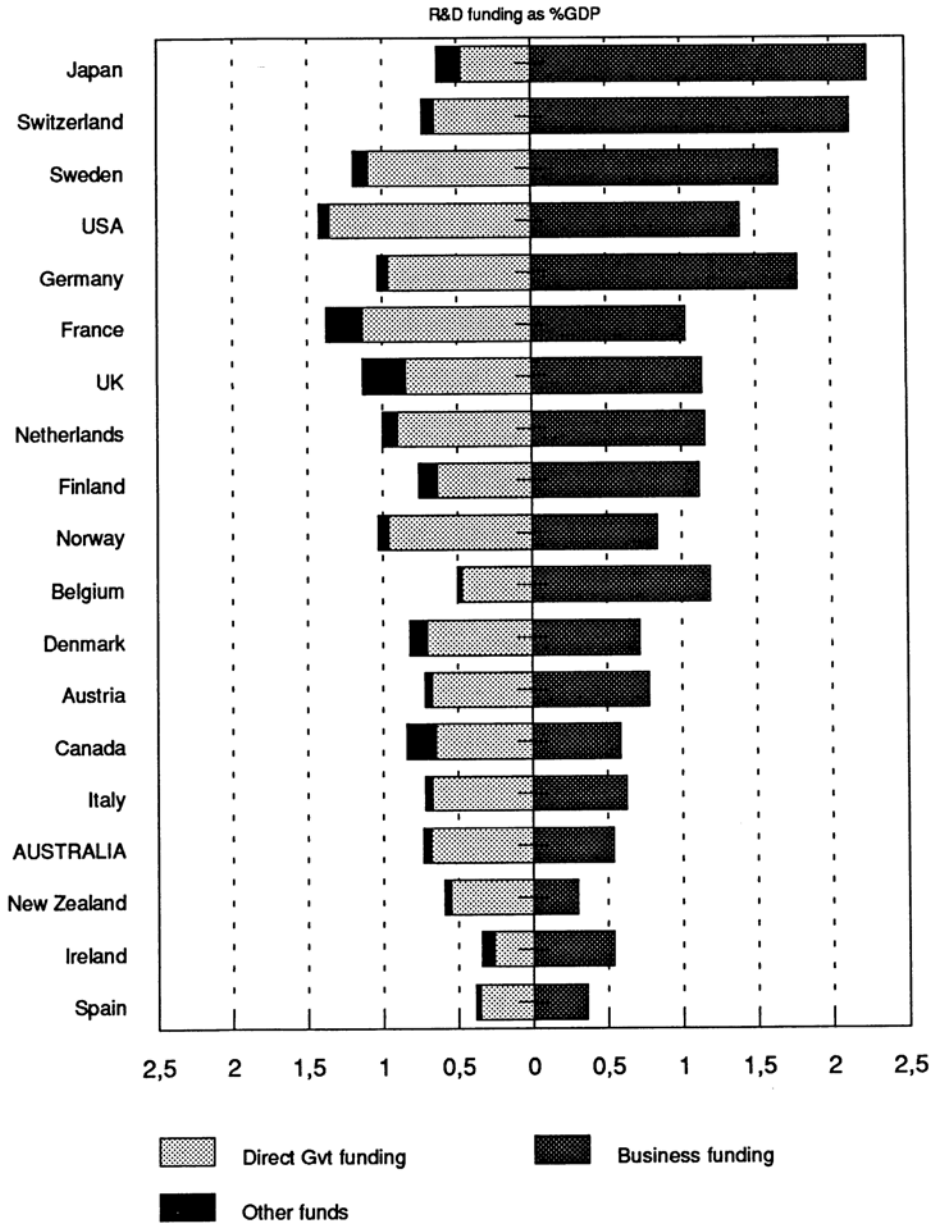
TABLE 6 R&D Expenditure as a Percentage of GDP by Sector - OECD Comparisons, Recent Australian Trends

	Latest	Source of Funds for R&D as % GDP			R&D Performance as % GDP				
	%GERD/GDP	Govt	Business	Other	Total Publ	= (Govt	+ Univs)	Business	Other
OECD COMPARISONS									
nation (year*)									
Japan (1990)	2.88	0.47	2.25	0.16	0.58	(0.23	0.35)	2.17	0.13
Switzerland (1989)	2.86	0.65	2.13	0.08	0.69	(0.12	0.57)	2.14	0.03
Sweden (1989)	2.85	1.09	1.66	0.10	1.02	(0.11	0.91)	1.82	0.01
United States (1991)	2.82	1.35	1.40	0.07	0.79	(0.34	0.45)	1.95	0.08
Germany (1990)	2.81	0.96	1.78	0.07	0.77	(0.37	0.40)	2.02	0.02
France (1990)	2.40	1.13	1.03	0.24	0.90	(0.56	0.34)	1.48	0.02
United Kingdom (1989)	2.27	0.84	1.14	0.29	0.68	(0.33	0.35)	1.47	0.12
Netherlands (1989)	2.16	0.90	1.16	0.10	0.84	(0.37	0.46)	1.28	0.04
Finland (1990)	1.88	0.63	1.12	0.13	0.70	(0.35	0.35)	1.17	0.01
Norway (1991)	1.87	0.96	0.84	0.07	0.79	(0.35	0.44)	1.08	0.01
Belgium (1990)	1.69	0.47	1.19	0.03	0.40	(0.10	0.29)	1.23	0.06
Denmark (1989)	1.54	0.70	0.72	0.12	0.68	(0.30	0.38)	0.85	0.01
Austria (1991)	1.50	0.67	0.78	0.05	0.55	(0.11	0.44)	0.70	0.03
Canada (1991)	1.43	0.64	0.59	0.20	0.64	(0.27	0.37)	0.77	0.02
Italy (1991)	1.35	0.67	0.63	0.05	0.56	(0.32	0.24)	0.79	0.00
AUSTRALIA (1988-89)	1.25	0.68	0.54	0.05	0.78	(0.44	0.34)	0.53	0.02
New Zealand (1989)	0.89	0.55	0.30	0.04	0.61	(0.41	0.20)	0.27	0.01
Ireland (1990)	0.88	0.26	0.54	0.08	0.31	(0.15	0.17)	0.55	0.02
Spain (1991)	0.87	0.35	0.36	0.03	0.35	(0.19	0.16)	0.52	0.00
RECENT AUSTRALIAN TRENDS									
year									
1984-85	1.12	0.76	0.32	0.04	0.77	(0.44	0.33)	0.34	0.02
1985-86	1.16	0.73	0.38	0.05	0.76	(0.44	0.32)	0.39	0.02
1986-87	1.27	0.75	0.48	0.04	0.78	(0.44	0.35)	0.48	0.02
1987-88	1.24	0.70	0.49	0.05	0.75	(0.40	0.35)	0.49	0.02
1988-89	1.25	0.68	0.52	0.05	0.73	(0.40	0.34)	0.52	0.02
1989-90	na	na	0.54	na	na	na	na	0.53	na
1990-91	na	na	na	na	na	0.44	na	0.53	0.02

* Year for latest available GERD/GDP. Other data are latest available but may be for different years.

Figure 8

OECD LEVELS OF FUNDING FOR R&D AS A PERCENTAGE OF GDP



Source: OECD Main Science and Technology Indicators, No 1,1992

TABLE 7 Growth in R&D levels and external patenting over the 1980s - comparisons between Australia and OECD nations

	1981 or nearest year (per unit GDP)	1989 or nearest year (per unit GDP)	Average annual real growth (%)	1981 or nearest year (per unit GDP)	1989 or nearest year (per unit GDP)	Average annual real growth (%)
	Average for 19 OECD countries			**Australia**		
Gross expenditure on R&D	1.55	1.87	+5.7%	1.00	1.23	+6.7%
Government funding of R&D	0.71	0.74	+3.3%	0.73	0.67	+2.2%
Business funding of R&D	0.78	1.05	+8.0%	0.24	0.52	+15.2%
R&D expenditure in Government agencies and universities	0.61	0.65	+3.7%	0.75	0.72	+2.4%
R&D expenditure in business enterprises	0.91	1.18	+7.4%	0.25	0.51	+14.0%
External patent applications by residents*	5.8	8.8	+9.2%	2.7	6.1	+17.5%

* Since the numerator in the ratio is no longer in units of national currency, the GDP values used are expressed in $US million at constant 1985 prices.

Source: See *Australian Science and Innovation Resources Brief 1992*

Time Series Comparisons of R&D Levels

Consideration of trends in R&D/GDP sometimes overlooks that it is not R&D expenditure itself which is being examined, but a ratio. Since growth in GDP is not always smooth (and consequent effects on R&D, if any, may be lagged), changes in GERD/GDP over a short time span can sometimes be misleading. For a particular country, changes in GERD/GDP (and the similar ratios based on sectoral R&D) are better compared over relatively long periods. For shorter time spans, it is better to consider growth in GERD (and corresponding sectoral R&D expenditures) converted to constant prices. Trends in R&D/GDP and growth data are complementary and a more informative picture is provided by considering both.

Growth in R&D and Innovation over the 1980s

In Table 7, R&D/GDP levels in 1981 are contrasted with 1989, both for Australia and the 19 OECD countries listed in Table 6. R&D data in Table 7 are dissected by the major categories of funding and performance and the ratios to GDP are supplemented by data on average real annual growth rates over the period. In addition, the table provides the corresponding information for external patent applications.

Comparative R&D data, particularly business R&D data, are often used as an indicator or proxy for innovation in the wider sense. National data on external patent applications (ie, patent applications by each country in all other countries) provide an alternative indicator.

The Table shows that for government R&D funding, and for the composite category of R&D expenditure in government agencies and universities, there were relatively small changes over the 1980s. In the OECD, on average, R&D in this category increased by 0.03-0.04 per cent of GDP with a growth rate of about 3.5%. In Australia, the shift expressed as per cent GDP was down, with R&D/GDP moving closer to the average in the composite category. The shift in direct government funding was also down (but in fact was balanced by indirect support for R&D at 0.06 per cent GDP through the tax concession scheme). In fact, over the 1980s there was a degree of convergence towards the average levels in these categories and the shifts and growth rates in Australia have parallels in other OECD countries.

For business funding of R&D, and for R&D expenditure in business enterprises, there were substantial changes. On average in the OECD, R&D increased by 0.27 per cent of GDP in both these categories with an average growth rate in the region of 8%. Australia, from a much lower base than the average, almost exactly matched this increase in R&D/GDP, while the Australian growth rates of 15.2% and 14.0% in the two categories were the highest of the 19 OECD countries in the table.

The data relating to external patenting, being completely independent of the R&D information, provides valuable confirmation. Per unit GDP, the Australian increase in external patent applications has increased by 3.4 compared with the average OECD increase of 3.0. The Australian growth rate of 17.5% is again the highest of the 19 OECD countries (and very substantially exceeds the second highest, Finland at 13.9%).

The ranking of countries by growth in external patent applications correlates well with their ranking by growth in business R&D funding and their ranking by growth in business performance of R&D. All these data confirm the picture of very significant increases in Australian business innovation over the 1980s, over a period in which an extensive range of Commonwealth programs were instigated with the aim of stimulating innovation. Nevertheless, there is no room for complacency. If Australia is to reach international levels, the latest data in Tables 6 and 7 clearly show that there is substantial ground still to make up.

Cat. No. 92 4695 6