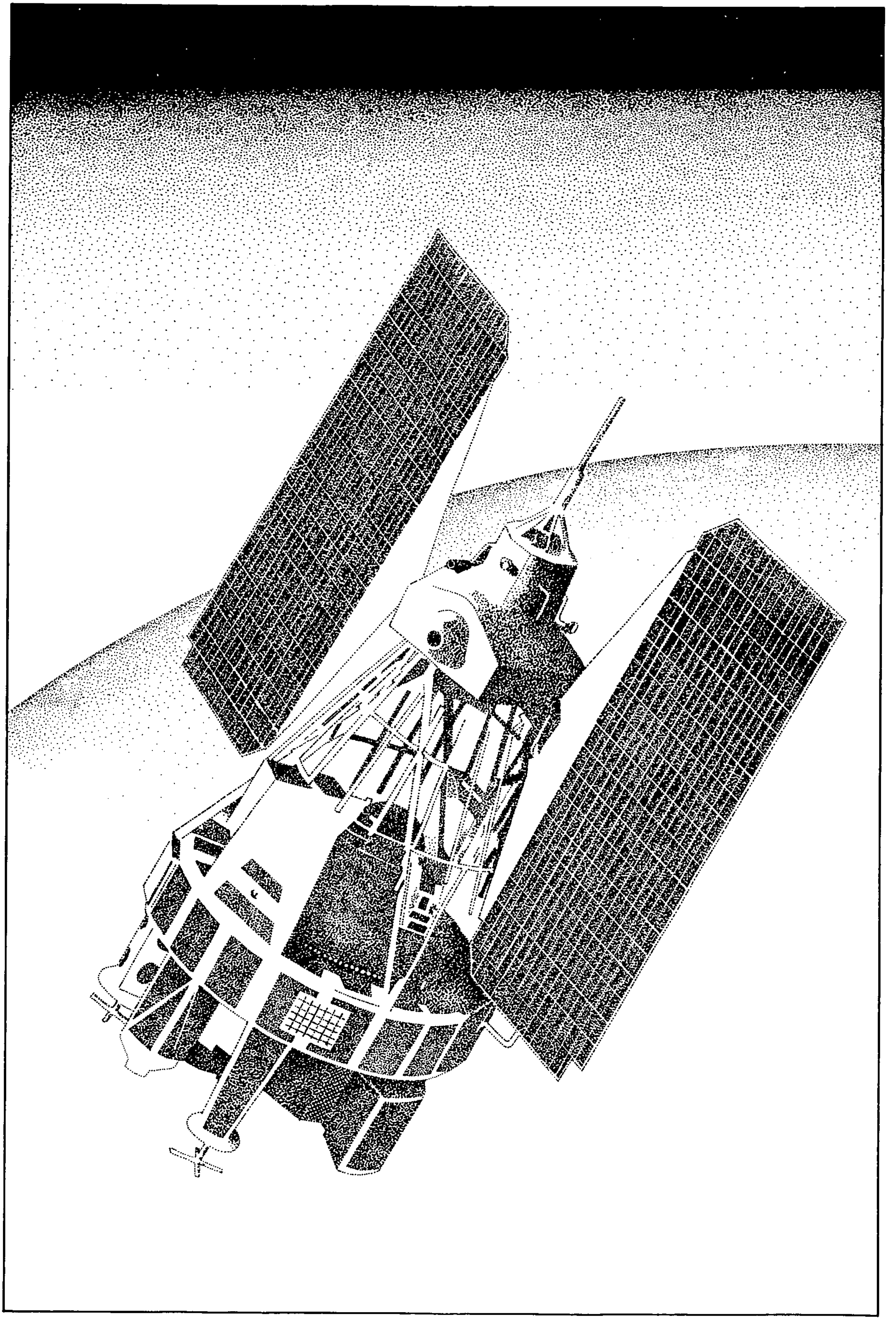
CHAPTER 25

SCIENCE AND TECHNOLOGY



CHAPTER 25

SCIENCE AND TECHNOLOGY

Overview

Much of the early history of Australian science was based largely on the individual achievements of a few outstanding scientists.

During and after World War I, governments in various parts of the world took initiatives aimed at encouraging scientific research and applying it to economic growth and national development; Australia was no exception. In 1926 the Council for Scientific and Industrial Research (CSIR) was established by the Commonwealth Government. Initially, it concentrated its efforts on the primary industries, typifying the trend of research in Australia at that time, when most major research initiatives were taken by Government and aimed at the primary industries. The level of research in the universities and industries remained much as before.

With the approach of World War II, however, moves were made to extend scientific support for secondary industry. In the CSIR Divisions created in the period 1937–40 were to play an important part in the rapid development of Australian industry that occurred under the stimulus of war-time needs.

Expansion of scientific research in general, and industrial research in particular, continued after the war. This expansion extended beyond government into the universities and industry.

Though, even today agricultural research absorbs a significant proportion of Australia's research effort, industrial, medical and defence research are now of major importance also. The volume of research in the social sciences remains small, although in Australia, as elsewhere in recent years, there has been increasing support for the view that adequate weight must be given in governmental policy-making to the social aspects of national proposals.

In 1976–77, the most recent year for which data are available, total expenditure on research and development (R & D) in both the natural and social sciences was estimated at $802 million, approximately equivalent to 1.0 per cent of the Gross Domestic Product in that year. The data are summarised in the table on page 705 of this Year Book.

In 1976–77, governments in Australia provided approximately 80 per cent of the funds devoted to R & D and undertook in their own agencies approximately 56 per cent (in terms of expenditure) of the overall national R & D effort.

Whilst these data serve to illustrate the dominant position occupied by governments in Australian scientific and technological R & D activities, they do not provide a complete picture since comprehensive information is not available on resources devoted to other scientific and technological activities in Australia.

Advice and co-ordination

In order to achieve at the national level integration of advice, relative assessment of priorities and the development of criteria and broad strategies for future directions, three national advisory bodies, in addition to the Department of Science and the Environment, have been established: the Australian Science and Technology Council (ASTEC), which is responsible to the Prime Minister; the National Energy Advisory Committee (NEAC), which advises the Minister for National Development on matters relating to national energy policy; and the Australian Manufacturing Council (AMC), which is served by some eleven advisory councils and advises the Minister for Industry and Commerce on matters of industry policy. In 1978, the Government decided to establish a Commonwealth Council for Rural Research and Extension, which will advise the Minister for Primary Industry.

Australian Science and Technology Council (ASTEC)

Prior to the establishment of ASTEC, there had been an intensive period of discussion and review concerning arrangements for the provision to the Government of adequate advice on policies for science and technology in Australia. An outline of the discussions can be found in Chapter 28 of Yearbook No. 61.

The ASTEC was established as a permanent body by executive action in April 1977. At that time the Prime Minister announced in Parliament that ASTEC would become a statutory body. The

ASTEC legislation passed through Parliament in the Autumn session of 1978. The ASTEC was established as a statutory authority in February 1979.

ASTEC's legislation states:

The functions of the Council are to investigate, and to furnish information and advice to the Commonwealth Government in respect of matters relating to science and technology, including the following matters:

- the advancement of scientific knowledge;
- the development and application of science and technology in relation to the furtherance of the national well-being;
- the adequacy, effectiveness and overall balance of scientific and technological activities in Australia;
- the identification and support of new ideas in science and technology likely to be of national importance;
- the practical development and application of scientific discoveries;
- the fostering of scientific and technological innovation in industry; and
- the means of improving efficiency in the use of resources by the application of science and technology.

These functions allow ASTEC a wide purview, ranging from pure science, to the problems of improving efficiency in industry by applying the results of research and development. It considers activities and technological problems of higher education institutions and private enterprise.

To discharge its functions, the Council is provided with appropriate powers. The Council is able to form committees, engage consultants, conduct inquiries and collect information on any matter within its functions arising either from its own initiative or at the direction of the Minister to whom ASTEC reports (presently the Prime Minister).

The Council's reports to the Government are made public unless there are overwhelming reasons in the national interest for not doing so. ASTEC's Act contains detailed provisions requiring the prompt tabling in Parliament of ASTEC reports except in closely defined circumstances.

The ASTEC's first major exercise since its formation has been a comprehensive review of the state of Australian science and technology, embracing description of various areas of national importance, and recommendation thereon. The first part of this report was made public in mid-1978, and it was published in its completed form in March 1979.

ASTEC has also provided reports to Government on the organisation of the Bureau of Mineral Resources, Geology and Geophysics, in November 1978; on arrangements for the direct funding of basic research in Australia, in March 1979; on the next generation of Australian telescopes, in May 1979; and on immediate issues in Australian marine science, in July 1979. Other referrals from Government, on subjects such as contracting research and development to industry, and interaction between sectors involved in science and technology, are under consideration and reports will be made about the end of 1979.

Following a recommendation in the abovementioned review of Australian science and technology, the Australian Marine Sciences and Technologies Advisory Committee was established in February 1979 as a standing committee of ASTEC. Its functions include assessment of present activities in marine sciences and technologies, and advising on priorities and mechanisms for achieving a balanced national program in this area.

The ASTEC is also proceeding with studies which will assist in the development of its strategic role involving the matching of Australia's science and technology effort to its resources, problems and goals. These studies include development of means to measure science and technology effort, examination of the mechanisms used in other countries for establishing priorities in science and technology, and of the scientific and technological implications of Government policies.

National Energy Advisory Committee (NEAC)

For information on NEAC *see* Chapter 18, Energy.

Department of Science and the Environment

Successive Governments have seen the Department of Science, and now the Department of Science and the Environment, as having a complementary role in relation to an advisory council on science and technology. As a government department it has ready access to information available to government concerning civil science and technology, and is able to provide a scientific and technological perspective at the interdepartmental level. It is also a focus for the Governments environmental concerns and its responsibilities include the administration of the Environment Protection (Impact of Proposals) Act. The Department's role includes the fostering of closer working relationships and consultation among government agencies, tertiary institutions, scientific associations, the private

sector and the community. The Department's administrative functions in relation to certain scientific services and research activities (such as the Bureau of Meteorology, the Australian Government Analytical Laboratories, the Antarctic Division, the Australian Biological Resources Study, the Australian Research Grants Scheme and Australia's science agreements with other countries), help to ensure that its policy advice is tempered with an awareness of practical problems in science and technology.

Department of Productivity

The Department was established in November 1976 as a technologically orientated agency to foster increased industrial productivity. It is responsible for technology development programs directed towards the development and utilisation of new or improved technologies, such as the Assistance to Inventors Scheme, Patent Information Service, and the promotion of industrial research and development. It also promotes technology development by encouraging the use of modern technology by industry and the commercial development of major Australian innovations by Australian industry; it assists the development of process technologies to increase the competitiveness of sectors of Australian industry, and assists the development and exploitation of Australian inventions.

The Department is involved with a number of technology transfer programs designed to assist industry in making the most effective use of existing and developing technology. These programs include quality development, in which the Department works closely with the Standards Association of Australia, the Industrial Design Council of Australia, and the Australian Organisation of Quality Control; information technology and the active participation and support of the Information Technology Council; and a technical referral network being established in conjunction with the Technology Transfer Council.

Other activities of the Department related to technology include specific productivity programs, materials handling (National Materials Handling Bureau) and programs in the physical, social and organisational aspects of the working environment which help to facilitate the introduction of new technology. The Department also supports the Productivity Promotion Council of Australia.

Energy Research and Development

The Department of National Development through the National Energy Office provides policy and technical advice on energy research, development and demonstration (R, D&D) and administers the National Energy Research, Development and Demonstration Program. The program is funded from levies paid to the Coal Research Trust Account under the provisions of the *Coal Research Assistance Act* 1977 and from a Departmental appropriation for energy research. Over $15 million was committed in the 1978–79 financial year for research, development and demonstration projects.

This was the first full year of operation of the National Energy Research, Development and Demonstration Council (NERDDC) established in May 1978 to advise the Minister on development and co-ordination of the Government's overall effort in energy R, D&D, on the allocation of grants for individual projects, and on support for international projects. The thirteen members of NERDDC have a wide range of backgrounds in private industry, academic fields, and government administration. During the 1978–79 year, on NERDDC's recommendations, the Minister established seven Technical Standing Committees, each chaired by a member of NERDDC and comprising thirty-four other members. These committees cover all energy fields and provide specialist technical advise to NERDDC. The Council and the committees are supported by a secretariat provided by the Energy Research and Development Division of the National Energy Office.

The main task of NERDDC during the 1978–79 year was to assess the applications received for support grants and to make recommendations to the Minister. The Council is required to report annually to the Minister. Grants approved by the Minister under the R, D&D Program are administered by the Department. With the assistance of NERDDC and the Technical Standing Committees, the Department also monitors scientific and technical progress and performance.

Other Organisations

Advice to government on scientific and technological issues comes also from various learned and professional bodies. Such counsel may be offered on the initiative of the organisation itself or in response to an official request. For example, the *Australian Academy of Science* maintains a number of sectional and standing committees which specialise in selected broad fields of science; ad hoc advisory committees are appointed by the Academy from time to time to examine and report on specific matters. In addition, the Academy has maintained since 1967 a Science and Industry Forum which

brings together leading scientists and industrialists to discuss topics of national significance, a complementary Science and Society Forum was inaugurated in 1973. Communication between government and the technology area of the science-technology spectrum is facilitated by the *Australian Academy of Technological Sciences.*

The most broadly based of the learned and professional bodies is the *Australian and New Zealand Association for the Advancement of Science* (ANZAAS). The Association has established a Science Policy Commission for giving increased attention to policy issues.

In recent years, matters of scientific and technological policy have received much discussion among such learned and professional organisations as well as in academic circles. Increasingly, other professional bodies with more specific charters are giving attention to matters of science and technology policy. Such bodies include the *Royal Australian Chemical Institute* (RACI), the *Institution of Engineers, Australia,* the *Australian Institute of Physics,* and the *Federation of Australian University Staff Associations* (FAUSA) which concentrates on issues specifically affecting the university sector.

There are a number of groups within the industry sector—e.g. the Australian Industrial Research Group (AIRG) and some specialist panels (Industry Advisory Councils) of the Australian Manufacturing Council (AMC)—which, from time to time, provide advice to government on industrial research and development.

Intergovernmental co-ordination is affected through bodies established for the purpose. While certain of these are concerned with promoting research and scientific and technical services, these are secondary objectives pursued in tandem with economic, social or environmental goals. Typical of these bodies are the Australian Agricultural Council, the Australian Minerals and Energy Council, the Australian Water Resources Council, and the Australian Environment Council.

The intergovernmental ministerial councils are assisted by standing committees of officials. Frequently, expert working groups and sub-committees are established to consider particular specialised aspects of a Council's broad field of interest and to advise the council through the relevant standing committee.

Councils do not directly undertake research or the provision of services, although such activities are commonly pursued within agencies coming under the control of individual ministerial members. In some instances, councils have control of research funds and provide grants or arrange for projects to be undertaken in particular fields of interest.

In some scientific and technical fields not coming directly within the purview of the Ministerial councils, there are standing arrangements at agency level for consultation and promotion of co-operation (the Electricity Supply Association of Australia is an example).

In addition to intergovernmental agencies, official advisory bodies have been established to deal with activities, interests and responsibilities of the Federal Government and its agencies, and to advise on Government support of higher education and of industry. Amongst these bodies are the Australian Research Grants Committee (ARGC); the National Health and Medical Research Council (NHMRC); the Australian Industrial Research and Development Incentives Board (AIRDIB); the CSIRO Advisory Council and its State Committees; the Rural Industry Research Fund Advisory Committees; the Tertiary Education Commission and its Councils; and the National Energy Research Development and Demonstration Council.

The Prime Minister announced the establishment of the *Antarctic Research Policy Advisory Committee* in February 1979 to advise the Government, through the Minister for Science and the Environment, on the development of an effective and balanced program of scientific and exploration activity in the Antarctic and sub-Antarctic region. In particular, the Committee will advise on priorities for scientific and technological research in areas such as mineral and living resources, and on the potential environmental effects of exploitation.

It will advise on the scientific merit and adequacy of Australian Antarctic research programs, on the organisational arrangements for implementation of programs, and on the role of the Antarctic Division of the Department of Science and the Environment in this effort. From time to time, it will also undertake reviews of existing programs and provide advice on new programs, taking into account current government policy in these areas.

The Committee is chaired by Professor D. E. Caro, Vice-Chancellor of the University of Tasmania.

In August 1979, the Prime Minister announced the creation of the *Marine Research Allocations Panel* to advise the Minister for Science and the Environment on the allocation of funds provided for grants in marine science and technology. An amount of $400,000 was provided for 1979–80 and the two succeeding financial years, with $300,000 to be devoted to the Great Barrier Reef region.

The *Building Research and Development Advisory Committee* is the main link between private industry and the principal Commonwealth research groups, the CSIRO Division of Building Research, the Department of Housing and Construction, and the Physical Working Environment Branch of the Department of Productivity.

The Committee advises the Commonwealth Government organisations concerned in building research and development on the technical problems of industry and where research, investigation, development work or technical liaison activity is required. It also assists in the dissemination of knowledge of the activities of organisations undertaking research and development work, and investigates the nature and extent of both government and privately funded research in the Australian building industry and advises all parties concerned of any overlapping or duplication of research effort.

The Technology Transfer Council was formally established in August 1978 to provide a technical referral program aimed at utilising the technological expertise resident in academic, government and private research institutions, and to assist in the effective use of existing technology in Australian industry. A network of technical referral centres is planned. For the first three years, the project will operate on a pilot scale in the metals manufacturing industry. There will be two specialist centres in the first stage of the project: the Centre of Machining Technology hosted by Swinburne College of Technology, and the Centre of Casting Technology hosted by the Division of Material Science, CSIRO, Melbourne. Four generalist centres are also planned for immediate establishment.

The Information Technology Council was established in March 1978 on the initiative of the Department of Productivity. It is concerned with establishing facilities for the guidance, instruction, demonstration and support to business management on the use of information technology. It also seeks to promote the importance of information technologies to business and to sponsor specific projects in the field.

Established in 1963, the *Australian Water Resources Council* (AWRC) is a Commonwealth and State Ministers' forum for dealing with water resources matters of mutual interest. Commonwealth and State collaboration through the AWRC initially concentrated on resources assessment and research, but more recently the Council's functions have been expanded to include management and planning. The AWRC and its committees have provided an important contribution to the development of Commonwealth water policies and programs and, in many cases, provide the means of implementing them.

As part of its secretariat role, the Department of National Development publishes reports and documents, and also arranges seminars and workshops on behalf of the AWRC.

The Commonwealth established the *Water Research Fund* in 1968 to provide support for a research program developed through the AWRC. The Fund is administered by the Department of National Development. Funds have been committed on a triennial basis, currently running at $390,000 annually.

The program covers basic and applied research into all aspects of water resources with the aim of providing a better basis for the assessment, planning, development and management of Australia's water resources. It complements research work being carried out by government agencies, universities and other organisations and, in general, is used to stimulate new work not handled within existing programs.

The program for the 1977–80 triennium is diverse with emphasis on projects concerned with various aspects of water quality and water re-use, groundwater investigations, water resources planning and development of measurement techniques.

Expenditure and manpower

Project SCORE

Project SCORE (Survey and Comparisons of Research Expenditures) provides details of Australian expenditure on research and experimental development activities. It should be noted, however, that is does not provide comprehensive data on all resources devoted to scientific and technological activities in Australia. Programs not covered by Project SCORE, some of which involve large expenditures, are those which have no research and development component; such programs include many of those aimed at providing scientific or technological services.

Coverage and Methodology. The first comprehensive survey of expenditure on research and experimental development (R & D) was carried out for the 1968–69 financial year. This survey, known as Project SCORE, covered R & D expenditure and manpower in the natural and social sciences in all sectors of the Australian economy. The Project was carried out principally by means of questionaires and, in order to provide direct comparison with other OECD countries, followed (with some exceptions) guidelines laid down by the OECD. In addition to a summary report dealing with

the overall national situation, separate Project SCORE reports cover the following sectors: Commonwealth Government, Private enterprise, State Government, Higher education, and Private non-profit. A summary of the results for 1968–69 is given in Year Book No. 60, pp 995–1005.

The results of the second survey, for the 1973–74 financial year (1974 calendar year for the Higher education sectors), were published in two volumes: Volume 1 contains the reports for the Commonwealth Government, State Government, and Private non-profit sectors, while Volume 2 presents an all-sector summary together with the reports for the Private enterprise and Higher education sectors. A summary of the results is given in Year Book No. 61, pp 989–998.

A third survey, for the 1976–77 financial year (1976 calendar year for the Higher education sector), was in press at the time of writing.

For the purposes of the surveys, *research* was defined as original investigation directed towards increasing the general body of knowledge about, or understanding of, the subject studied. Within this category, *basic research* was taken to be original investigation of which the primary aim was more complete knowledge or understanding of the subject under study, while *applied research* was taken to be original investigation of which the primary aim was the solution of a recognised practical problem. Work was defined as *experimental development* where it involved the systematic use or adaptation of research results directed towards the production of new or improved products, processes, systems or methods. The physical, chemical, biological, earth, engineering and applied, agricultural and medical sciences were included in the natural sciences, which together with the social sciences, were covered in all the surveys. The 1973–74 and 1976–77 surveys also covered R & D in the humanities, which was excluded in 1968–69.

Because of changes in definition and interpretation, as well as retrospective revision, the published data are not completely comparable between surveys.

All sectors. Gross expenditure on R & D performed in Australia (GERD) in 1976–77 was $803 million, of which $726 million (91 per cent) was spent in the natural sciences, engineering and technology; and $76 million (9 per cent) was spent on research in the social sciences and humanities. Expenditure and manpower according to sector of performance were as follows.

EXPENDITURE AND MANPOWER DEVOTED TO R & D IN AUSTRALIA IN 1976–77 BY SECTOR OF PERFORMANCE

	Expenditure		*Manpower*	
Sector of performance	*$ million*	*per cent*	*man-years*	*per cent*
Private enterprise	157	20	7,895	18
Commonwealth Government	319	40	12,982	30
Higher education	184	23	15,290	35
State Government	132	16	6,829	16
Private non-profit	11	1	579	1
Total	**803**	**100**	**43,574**	**100**

The following tables contain figures for expenditure on R & D in 1976–77 according to source and sector of performance and for both expenditure and manpower according to major objectives.

EXPENDITURE ON R & D IN AUSTRALIA IN 1976–77 BY SECTOR OF PERFORMANCE AND SECTOR OF SOURCE OF FUNDS

($'000)

	Source						
Sector of performance	*Commonwealth Government*	*State Government*	*Private enterprise*	*Higher education*	*Private non-profit*	*Overseas*	*Total*
Commonwealth Government	308,252	220	1,139	1	848	8,239	318,699
State Government	15,401	114,123	2,011	2	384	178	132,099
Private enterprise	8,397	651	143,365	..	..	4,217	156,632
Higher education	174,243	2,216	1,857	..	5,237	768	184,322
Private non-profit	4,572	1,438	214	113	3,571	804	10,712
Total	**510,865**	**118,648**	**148,587**	**116**	**10,040**	**14,206**	**802,464**

EXPENDITURE AND MANPOWER DEVOTED TO R & D IN AUSTRALIA IN 1976-77 BY OBJECTIVE SUB-GROUP

	Natural sciences				*Social sciences and humanities*			
	Expenditure		*Manpower*		*Expenditure*		*Manpower*	
Objective sub-group	*$'000*	*per cent*	*man-years*	*per cent*	*$'000*	*per cent*	*man-years*	*per cent*
Private enterprise (*a*)	156,632	21.6	7,895	21.1	..	..	..	..
Other sectors–								
Defence	87,588	12.1	4,232	11.3	63	..	8	0.1
Primary industry	153,415	21.1	7,865	21.0	1,221	1.6	53	0.9
Secondary industry	56,570	7.8	2,725	7.3	148	..	9	0.1
Other economic development	79,935	11.0	3,018	8.1	15,978	20.9	885	14.5
Health	40,742	5.6	2,357	6.3	1,223	1.6	87	1.4
Environment	18,543	2.6	1,066	2.8	730	1.0	43	0.7
Other community welfare	4,139	0.6	247	0.7	17,928	23.5	1,258	20.7
Advancement of knowledge	128,619	17.7	8,076	21.6	38,990	51.1	3,748	61.5
Total	**726,183**	**100.0**	**37,482**	**100.0**	**76,280**	**100.0**	**6,092**	**100.0**

(*a*) Because of the low incidence of R & D in the Social Sciences reported by Private enterprises in the 1976-77 survey of research and experimental development, all Private enterprise R & D has been assigned to the natural sciences. Private enterprise R & D cannot be assigned unambiguously to objective sub-groups because the survey classification was by industry rather than by objective.

Australian R & D effort in real terms rose by about 20 per cent between 1968-69 and 1973-74 and then declined sharply between 1973-74 and 1976-77 to a level only slightly greater than in 1968-69. Gross expenditure on R & D (GERD) as a percentage of gross domestic product (GDP) decreased from about 1.3 to 1.2 per cent between 1968-69 and 1973-74 and fell further to 1.0 per cent by 1976-77, while GDP continued to rise steadily in real terms throughout the period.

Performance of R & D increased in all sectors between 1968-69 and 1973-74, thereafter continuing to rise in the State Government sector, while remaining almost stationary in the Commonwealth Government, Higher education and Private non-profit sectors, and declining sharply in the Private enterprise sector.

INTRAMURAL R & D EXPENDITURE BY SECTOR OF PERFORMANCE, 1968-69 TO 1976-77

(estimated values at constant (average 1974-75) prices)

	1968-69		*1973-74*		*1976-77*	
	$ million	*Per cent*	*$ million*	*Per cent*	*$ million*	*Per cent*
Commonwealth Government	202	34	245	34	251	39
State Government	70	12	90	12	104	16
Higher education	118	20	157	22	153	24
Private non-profit	4	1	7	1	8	1
Private enterprise	205	34	225	31	123	19
Total	**599**	**100**	**724**	**100**	**639**	**100**

Total R & D manpower effort as a percentage of the civilian labour force showed little change between 1968-69 and 1973-74, but declined significantly from about 0.85 to 0.7 per cent between 1973-74 and 1976-77. Researchers provided an increasing relative share of the total R & D manpower effort over the period 1968-69 to 1976-77, mainly at the expense of other supporting staff. This is summarised in the following table.

TOTAL R & D MANPOWER EFFORT BY TYPE OF MANPOWER, 1968-69 TO 1976-77

	1968-69		*1973-74*		*1976-77*	
	Man-years	*Per cent*	*Man-years*	*Per cent*	*Man-years*	*Per cent*
Researchers	17,700	42	24,600	48	22,500	52
Technicians	12,600	30	16,700	33	12,600	29
Other support staff	11,900	28	10,100	20	8,500	20
Total	**42,200**	**100**	**51,400**	**100**	**43,600**	**100**

Commonwealth Government sector. Within the Commonwealth Government sector, total intramural expenditure on R & D was $319 million, representing 1.3 per cent of Commonwealth Government outlays for 1976–77 ($24,925 million). Manpower involved in this R & D effort was equivalent to 13,000 man-years. Of this effort about 4,800 man-years were attributed to workers who held professional qualifications. Distribution of this expenditure and manpower effort by objectives and field of science is shown in Plates 49 and 50, pages 707 and 708. Other major features were:

(*a*) Socio-economic objective groups accounted for the intramural R & D expenditure of the Commonwealth Government as follows:

	per cent
Economic development	52
National security	27
Advancement of knowledge	14
Community welfare	7

(*b*) Expenditure in the Economic development group was distributed between the following sub-groups:

	per cent
Primary industry	17
Secondary industry	12
Energy	5
Other	17

(*c*) Two respondents, CSIRO and the Department of Defence, accounted for 71 per cent of the total intramural expenditure.

(*d*) Intramural expenditure on R & D in the natural sciences and in the social sciences was distributed as follows:

	per cent
Natural sciences	96
Social sciences	4

(Humanities research was negligible in this sector.)

46 per cent of the total effort was in Engineering and Applied Sciences, the dominant major field of science in the natural sciences.

A diagrammatic representation of the principal ways in which Commonwealth Government support is channelled into R & D is shown in Plate 51, page 709.

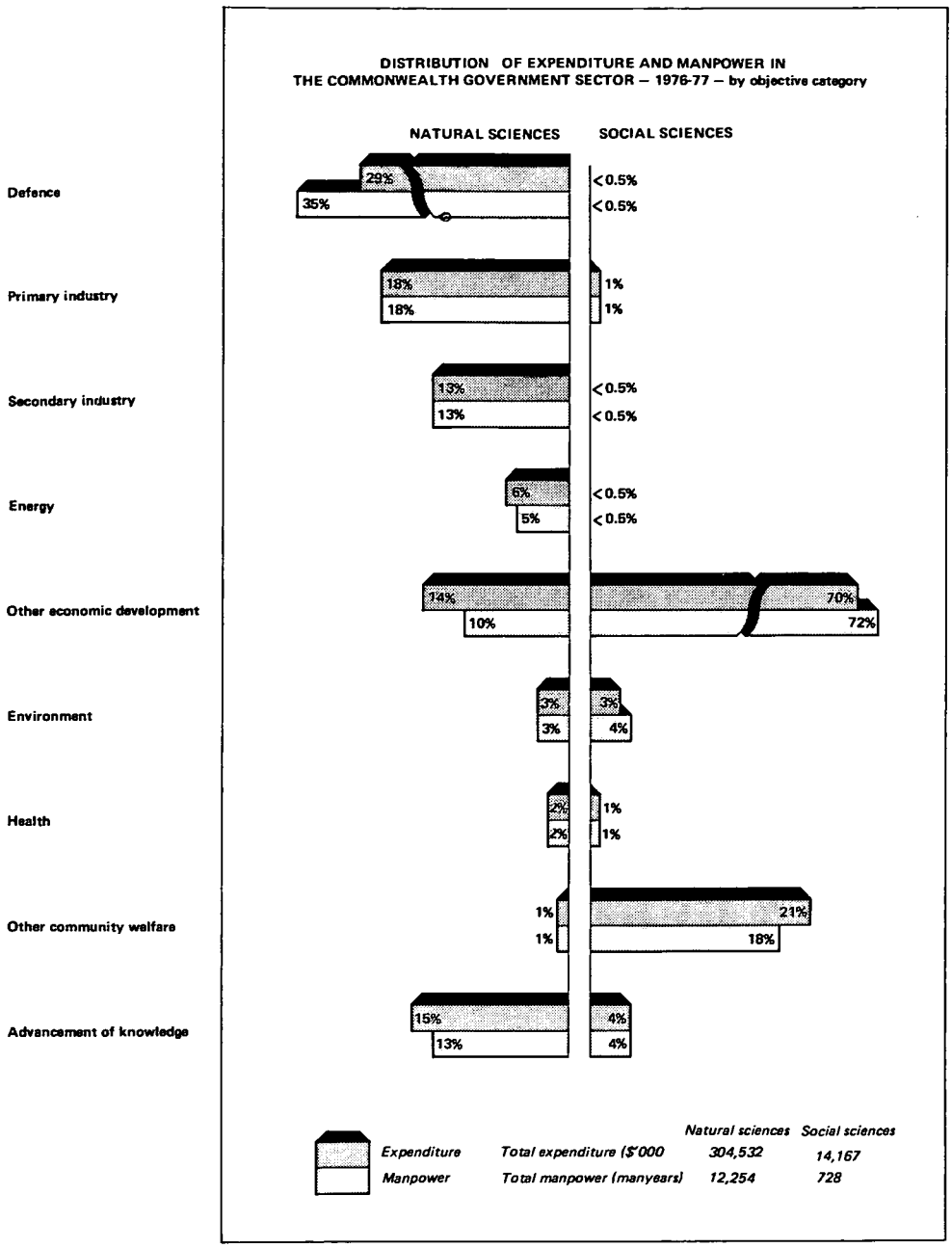

DISTRIBUTION OF EXPENDITURE AND MANPOWER IN THE COMMONWEALTH GOVERNMENT SECTOR – 1976-77 – by objective category
NATURAL SCIENCES
SOCIAL SCIENCES
Defence
29%
35%
<0.5%
<0.5%
Primary industry
18%
18%
1%
1%
Secondary industry
13%
13%
<0.5%
<0.5%
Energy
6%
5%
<0.5%
<0.5%
Other economic development
14%
10%
70%
72%
Environment
3%
3%
3%
4%
Health
2%
2%
1%
1%
Other community welfare
1%
1%
21%
18%
Advancement of knowledge
15%
13%
4%
4%
Expenditure
Manpower
Total expenditure ($'000
Total manpower (manyears)
Natural sciences
304,532
12,254
Social sciences
14,167
728

PLATE 49

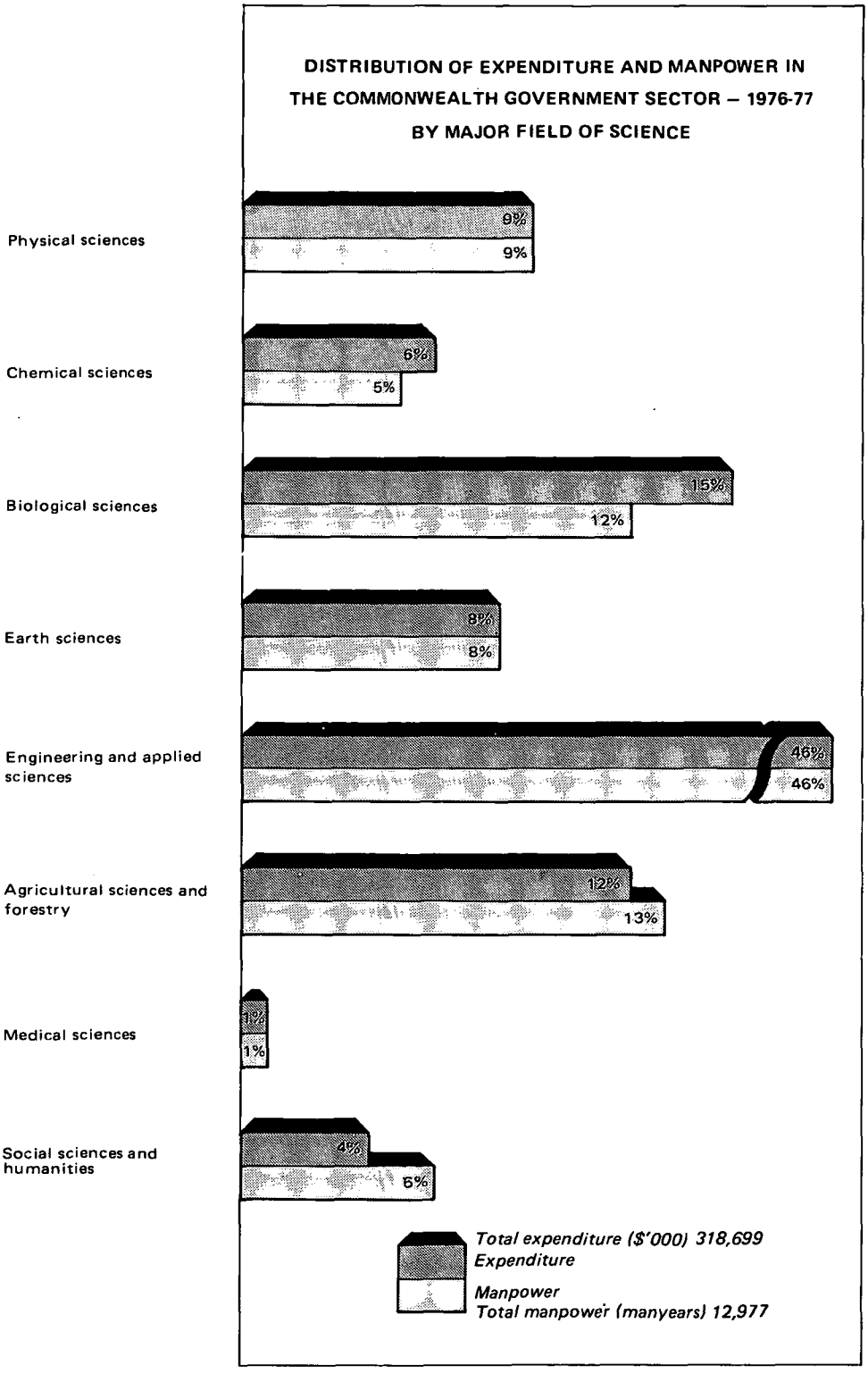

DISTRIBUTION OF EXPENDITURE AND MANPOWER IN THE COMMONWEALTH GOVERNMENT SECTOR – 1976-77 BY MAJOR FIELD OF SCIENCE
Physical sciences
9%
9%
Chemical sciences
6%
5%
Biological sciences
15%
12%
Earth sciences
8%
8%
Engineering and applied sciences
46%
46%
Agricultural sciences and forestry
12%
13%
Medical sciences
1%
1%
Social sciences and humanities
4%
6%
Total expenditure ($'000) 318,699
Expenditure
Manpower
Total manpower (manyears) 12,977

PLATE 50

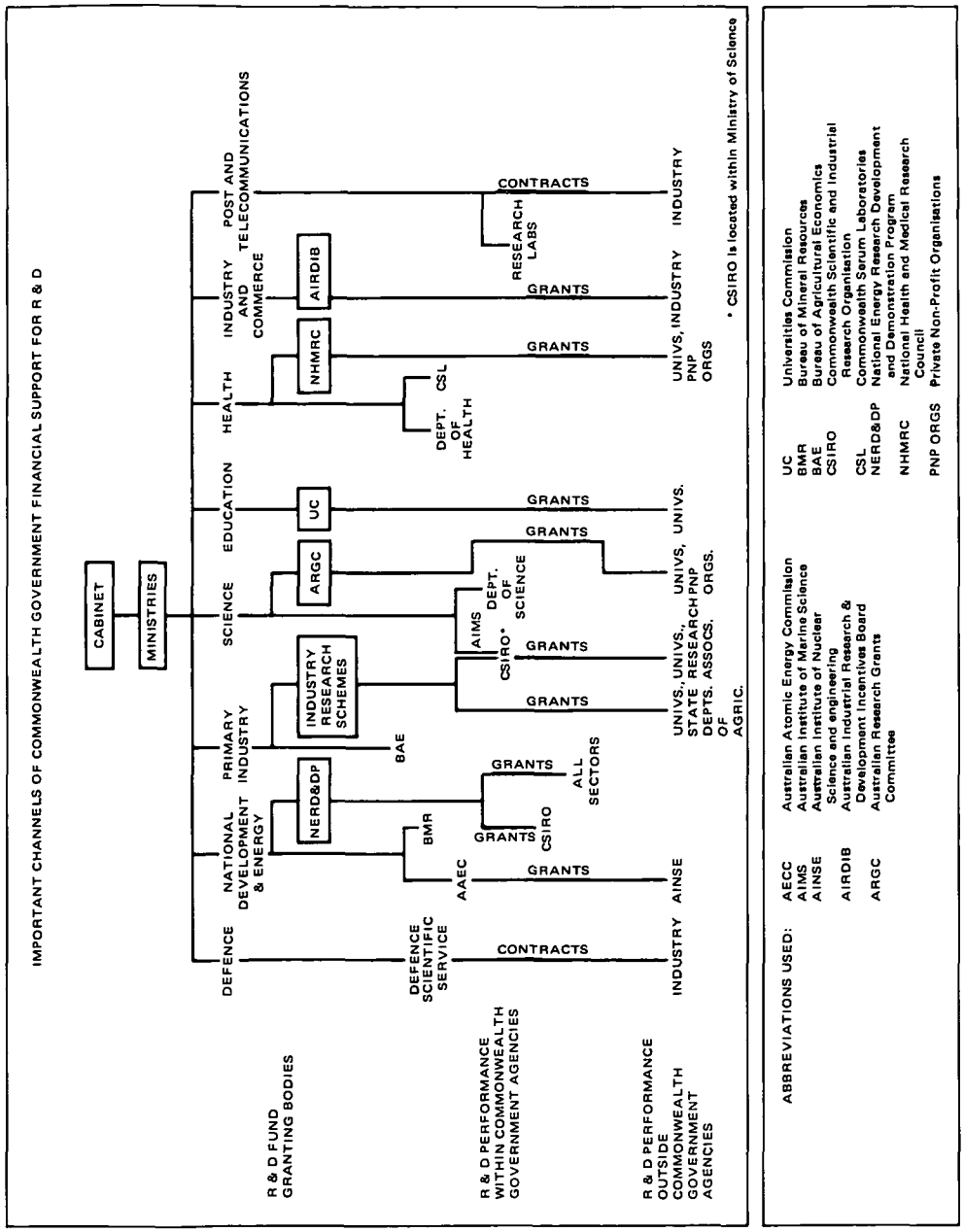

IMPORTANT CHANNELS OF COMMONWEALTH GOVERNMENT FINANCIAL SUPPORT FOR R & D
CABINET
MINISTRIES
DEFENCE
NATIONAL DEVELOPMENT & ENERGY
PRIMARY INDUSTRY
SCIENCE
EDUCATION
HEALTH
INDUSTRY AND COMMERCE
POST AND TELECOMMUNICATIONS
NERD&DP
INDUSTRY RESEARCH SCHEMES
ARGC
UC
NHMRC
AIRDIB
BAE
BMR
AAEC
AIMS
CSIRO*
DEPT. OF SCIENCE
DEPT. OF HEALTH
CSL
RESEARCH LABS
DEFENCE SCIENTIFIC SERVICE
AINSE
INDUSTRY
ALL SECTORS
GRANTS
CONTRACTS
UNIVS., STATE DEPTS. OF AGRIC.
UNIVS., RESEARCH ASSOCS.
UNIVS, PNP ORGS.
UNIVS.
UNIVS, INDUSTRY PNP ORGS
INDUSTRY
R & D FUND GRANTING BODIES
R & D PERFORMANCE WITHIN COMMONWEALTH GOVERNMENT AGENCIES
R & D PERFORMANCE OUTSIDE COMMONWEALTH GOVERNMENT AGENCIES
* CSIRO is located within Ministry of Science
ABBREVIATIONS USED:
AECC Australian Atomic Energy Commission
AIMS Australian Institute of Marine Science
AINSE Australian Institute of Nuclear Science and engineering
AIRDIB Australian Industrial Research & Development Incentives Board
ARGC Australian Research Grants Committee
UC Universities Commission
BMR Bureau of Mineral Resources
BAE Bureau of Agricultural Economics
CSIRO Commonwealth Scientific and Industrial Research Organisation
CSL Commonwealth Serum Laboratories
NERD&DP National Energy Research Development and Demonstration Program
NHMRC National Health and Medical Research Council
PNP ORGS Private Non-Profit Organisations

PLATE 51

State Government sector. Within the State Government sector the overall intramural expenditure on R & D was $132 million, representing 0.9 per cent of State Government outlays ($14,992 million). Manpower involved in this R & D effort was 6,800 man-years. Of this effort, about 2,800 man-years were attributed to workers holding professional qualifications. Distribution of this expenditure and manpower effort by objectives and field of science is shown in Plates 52 and 53, pages 711 and 712. Other major features were:

Within socio-economic objectives, Economic development accounted for 83 per cent of intramural R & D expenditure. The remaining expenditure was distributed between Community welfare (14 per cent) and Advancement of knowledge (3 per cent). Expenditure in the Economic Development Group was distributed between sub-groups as follows:

	per cent
Primary industry	66
Economic services (excluding energy)	10
Secondary industry	4
Energy	3

Expenditure in the Primary Industry Sub-Group was distributed between the objectives:

	per cent
Agriculture	59
Forestry	5
Fisheries	3

In every State, the Department of Agriculture was by far the largest performer of R & D.

Intramural expenditure on R & D in the natural sciences and in the social sciences and humanities was distributed as follows:

	per cent
Natural sciences	94
Social sciences and humanities	6

62 per cent of the total effort was in Agricultural sciences, the major field of science in the natural sciences.

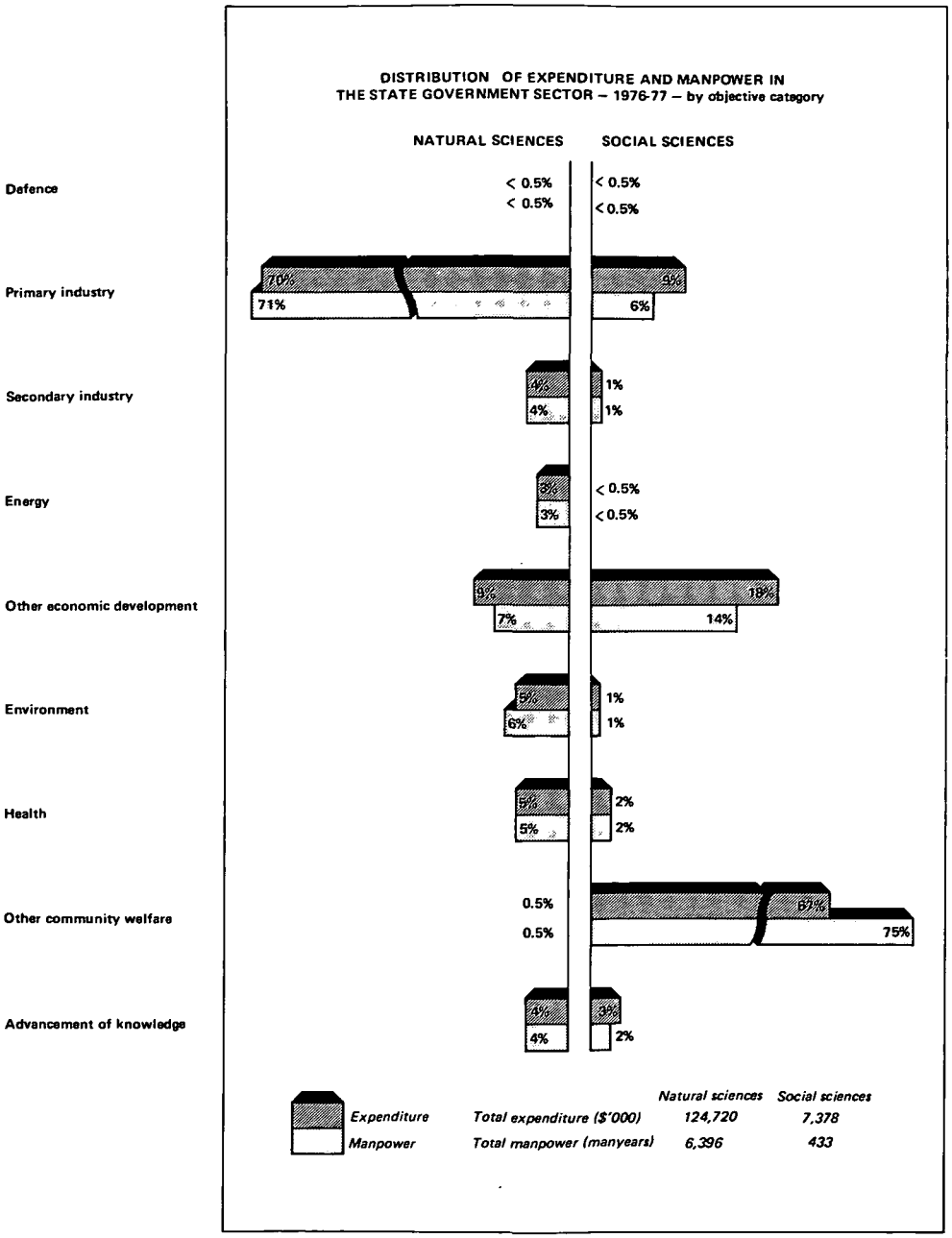

DISTRIBUTION OF EXPENDITURE AND MANPOWER IN THE STATE GOVERNMENT SECTOR – 1976-77 – by objective category
NATURAL SCIENCES
SOCIAL SCIENCES
Defence
< 0.5%
< 0.5%
< 0.5%
< 0.5%
Primary industry
70%
71%
9%
6%
Secondary industry
4%
4%
1%
1%
Energy
3%
3%
< 0.5%
< 0.5%
Other economic development
9%
7%
18%
14%
Environment
5%
6%
1%
1%
Health
5%
5%
2%
2%
Other community welfare
0.5%
0.5%
67%
75%
Advancement of knowledge
4%
4%
3%
2%
Expenditure
Manpower
Total expenditure ($'000)
Total manpower (manyears)
Natural sciences
Social sciences
124,720
7,378
6,396
433

PLATE 52

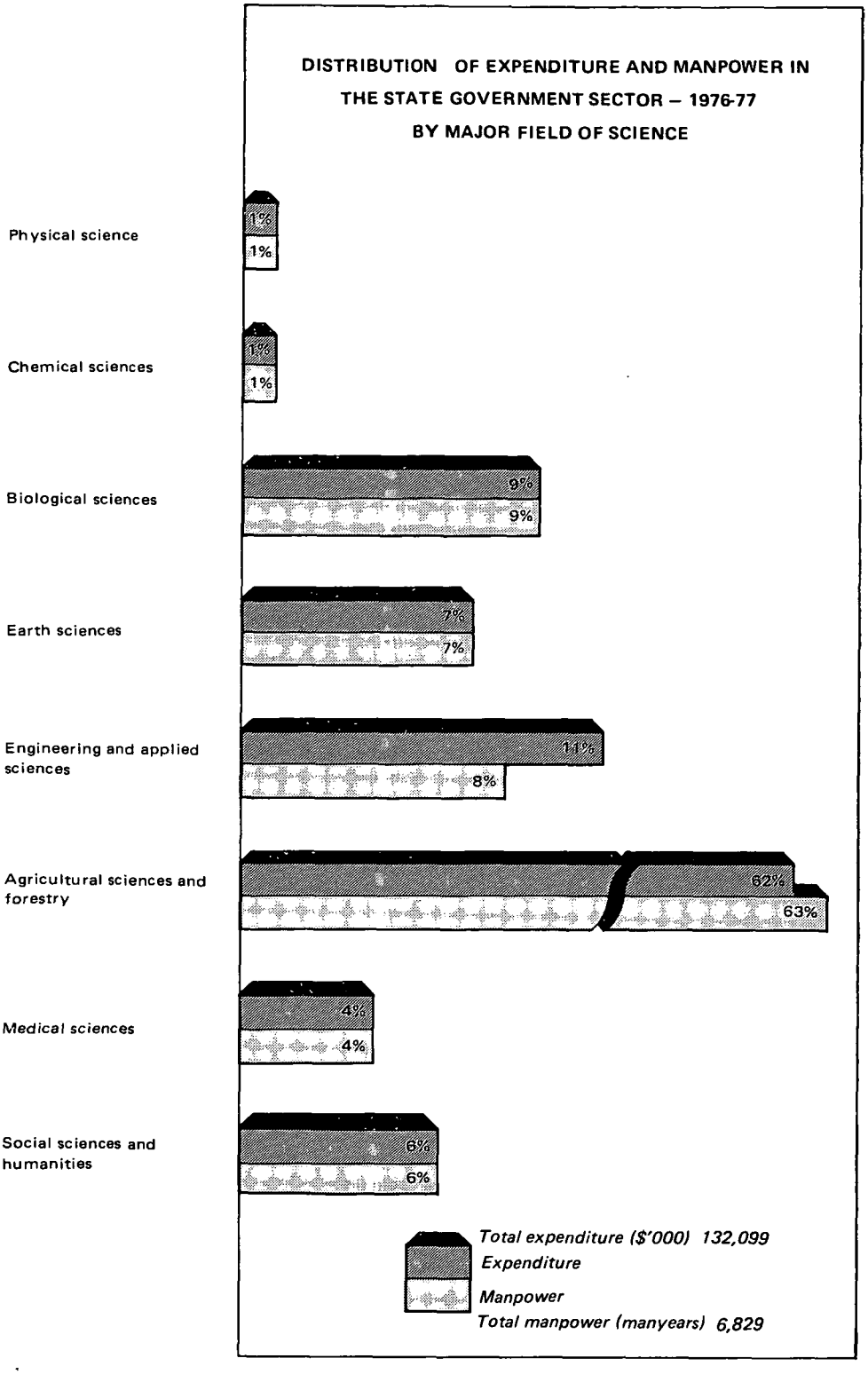

DISTRIBUTION OF EXPENDITURE AND MANPOWER IN THE STATE GOVERNMENT SECTOR – 1976-77 BY MAJOR FIELD OF SCIENCE
Physical science
1%
1%
Chemical sciences
1%
1%
Biological sciences
9%
9%
Earth sciences
7%
7%
Engineering and applied sciences
11%
8%
Agricultural sciences and forestry
62%
63%
Medical sciences
4%
4%
Social sciences and humanities
6%
6%
Total expenditure ($'000) 132,099
Expenditure
Manpower
Total manpower (manyears) 6,829

PLATE 53

Private non-profit sector. In this sector the intramural expenditure on R & D was $11 million. The manpower involved in this effort was 580 man-years of which about 260 man-years were attributed to workers who held professional qualifications. Within socio-economic objectives, the Community welfare group accounted for 94 per cent of R & D expenditure. Within this sector almost 76 per cent of R & D was performed by ten medical research institutes.

Higher education sector. The gross intramural expenditure on R & D in this sector was $184 million, consisting of $75 million directly spent on research in the universities, together with an estimated value of $105 million for R & D performed in combined teaching and research activities. Colleges of Advanced Education accounted for the remaining $4 million, giving a gross expenditure of $184 million. The manpower involved in this effort was 15,300 man-years.

An analysis of expenditure and manpower effort according to field of science is shown in the following table.

EXPENDITURE AND MANPOWER DEVOTED TO R & D IN AUSTRALIA IN 1976-77
HIGHER EDUCATION SECTOR

	Expenditure		*Manpower*	
	$'000	per cent	man-years	per cent
Physical sciences	21,371	12	1,485	10
Chemical sciences	14,393	8	1,136	7
Biological sciences	29,597	16	2,518	16
Earth sciences	9,046	5	748	5
Engineering	19,622	11	1,786	12
Medical sciences	25,893	14	1,692	11
Agricultural	11,305	6	1,096	7
Social science and humanities	53,092	29	4,828	32
Total	**184,322**	**100**	**15,290**	**100**

Private enterprise sector. The gross intramural expenditure on R & D in the Private enterprise sector was $157 million, representing 0.19 per cent of Australia's 1976-77 GDP. The manpower involved in this effort was 7,900 man-years, representing 0.12 per cent of the total effort of the Australian workforce. Figures for expenditure and manpower effort according to industry are shown in the following table.

EXPENDITURE AND MANPOWER DEVOTED TO R & D IN AUSTRALIA IN 1976-77
BUSINESS ENTERPRISE SECTOR

	Expenditure		*Manpower*	
Industry	$'000	per cent	man-years	per cent
Food, beverages and tobacco	12,450	8	588	7
Paper and printing	2,707	2	116	1
Chemicals	32,790	21	1,530	19
Non-metallic mineral products	6,680	4	300	4
Basic metal products	12,432	8	663	8
Fabricated metal products	5,398	3	307	4
Transport equipment	16,774	11	861	11
Other machinery and equipment	44,694	29	2,375	30
Other manufacturing	7,481	5	379	5
Mining (excluding services)	6,693	4	405	5
Services to mining	3,649	2	156	2
Other industries	4,884	3	215	3
Total	**156,632**	**100**	**7,895**	**100**

Resources and services

Although power to regulate the development and utilisation of Australia's natural resources rests largely with the States, the Commonwealth Government, in part because of its jurisdiction in the control of Australia's overseas trade, also plays an important role. Extensive machinery exists for consultation and collaboration between the Commonwealth and State governments in relation to the development and management of natural resources.

Several important resources and services are dealt with elsewhere in this Year Book and are thus not included in this chapter. These include health (Chapter 10), the rural industry (Chapter 13), forestry (Chapter 14), fisheries (Chapter 14), water (Chapter 15), the mineral industry (Chapter 16), transport (Chapter 20), and communications (Chapter 20).

Soil resources

A Standing Committee on Soil Conservation was established in 1964. It comprises the heads of soil conservation bodies in the States and representatives of relevant Commonwealth agencies. The Committee co-ordinates activities of interest to its member bodies such as the survey of erosion throughout Australia which was carried out in the late 1960s, and the development of co-operative arrangements for in-service training of technical personnel.

Fauna and flora resources

During the last century, as each State became established, museums and botanical gardens containing herbaria were set up. Studies of fauna and flora were carried out by these bodies and by the universities. Various divisions of CSIRO have also carried out work on fauna and flora, but an important part of total Australian research into inventorying biological resources continues to be undertaken in the museums and herbaria of the State governments.

In 1973, the Commonwealth Government set up the Australian Biological Resources Study (ABRS) under an Interim Council. Funds were made available through it to stimulate taxonomic and ecological studies of Australian fauna and flora. In 1978, following recommendations by the Interim Council and by the Australian Science and Technology Council, ABRS was established as a continuing program within the Department of Science and the Environment.

Funds are made available through ABRS on the recommendation of an Advisory Committee to the Minister for Science and the Environment for work designed to fill the gaps in the scientific knowledge of the Australian fauna and flora. The role of ABRS is to co-ordinate all work aimed at collecting, describing, classifying and determining the distribution of Australian animals and plants. Its responsibilities include the maintenance of a comprehensive network of national taxonomic collections and a national taxonomic data bank. Its current major projects are the writing of a concise flora of Australia, the compilation of an Australian Faunal List and the establishment of an Australian Biotaxonomic Information System.

Fauna and flora conservation

Responsibility for the conservation and management of fauna and flora resources rests, in the main, with the State Governments. However, the Commonwealth has responsibility for such resources in its own Territories.

In 1975, the Commonwealth Government established the Australian National Parks and Wildlife Service, whose functions include care and management of national parks and wildlife in Australia and its Territories, conduct of ecological studies to determine additional areas which should be reserved as national parks and nature reserves, and survey and assessment of wildlife populations with particular reference to endangered species.

Environmental protection

Responsibility for most pollution control aspects of environmental protection rests with the State Governments, which have all enacted legislation to control the operations of government and private enterprises that may have a deleterious effect on the physical environment.

The Commonwealth Government is responsible for pollution control in its own Territories and in respect of the operation of its own agencies within the States. It is also concerned with the enforcement of provisions of relevant international conventions to which Australia is a signatory.

Both the Commonwealth and State Governments also have legislation or procedures for assessing the environmental impact of proposed actions that may have a significant effect on the environment. These procedures generally provide for the preparation of environmental impact statements—sometimes allowing for public review—as a prerequisite to approval of new development projects or other activities with significant environmental consequences.

The various governments collaborate in environmental and conservation matters through three Ministerial Councils: the Australian Environment Council, which provides a framework for consultation on environmental matters; the Council of Nature Conservation Ministers, which is concerned with preservation of wildlife and the establishment and management of national parks; and the Australian Water Resources Council which is concerned with the assessment, development and use of national water resources.

Special arrangements have been made for minimising the environmental impact of uranium developments in the Northern Territory. An Office of the Supervising Scientist has been established

under Commonwealth legislation. The Supervising Scientist has overall responsibility for the co-ordination and supervision of measures for the protection and restoration of the environment in the Alligator Rivers Region from the effects of uranium mining. The Supervising Scientist also manages the Alligator Rivers Region Research Institute.

Meteorology

The Bureau of Meteorology, which is a Division of the Department of Science and the Environment, is the national authority for providing weather forecasting and warning services, and general meteorological information and consultative advice. Users of these services include the general public, defence forces, civil aviation and marine authorities, and specialist groups in primary and secondary industries.

Programs of research are carried out in support of these services, often in co-operation with other institutions concerned with meteorological science including universities and the CSIRO. The Australian Numerical Meteorology Research Centre, which specialises in the development of numerical model techniques for predicting atmospheric behaviour, is operated jointly by the Department of Science and the Environment and CSIRO.

Total expenditure by the Bureau in 1978–79 was approximately $38.7 million.

Ionospheric Prediction Service

The Ionospheric Prediction Service (IPS) Branch of the Department of Science and the Environment exists to assist users of radio communications to achieve the most effective and efficient use of radio transmissions that are influenced by or dependent on the ionosphere. The staff of the Branch make regular measurements of the ionosphere above Australia and its territories, and of the sun, and issue both short and long term predictions of the state of the ionosphere as it applies to radio communication.

Research into physical phenomena affecting the condition of the ionosphere forms part of the regular activity of the IPS.

Satellite remote sensing

In 1978 the Commonwealth Government decided to establish facilities for receiving and processing information from the U.S. National Aeronautics and Space Administration's series of Landsat satellites. The Department of Science and the Environment is managing this project. A data receiving station is under construction in Alice Springs and data processing equipment is being procured for installation in Canberra. Additional information on Landsat stations is provided at pages 722–4 of this Year Book.

Scientific and Technological Information Services

Scientific literature for scientists and technologists is provided through national and State libraries, libraries operated by scientific and technological agencies of the Commonwealth and State Governments, tertiary education institutions and industrial organisations. Two important scientific libraries within the Commonwealth Government sector are the CSIRO Central Library and the Australian National Scientific and Technological Library.

Several Commonwealth Agencies including the Australian Atomic Energy Commission, the CSIRO, the Department of Productivity and the National Library of Australia are now offering Australian subscribers access to overseas bibliographic and numerical data bases. The Overseas Telecommunications Commission is developing an international data transmission service to be known as MIDAS (Multi-mode International Data Acquisition Service) which should improve access to international data stores.

Another overseas trend now arousing interest amongst Australian scientists is the development of numerical data bases which provide quick access to factual data. The CSIRO is currently operating Thermodata, a metallurgical thermodynamic data base, and is in the process of developing other similar data bases.

A number of Australian scientific and technological indexes and directories now exist or are in the course of production by Commonwealth Government departments and agencies. Two recent initiatives are:

- a Directory of Technical Information Sources for Industry which has been produced by the National Library of Australia; and
- a directory of Australian research projects undertaken in the natural sciences and selected social sciences in the Higher education sector. The directory, in microfiche form, was produced by the Department of Science and the Environment (in conjunction with its work on Project SCORE) and the CSIRO.

Units and Standards of Physical Measurement

The National Standards Commission, originally established in 1948 and given further responsibilities under the *Weights and Measures (National Standards) Act* 1960, advises on matters relating to weights and measures such as the establishment and use of uniform units and standards of measurement of physical quantities. The Commission is also responsible for the examination, approval and certification of the design and performance of patterns of measuring instruments used for trade, Australian participation in the preparation of international standards applicable to legal metrology and their subsequent adoption, and liaison with State government on the regulation of weighing and measuring practice in trade.

Major government research agencies

Commonwealth Scientific and Industrial Research Organization (CSIRO)

The CSIRO is the largest scientific research organization in Australia. It has a total staff of some 7,000 people located in more than 100 laboratories and field stations throughout Australia. About one-third of the staff are scientists.

The CSIRO is a statutory body established by the *Science and Industry Research Act* 1949. Under the Act CSIRO replaced, but had continuity with, the former Council for Scientific and Industrial Research (CSIR) which was established in 1926. The *Science and Industry Research Act* 1949 as amended by the *Science and Industry Research Amendment Act* 1978 provides that the functions of CSIRO are:

- to carry out scientific research for any of the following purposes:
  - (i) assisting Australian industry;
  - (ii) furthering the interests of the Australian community;
  - (iii) contributing to the achievement of Australian national objectives or the performance of the national and international responsibilities of the Commonwealth;
  - (iv) any other purpose determined by the Minister;
- to encourage or facilitate the application or utilization of the results of such research;
- to act as a means of liaison between Australia and other countries in matters connected with scientific research;
- to train, and to assist in the training of, research workers in the field of science and to co-operate with tertiary-education institutions in relation to education in that field;
- to establish and award fellowships and studentships for research, and to make grants in aid of research for a purpose referred to in scientific research above;
- to recognize associations of persons engaged in industry for the purpose of carrying out industrial scientific research and to co-operate with, and make grants to, such associations;
- to establish, develop and maintain standards of measurement of physical quantities and, in relation to those standards—
  - (i) to promote their use;
  - (ii) to promote, and participate in, the development of calibration with respect to them; and
  - (iii) to take any other action with respect to them that the Executive thinks fit;
- to collect, interpret and disseminate information relating to scientific and technical matters; and
- to publish scientific and technical reports, periodicals and papers.

The Act provides for CSIRO to be governed by an Executive comprising a full-time Chairman, two other full-time Members and between three and five part-time Members. It also provides for a statutory Advisory Council and State Committees as independent sources of advice to the Executive.

The CSIRO's research is carried out in some thirty seven divisions and five smaller units. The divisions and units are grouped into the following five Institutes:

Institute of Animal and Food Sciences Divisions of Animal Health, Animal Production, Food Research, Human Nutrition; Centre for Animal Research and Development; Molecular and Cellular Biology Unit; Wheat Research Unit.

Institute of Biological Resources Divisions of Entomology, Fisheries & Oceanography, Forest Research, Horticultural Research, Irrigation Research, Plant Industry, Tropical Crops & Pastures, Wildlife Research.

Institute of Earth Resources Divisions of Applied Geomechanics, Land Resources Management, Land Use Research, Mineral Chemistry, Mineral Engineering, Mineralogy, Mineral Physics, Process Technology, Soils; Fuel Geoscience Unit.

Institute of Industrial Technology Divisions of Applied Organic Chemistry, Building Research, Chemical Technology, Mechanical Engineering, Protein Chemistry, Textile Industry, Textile Physics.

Institute of Physical Sciences Divisions of Applied Physics, Atmospheric Physics, Chemical Physics, Cloud Physics, Computing Research, Environmental Mechanics, Materials Science, Mathematics and Statistics, Radiophysics; Australian Numerical Meteorology Research Centre.

There is also a Bureau of Scientific Services comprising the Central Information, Library and Editorial Section, the Centre for International Research Co-operation and various groups concerned with information and technology transfer.

The CSIRO has an annual budget of more than $150 million. Some 85 per cent of this money is provided directly by the Commonwealth Government. The remainder is contributed by trust funds concerned with the wool, meat, wheat, dairying, fishing and dried fruit industries, by individual companies, by Australian and overseas government instrumentalities, and by private foundations. The trust funds constitute approximately two-thirds of these contributory funds. They are derived principally from industry levies supported by Commonwealth Government contributions.

The Australian Atomic Energy Commission (AAEC)

For information on AAEC *see* Chapter 18, Energy.

Antarctic Division, Department of Science and the Environment

Australia has been active in research and exploration in the Antarctic region since early in the present century, but the overall effort has expanded appreciably since the 1940s when the Government established the Australian National Antarctic Research Expeditions (ANARE) and the Antarctic Division.

At any given time the total staff complement of the Division varies between 170 and 220 persons, about half of whom are engaged on a short-term basis to man annual expeditions and provide general support. Expenditure by the Division in 1978–79 was approximately $9.64 million.

Services provided by the Antarctic Division in relation to research expeditions include:

- the supply and maintenance of three permanent stations in the Australian Antarctic Territory on the Antarctic continent and one on sub-Antarctic Macquarie Island;
- the mounting of annual and shorter-term research expeditions;
- the co-ordination of activities of agencies involved with ANARE (which include the Antarctic Division itself, the Bureau of Meteorology and the Ionospheric Prediction Service of the Department of Science and the Environment); the Bureau of Mineral Resources, Geology and Geophysics, and the Division of National Mapping of the Department of National Development; certain sections of the Army; various university departments; and the CSIRO.

In addition to its general support function, the Division directly undertakes research in such fields as cosmic ray and upper atmosphere physics, glaciology, Antarctic biology and medical science matters relevant to Antarctic conditions. In 1977, the Government approved an extension of the Division's scientific program into the marine areas around Antarctica. Personnel at research stations include meteorologists, physicists, glaciologists, biologists and logistic staff.

Australia is a signatory to the Antarctic Treaty, and many of its scientific activities in Antarctica are undertaken in collaboration with other signatory countries.

Australian Institute of Marine Science (AIMS)

The AIMS has been established on a 190 hectare site within a national park at Cape Ferguson, 50 kilometres south of Townsville in North Queensland. Comprehensive headquarters facilities were opened in September, 1977 and include laboratories, lecture theatre, library, computer centre, administrative and other support services. A harbour for the Institute's vessels was completed in April, 1976. A 24.4 metre ocean-going research vessel constructed specifically for the Institute was delivered during October, 1978.

The Institute is essentially concerned with research and emphasises multidisciplinary projects, many of which are focussed on tropical marine science. Research projects at the AIMS during 1978–79 fell into 3 areas: estuarine and oceanic marine food webs; reef-building organisms and the Great Barrier Reef and marine pollution. These areas were selected both for their current importance to marine science and for their relevance to many applied problems. Specific programs being undertaken by the Institute concern: inshore ecology and productivity; pelagic biology; coral taxonomy; coral calcification; reef origins and maintenance; sedimentology; and physical oceanography.

Defence Science and Technology Organisation

The Defence Science and Technology Organisation, Department of Defence, conducts a significant amount of research and development in engineering and the physical sciences. Operational

research, human and sociological studies and research into the environment are also carried out. Current expenditure is about $90 million per year.

Further details on the work of the organisation are found in Chapter 4, Defence.

Technology Division, Department of Housing and Construction

To support its operations as the major design and construction authority for the Commonwealth, the Department of Housing and Construction carries out applied research and laboratory testing and provides a comprehensive range of technical services. In many cases, these services directly or indirectly benefit the needs of private industry and the public generally.

Research and special testing is conducted mainly by the Technology Division at establishments such as the Experimental Building Station in Sydney, which specialises in building and building components, and the Central Investigation and Research Laboratory in Melbourne, which specialises in engineering materials and products.

Telecom Australia Research Laboratories

Telecom Australia maintains significant facilities and a staff of approximately 500 for research in telecommunications science and technology.

Research in private industry

Expenditure on research and experimental development performed by private enterprises in 1976–77 was $157 million of which $143 million came from industry's own funds. At current prices this represents an 18 per cent decrease in expenditure since 1973–74. Manpower effort devoted to R & D performed by Private enterprises was 7,895 man years. This represents a decrease of 36 per cent since 1973–74. In addition Private enterprises contributed $10 million towards the cost of R & D performed overseas and in the Higher education, Government and Private non-profit sectors.

The Government provides funding to encourage industrial research and development (IR and D) under the provisions of the *Industrial Research and Development Incentives Act* 1976. Two types of grants are payable under the Act: commencement grants to encourage companies to develop a basic R & D capability; and grants designed to give on-going support for companies with established IR and D facilities to undertake specific IR and D projects showing technical and commercial promise. In 1979–80 commencement grants will be paid at the rate of 50 per cent of eligible expenditure up to a ceiling of $25,000, and project grants at 50 per cent of eligible expenditure up to a ceiling of $500,000. In addition the Minister for Productivity is empowered under the Act to approve full funding of projects considered to be in the 'public interest'. $27 million was appropriated in the 1979–80 Budget for the Industrial Research and Development Incentives Scheme. A further $9 million was appropriated for industry technology programs, including $4 million for 'public interest' projects.

The Assistance to Inventors' Scheme provides financial grants to individual inventors to enable them to develop worthwhile inventions, after patent application, to the prototype or demonstration stage. Grants of up to $10,000 can be provided for each invention, as well as technical, industrial or commercial advice on how to develop the invention. Government assistance for research and development by private industry is also available through grants from the *National Energy Research Development and Demonstration Council* (NERDDC) (*see* page 460 of the Energy chapter for additional information on NERDDC) and the *Australian Research Grants Committee.*

Payments Overseas for Technical Know-How

Australian R & D efforts have been significantly supplemented by overseas technology largely associated with the activities of foreign firms. Australian firms in many industries have bought or licensed foreign technology. According to Project SCORE Australian Private enterprises made total payments overseas during 1976–77 of approximately $65 million for patent rights and other technical know-how e.g. patent licences, technical data and information and scientific, technical, or engineering assistance which increased technical knowledge and understanding within the enterprise. Of this, approximately $35 million was paid to the U.S.A. and approximately $14 million to the U.K. Australian private enterprises received payments of approximately $7 million from overseas for the sale of technical know-how. The adoption by industry of new technology also attracts financial support from the Commonwealth through the *Industrial Design Council of Australia* and the *Standards Association of Australia* which receive subsidies from the Commonwealth Government.

Metric Conversion

The conversion to the metric (SI) system of weights and measures is now well advanced in Australia. The conversion program has been developed and implemented under the guidance of a

Metric Conversion Board established by the Commonwealth Government. The Board considers that the conversion will be effectively achieved by 1980 as originally envisaged, although it has always been recognised that some residual use of imperial units will continue for a time thereafter, e.g. in association with equipment of long life. The implementation of the program has depended in large measure on general community co-operation. The Board sought and gained assistance from advisory groups representative of all sectors of the community.

The Australian Patent Information Service

The Australian Patent Information Service has recently been formed with the major purpose of making Australian industry aware of the wealth of technological information contained in the world collection of patent specifications held by the Patents Office. The Service is available to assist industry to gain access to this information by providing copies of patent specifications (Australian and foreign), covering the relevant area(s) of technology in which an inquirer is interested.

Industry organisations

A number of organisations aiming, wholly or in part, to support and encourage R & D have been established within industry. By far the majority support sectional interests. Examples of such organisations are the Bread Research Institute and the Australian Mineral Industries Research Association.

Research in universities and colleges

General financial support for Higher education is provided primarily by the Commonwealth Government through the Councils of the Tertiary Education Commission (the Universities Council; and Technical and Further Education Council; and the Advanced Education Council).

In addition, the Government funds research undertaken in the universities and elsewhere through a number of granting schemes. In some cases, Commonwealth Government funds are supplemented by State governments or by levies imposed on or by specific industries (e.g. the wool, wheat and beef industries) for that purpose.

The two principal granting schemes through which supplementary funds are made available for research in universities are those administered by the Australian Research Grants Committee (ARGC), and the National Health and Medical Research Council (NHMRC). For both schemes the principal criteria for awards are the scientific excellence of the applicant and the research project. Applications are judged by expert advisory committees composed of practising scientists, and recommendations are made to the Minister for Science and the Environment and the Minister for Health for the ARGC and NHMRC awards respectively.

The Commonwealth Department of Health administers the Health Service Research and Development Grant program which provides grants to researchers in educational and health institutions and to independent researchers. The Department receives advice from the Health Services Research and Development Grants Advisory Committee.

Fellowships such as the Queen Elizabeth the Second Fellowships and the like, while providing some additional funds, are significant more for the prestige they carry than for their contribution to overall funding levels. They are, however, more readily available to the young scientists than are the ARGC awards.

Colleges of Advanced Education do not maintain expensive research facilities or programs akin to those of the universities; nevertheless, staff are encouraged to undertake research to the extent that this is possible. Research of an applied nature, and associated consultancy services to industry and commerce, are expected to become increasingly prominent within the colleges.

Research organisations associated with education institutions

Several of the tertiary education institutions have established independent, commercial companies to promote and manage research and consultancy services to industry, commerce, government and the community. Examples are: Unisearch Ltd, associated with the University of New South Wales; Wait-Aid Ltd, associated with the Western Australian Institute of Technology; Technisearch Ltd, associated with the Royal Melbourne Institute of Technology; SARD, associated with the Swinburne College of Technology; Techsearch Inc., associated with the South Australian Institute of Technology; and TUNRA, the University of Newcastle Research Association.

These organisations play an important role in promoting communication between the Higher education and other sectors. They undertake investigational and research projects, mainly in the fields of engineering and science. However, activities in other fields such as management, marketing and the social sciences are increasing. Testing work, performed generally by full-time employees, is undertaken in some instances. Results of work are confidential to the client and are not published unless authorised by that client.

Social science research

Research in the social sciences is undertaken primarily in universities and agencies of the Australian and State governments. Financial support for research in non-government bodies, especially universities, is provided by government. This support comes both from general funds, provided to the universities and also from specific granting bodies such as the ARGC and the Australian Advisory Committee on Research and Development in Education.

The bulk of social science research carried out within Commonwealth Government agencies is performed as part of the general activities of various departments. However, several agencies have been established specifically to undertake research. Agencies which have been established to undertake research in particular areas include the Australian Institute of Aboriginal Studies, the Australian Institute of Criminology, the Bureau of Agricultural Economics and the Bureau of Transport Economics.

Agencies of the various State governments undertake research relevant to their own activities and programs especially related to health, youth and community services. A number of research organisations in the transport spheres are funded from both Commonwealth and State sources. The Australian Railway Research Board and the Australian Railway Research and Development Organisation are active in social science research.

Exchange of ideas and information on the social sciences is promoted through a number of professional and learned bodies, of which the Australian and New Zealand Association for the Advancement of Science and the Academy of the Social Sciences in Australia are the most broadly based. In addition to encouraging the advancement of the social sciences, the Academy sponsors and organises research, subsidises publications and acts as a consultant and advisor on the social sciences.

Non-government bodies which undertake or promote research in specific fields of the social sciences include the Australian Institute of International Affairs, the Australian Institute of Urban Studies, and the Australian Institute of Political Science.

International activities

International Organisations

Australia participates in a range of United Nations Environment Program activities and in the activities of both governmental and non-governmental international scientific organisations. To facilitate scientific liasion and representation, some Government agencies have scientific and technological representation at overseas posts (e.g. Japan, United Kingdom, United States of America, USSR, the International Atomic Energy Association and the OECD). Australia also plays an active role in regional bodies such as ESCAP (formerly ECAFE), the Pacific Science Congress, and the Association for Science Cooperation in Asia, and has provided technical assistance to countries in the region under both multilateral and bilateral arrangements.

Australia participates in the programs of the Committee for Scientific and Technological Policy of the OECD.

Participation in international non-governmental scientific bodies is arranged through learned and professional bodies. For example, the Australian Academy of Science provides representation to the International Council of Scientific Unions (ICSU) and a number of its affiliated bodies.

Studentships and Fellowships

Australia has assisted other countries, principally in the Asian and Pacific regions, by training their nationals. Large numbers of such students, mainly seeking first qualificatons at tertiary level, have been accommodated under schemes such as the Colombo Plan. There are also arrangements under which established scientists from overseas are assisted to undertake study and research in Australia.

Bilateral Arrangements

Various bilateral arrangements at both government and non-government levels have contributed to the development and maintenance of co-operation in science and technology between Australian institutions and scientists and those in other countries. Formal bilateral agreements solely devoted to scientific and technological co-operation have been entered into with the USA (1968), India (1975) and the Federal Republic of Germany (1976) and are administered by the Department of Science and the Environment. Similar agreements with the USSR (1975) and the People's Republic of China (1979) are administered by the Department of Foreign Affairs. Support is provided for both individual visits and specialist seminars over the whole range of civil science. Where opportunities exist, other cooperative projects which depend on special facilities are supported.

A scientific exchange program between the Australian Academy of Science and the Academy Sinica of Peking was initiated in 1976–77. Scientific fields considered most promising are plant physiology, entomology and earth science. A similar exchange program between the Australian Academy of Science and the Japan Society for the Promotion of Science was also initiated during 1977.

Visits to Japan and China by Australian scientists can be supported by the Australia/Japan Foundation and the Australia/China Council.

Meteorology

Australia is a Member of the World Meteorological Organisation (WMO), with the Director of Meteorology being Australia's Permanent Representative on WMO.

Australia operates one of the three World Meteorological Centres in WMO's Global Weather Experiment, which is being conducted from December 1978 to November 1979. The Experiment is of particular relevance to Australian meteorology because of the opportunity to use special systems to observe conditions over the southern oceans where data are normally scarce.

Astronomy

In the field of optical astronomy, the Anglo-Australian Telescope Board, established under the provisions of an international agreement between Australia and the United Kingdom and drawing its funds in equal shares from each country, operates the 3.9 metre Anglo-Australian Telescope at Siding Spring Mountain near Coonabarabran in New South Wales. The Telescope, among the largest in the world, came into full scientific operation during 1975. Its technical excellence and the scientific work which it has made possible have brought it to be widely recognised as the world's foremost optical telescope.

Space

An agreement was signed in 1960 and has been renewed at ten-year intervals by the Governments of Australia and the United States of America to co-operate in the establishment and operation in Australia of space vehicle tracking stations. The agencies for the Australian and American Governments are the Department of Science and the Environment and the National Aeronautics and Space Administration (NASA) respectively.

As part of the world-wide network supporting NASA's space program, the stations track spacecraft in their orbits around the earth or on their journeys into space, receive telemetred data from the spacecraft, and relay radio commands controlling the spacecraft.

The Department of Science and the Environment is responsible for managing, staffing and operating the tracking stations on behalf of NASA. The stations are located at Orroral Valley, Honeysuckle Creek and Tidbinbilla in the Australian Capital Territory. A communications system links them with control centres in the United States of America.

Expenditure by NASA on its tracking station operations in Australia in 1978–79 was approximately $11 million.

An agreement has been signed between the Commonwealth Government and the European Space Agency (ESA) for the establishment and operation of a space vehicle tracking facility in Australia in support of ESA programs. The facility will be located at the site of the Overseas Telecommunications Commission (Aust) earth station at Carnarvon, W.A., and is expected to be operational before June 1980.

Scientific Ballooning

The Australian Balloon Launching Station (ABLS) at Mildura, Victoria is operated by the Department of Science and the Environment under a joint-sponsorship arrangement with the US National Science Foundation. The station provides a service for scientific research, requiring the use of high altitude balloons, to research workers from the USA, Australia and other countries. Research objectives are generally either in the fields of X-ray and gamma-ray astronomy or atmospheric studies.

Seismology

A comprehensive seismic station at Alice Springs (Joint Geological and Geophysical Research Station) is operated jointly under an agreement between the Governments of Australia and the United States of America. The agencies for the Governments are, respectively, the Department of Science and the Environment and the United States Air Force.

The station provides continuous seismic records to assist the United States Government in the identification of underground nuclear explosions and, through the Department of Science and the Environment provides seismic records to the Bureau of Mineral Resources, Geology and Geophysics.

Records are also available, through the Department of Science and the Environment, to Australian scientists for research in earth physics.

Defence

In the field of defence science, Australia collaborates with other countries through a variety of arrangements at intergovernmental level. Further information is given in Chapter 4, Defence.

Transport

Australia is represented at Federal and State levels on a number of transport research-orientated international organisations through a variety of arrangements at intergovernmental level. Further information is given in Chapter 20, Transport and Communication.

Other

At the non-governmental level, formal arrangements for scientific co-operation with counterpart institutions in other countries have been concluded by a number of Australian bodies. For example, an arrangement covering co-operation in astronomy exists between the University of Sydney and Cornell University (USA), while over a broader area the Australian National University has an arrangement with the University of Moscow which includes exchanges in the scientific fields.

Additional information

Additional information on topics presented in this chapter may be found in the annual reports of the organisations mentioned, particularly the Department of Science and the Environment, the CSIRO and its divisions, the Australian Atomic Energy Commission, and the Department of Defence. Statistical information for the years 1968–69, 1973–74 and 1976–77 may be found in the reports published by the Department of Science and the Environment on Project SCORE. Statistical information on R & D performed by Private enterprises for 1976–77 may be obtained from the Australian Bureau of Statistics publication *Research and Experimental Development—Private Enterprises,* 1976–77 (8104.0). The ABS will publish statistical information for all SCORE sector surveys for 1978–79 and biannually thereafter.

Also relevant are reports published by the former Office of Secondary Industry of the Department of Trade and Industry (*Survey of Industry Research and Development in Australia* (1968–69) and by the former Department of Manufacturing Industry (Bulletin No. 11, November 1974 *R & D in Manufacturing Industry* 1971–72).

Information on manufacturing industry research and development is contained in Chapter 6, Vol. 1A of ASTEC's report on *Science and Technology in Australia* 1977–78 (June 1978) Chapter 7, Vol. 1 of the Report of the Study Group on Structural Adjustment (March 1979) and the Report of the Senate Standing Committee on Science and the Environment on *Industrial Research and Development in Australia* (May 1979).

Landsat Satellite

Australian Landsat Station

Landsat is the name given to a series of U.S. National Aeronautics and Space Administration (NASA) experimental orbiting spacecraft designed to determine the usefulness of satellite-acquired data in managing the environment and natural resources.

To date NASA has launched three Landsat satellites: the first in 1972, the second in January 1975 and the third in March 1978. The first was turned off in January 1978 but data continued to be transmitted from the second and third satellites. A fourth satellite is due to be launched in 1982 and more are contemplated. Other countries such as Japan, the Soviet Union and France have plans to develop remote sensing satellites similar in many ways to Landsat.

For a number of years, Australian Federal and State government agencies, universities and colleges and industry have been investigating the application of Landsat remote sensing data in the Australian context and also the means of processing data electronically to improve its usefulness. For this work, investigators have relied on data recorded on an opportunity basis during satellite passes over Australia and have also had to contend with unavoidable delays in supply of data from the U.S.A.

In August 1977, the Government decided to establish its own receiving and processing facilities in Australia. The decision followed the completion in 1976–77 of an assessment of the value of remote sensing to Australia and took account of the overall technical success of the Landsat series of satellites.

The Landsat system

As a Landsat satellite orbits the Earth, its two main instruments, the multi-spectral scanner and return beam vidicon camera system, each construct images of an 185 km square scene of the Earth below. The multi-spectral scanner sweeps across the scene or segment in four wavelength bands: green (0.5-0.6 micrometres), red (0.6-0.7), infrared 1 (0.7-0.8) and infrared 2 (0.8-1.1). Its photo-electric detectors measure the intensity of sunlight reflecting back from individual units of the Earth's surface just under 80 metres square. These units are the fundamental elements of the picture and are known as pixels, some 7.5 million of which make up a standard 185 km square scene. The light intensity for each pixel is converted into electronic signals and transmitted to an appropriate ground receiving station.

Different materials on the Earth's surface such as water and crops and forests of different types reflect light differently, and the signals reaching the Earth can be measured and reconstructed to show the difference in detail and enable substances to be identified. Resource managers are then able to use photographic images or data classified by computer from magnetic tapes to monitor details of the Earth's surface.

Landsat spacecraft orbit the earth every 103 minutes, passing over each pole and crossing the Equator on the sunlit side of the Earth at the same local time each day, about 9.30 a.m. In this way, the satellites receive reflected sunlight of about the same illumination intensity arising from the same sun angle.

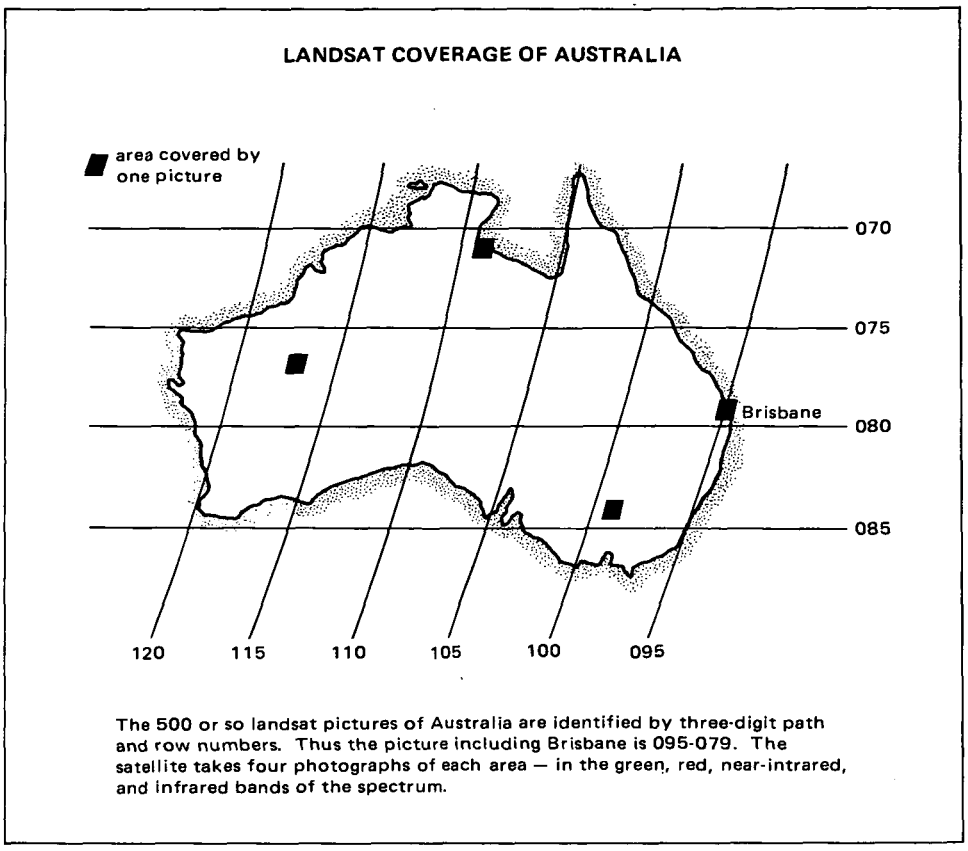
From its position in orbit 917 km above the Earth, each satellite views an area at the surface 185 km square. As each orbit proceeds, the satellite sees and transmits data for a swath 185 km wide, and the whole globe is scanned once every eighteen days. With two satellites in service, a spot on the Earth is scanned once every nine days.

Landsat applications

The advantages offered by remote sensing from space are now generally recognised as synoptic pictures of sizeable areas, acquisition of near real-time data, repeated coverage to record changing phenomena even in areas which have been well surveyed and mapped, reduced data acquisition time, uniform measurements, wide-area coverage reducing the problems of assembling broadscale mosaics, coverage of areas beyond practical range for aircraft, global survey without large on-site support requirements, and reduction in costs for large-scale coverage. While Landsat does not supplant aerial remote sensing, particularly photography, it is an important adjunct to it. For the cost of only a few dollars, Landsat products allow the performance of many monitoring functions which, if carried out by aircraft, would be prohibitively expensive.

Among the applications of Landsat imagery are monitoring of the environment, studies in agriculture and forestry, geography, geology and mineral resources, hydrology and water resources, oceanography and marine resources, the atmosphere and meteorology, and monitoring the effects of national disasters such as floods and bushfires.

In the Australian context, Landsat offers great benefits in agriculture in the management of wheat crops. The broad overview provided by satellite images allows annual planting of crops to be estimated accurately and the development of growth to be monitored for disease and climate stress. With further information, the Australian annual wheat yield can be estimated. Another area of proven benefit has been in mineral exploration, where the broad overview of geological features in areas previously lacking in detailed aerial survey or detailed geological mapping has enabled mineral prospectors to concentrate their search to areas of higher probability of success.



The 500 or so landsat pictures of Australia are identified by three-digit path and row numbers. Thus the picture including Brisbane is 095-079. The satellite takes four photographs of each area — in the green, red, near-intrared, and infrared bands of the spectrum.

PLATE 54

Data acquisition and processing facilities

Following the Government decision in 1977 to establish Landsat facilities in Australia, the Department of Science and the Environment took steps to have the Australian Landsat Station fully operational by March 1980. The station is managed by the Department and operated and maintained by private industry under contract to the Department. Formal arrangements between the Department and NASA permitting Australian reception and processing of Landsat data were concluded under a Memorandum of Understanding signed in January 1979.

The $4.2 million station consists of a Data Acquisition Facility at Alice Springs and a Data Processing Facility in Canberra.

The Data Acquisition Facility comprises a 9 metre steerable antenna capable of tracking Landsat satellites from horizon to horizon, and radio receiving, tape-formatting and recording equipment. The facility, which is located within the CSIRO Land Resources Management Field Centre, is able to receive imagery of every part of Australia. Magnetic tapes of data recorded during each Landsat pass over Australia are flown daily to Canberra for processing, archiving and meeting customer requirements.

The Canberra Data Acquisition Facility is fitted with modern computer, electronic printing and photographic reproduction equipment and provides a wide range of products to Australian and overseas customers. Products include computer-compatible magnetic tapes, which customers can process through their own computers to provide imagery in formats to meet their particular requirements, and a large number of photographic products corrected and enhanced in accordance with customers' wishes. Distribution of Landsat products is arranged direct from the Data Processing Facility or through outlets in each of the States.

The Department of Science and the Environment receives advice on user needs from the Australian Liaison Committee on Remote Sensing by Satellite, a committee comprising representatives from Commonwealth and State governments, universities and colleges and private industry. The committee also provides a useful forum for consultation and co-operation among users and potential users of remote sensing data.