Interaction Between Industry, Higher Education and Government Laboratories

1980
INTERACTION BETWEEN INDUSTRY, HIGHER EDUCATION, AND GOVERNMENT LABORATORIES

A REPORT TO THE PRIME MINISTER

BY THE

AUSTRALIAN SCIENCE AND TECHNOLOGY COUNCIL (ASTEC)

OCTOBER 1980

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Canberra 1980
My dear Prime Minister,

We have the honour to present our report on the interaction between industry, higher education and government laboratories, as requested by the Government following its consideration of Volume 1A of ASTEC's report "Science and Technology in Australia 1977-78".

Yours sincerely,

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CONTENTS

1. SUMMARY AND RECOMMENDATIONS 1

2. INTRODUCTION
   EXTENT AND ORIGINS OF THE REPORT 3
   PRESENT INTERACTION ACTIVITIES IN AUSTRALIA 4
   Types of Interaction 4
   References to the Need for Greater Interaction 6
   GENERAL BARRIERS TO INTERACTION 10
   Motivation and Attitude 10
   Institutional Constraints 11
   BENEFITS TO BE EXPECTED FROM INTERACTION 12
   Benefits to Industry 12
   Benefits to Higher Education 13
   Benefits to Government R&D 13
   Benefits from Interchanges of Staff 13
   Studies and Specific Examples of Benefits 13
   INTERACTION ACTIVITIES IN OTHER COUNTRIES 14

3. INTERACTION IN AUSTRALIAN AGRICULTURE AND MINERAL INDUSTRIES 15
   AGRICULTURE 15
   Co-ordination 15
   Research Funding 15
   Extension Services 16
   Minor Mechanisms 16
   MINING AND MINERAL PROCESSING 16
   AMIRA 17
   The Julius Kruttschnitt Mineral Research Centre 18
   Other Organisations 18
   SUMMARY 19

4. INTERACTION IN MANUFACTURING 19
   CHARACTERISTICS OF AUSTRALIAN MANUFACTURING 19
   The Domestic Market Orientation 19
   Publications, Patents and Confidentiality 21
   SCOPE FOR INCREASING INTERACTION 21

5. CONCLUSIONS AND RECOMMENDATIONS 22
   GENERAL CONCLUSIONS 22
   INCREASED INTERACTION INVOLVING GOVERNMENT LABORATORIES 23
   Advisory Councils and Committees 23
   Staff Interchanges 24
   Seminars and Workshops 24
   'Incubator' Schemes 25
   Contracting of Government R&D to Industry 25
   THE AVAILABILITY OF RISK CAPITAL FOR DEVELOPMENT 25
   ADDITIONAL STAFF INTERCHANGES AND SECONDMENTS 26
   Industrial Fellowships 26
   Changes in Study Leave 28
   Joint Appointments 28
   JOINT PROGRAMS, INCLUDING CONTRACTING AND CONSULTING 29
1. SUMMARY AND RECOMMENDATIONS

1.1 Increased interaction between industry, government and higher education has considerable benefits to researchers, to their firms, agencies or institutions, and to Australian research and development (R&D) generally. These benefits outweigh the costs involved in establishing and operating formal schemes which will promote useful levels of interaction.

1.2 Interaction in agriculture and the mining and mineral processing industries is generally satisfactory, although opportunities should be taken to maintain or increase interaction, particularly by secondments or interchanges of staff. The structure of the Australian manufacturing sector is not so conducive to interaction, and there is scope for increased government sponsoring of interaction, in the interests of restoring the vigour of Australian industrial innovation.

1.3 Mechanisms which ASTEC supports, and believes should be promoted, include:

- use of advisory councils and committees to government research agencies;
- interchange of staff between government and industry laboratories;
- increased use of seminars and workshops between government and industry;
- use of 'incubator' schemes which encourage industry to use vacant space or unused equipment in government laboratories;
- contracting of government R&D to industry, as recommended in a recent ASTEC report and now accepted by the Government;
- increased access to venture capital to allow the industrial development of research discoveries made in government or tertiary education institutions;
- changes to university study leave arrangements, and the use of appointments of industrial researchers to part-time or visiting academic posts;
- development of more industry research committees;
- use of short refresher courses for industrial researchers in universities, and of 'sandwich' courses.
1.4 Four mechanisms have been identified by ASTEC as being particularly suitable for increasing interaction between Australian manufacturing industry and government and academic institutions. These are industrial fellowships, research associations, industry-tertiary education co-operative research projects, and a scheme for increased technology transfer.

1.5 Industrial fellowships would provide worthwhile opportunities for interested academic staff to spend time in industrial laboratories. ASTEC believes that the Government should provide approximately half the salary, and salary-related costs of each fellow, while the host organisation should cover the remainder of the fellow's salary and any other costs. A proposal for a three-year pilot program, operating along these lines is being developed by the Minister for Science and the Environment. It would involve about 15 fellowships in the first year, rising to 30 in the second and third years. This would cost the Government about $160,000 in the first year, and $320,000 in each of the subsequent two years.

Recommendation 1
That a three-year pilot program of industrial fellowships be implemented.

1.6 Research associations provide a highly suitable vehicle for solving the research problems of some manufacturing firms, particularly smaller firms with no in-house R&D activity. ASTEC believes that one effective type of research association for manufacturing industry is that which acts as a contracting broker. Research associations may also need to establish facilities and conduct research if suitable facilities are not otherwise available. Moreover, research associations should operate in areas of common interest to substantial groups within manufacturing, for example on techniques or problems common to a wide range of manufacturing firms. ASTEC welcomes the recently-announced Government decisions on an active program to assist research associations, on the continuation of block grants to existing associations, and on assistance to new associations. ASTEC is of the opinion that, in the interest of greater interaction and to support the raising of technological standards among smaller firms, there is scope for the establishment under this program of up to five new research associations, at a cost to the Government of up to $1 million per annum.
Co-operative research projects, involving researchers from higher education and industrial researchers working together on projects of interest to industry, have been promoted by the Australian Industrial Research Group (AIRG), a group of about 50 industrial research managers from Australia's larger manufacturing and mining companies. ASTEC endorses the AIRG program as a means of aligning a proportion of academic R&D with industry, and suggests that incentives should be given to stimulate these activities. This could be done through the Australian Industrial R&D Incentives (AIRDI) Scheme, with modification as necessary of the existing legislation. Steps also need to be taken to make such co-operative research grants relatively more attractive than the standard AIRDI project grant. It is expected that, in the first instance, an amount of about $0.5million per annum needs to be provided, to support 10 to 20 major projects.

Recommendation 2
That a pilot program of co-operative research grants be established under the Australian Industrial Research and Development Incentives Act 1976 (amended as necessary), taking into account the operations of the UK Special Co-operative Research Grants program.

More effective technology transfer is essential to the continued health of the manufacturing sector. This can in part be achieved by increasing interaction between industry and government and academic laboratories. One means of doing this requires the establishment of a technology transfer network employing highly qualified and experienced professionals, able to provide effective links between researchers and those with knowledge, and potential users of new technology. The Department of Productivity has recently established a pilot program in technology transfer. ASTEC commends this development and believes that such a program needs to be complemented by the inclusion of a Technology Information Service along the lines of that operated by the Canadian National Research Council. This could be achieved at a cost of $2.5million per annum.

Recommendation 3
That the activities of the Technology Transfer Council be upgraded and broadened in scope, including bringing a scheme similar to the field-service aspect of the Canadian Technical Information Service into the program.

2. INTRODUCTION

EXTENT AND ORIGINS OF THIS REPORT

In ASTEC's report 'Science and Technology in Australia 1977-78', the Council commented in a preliminary
way on interaction, and recommended:

That initiatives leading to a greater interpenetration between industry, universities, colleges and government-funded laboratories be encouraged and, if necessary, funded [1].

The Government asked ASTEC to examine this matter further, and report on initiatives that might encourage increased interaction. This report is in response to that request.

2.2 Almost all research and development (R&D) in Australia is conducted in three principal sectors of performance; the governments (Commonwealth and State), which undertook 56% of Australian research and development in 1976-77; tertiary education institutions, which undertook 23%; and business enterprise, which undertook 20% [2]. This report examines the extent and types of interaction between these sectors, in R&D as well as in wider scientific and technological activities, and draws conclusions and makes recommendations on how interaction could be improved in those areas where it is judged to be most seriously deficient.

2.3 In this report, interaction is meant to include only formal, or structured interactions between the sectors, such as the establishment and operation of research associations, schemes for the interchange or secondment of staff, the undertaking of joint R&D, and the continuation of a project from one sector to another, as it develops. Less formal interactions are not explicitly considered in this report although ASTEC recognises that such interactions exist and are of great value. An example is the Australian Academy of Science's Science and Industry Forum, which consists of about 80 senior scientists and industrialists, and has been active since 1967 in promoting interaction at the highest levels between science and industry in Australia, through regular meetings on issues of interest. Another type of interaction not explicitly considered here, but also recognised as being of great benefit, is interaction within sectors, e.g. between universities, between government agencies and between firms in industry.

PRESENT INTERACTION ACTIVITIES IN AUSTRALIA

Types of Interaction

2.4 As part of the preparation of this report, ASTEC advertised in the national press for written submissions on the issue of interaction. One hundred and three submissions were received. From these submissions and from other material, ASTEC has compiled a summary of present, formal arrangements for R&D interaction in Australia. This is at Appendix A, and is further summarised, for ease of reference, in Table 2.1.
The interactions detailed in Appendix A are of three principal types. First, there is entrepreneurial interaction, involving personal interactions between leaders of innovation in the various sectors. These interactions usually centre on new ideas, products or processes which have the potential to lead, in favourable circumstances, to new technologies and new internationally-competitive products. Examples include the Interscan aircraft landing system, developed initially within CSIRO and now the subject of joint government-industry activity, and the Barra expendable sonobuoy, the concept of which was conceived and validated by the Defence Science and Technology Organisation and the development contracted to industry. Secondly, there is developmental interaction, involving more routine development, testing, assessment and modification of products or processes that can lead to new markets or to a competitive edge in existing markets. Thirdly, there is 'trouble-shooting' interaction involving the solution of routine problems, arising during the production of standard products, such as the use of slightly different raw materials, and minor changes to procedures.

Since there are three sectors, there are three ways in which any two of these sectors can interact. It is of value to consider each of these three interfaces between pairs of sectors, in terms of the overall characteristics of the structure of R&D in Australia. Higher education research is closely interwoven with teaching and research training, and is mostly basic research, either undirected (curiosity-motivated) or strategic mission-oriented. Industry, on the other hand, relies more heavily on tactical, problem-solving, applied research and development, often based on known science and technology, to aid it in its day-to-day goals. Government R&D occupies a position somewhere in between, with a mixture of long-and short-term research [3].

Government-higher education interfaces therefore tend to involve exchange of information, staff etc. more involved with the basic research end of the R&D spectrum, and typically involve a government worker seeking the answer to his strategic research problem from the expertise existing in the higher education sector. Government-industry exchanges concentrate more on the provision of advice to industry on its immediate problems. However, some government laboratories interact with industry in order to assist in the development of research opportunities and to determine the direction of strategic research likely to be of benefit to whole industries or large portions of them. Higher education-industry interchanges occur in areas such as the work of colleges of advanced education, particularly the major institutes of technology, who concentrate more on applied R&D, and in the higher-technology industries, whose research problems are more akin to those in universities, or for whom there may be no corresponding government R&D agencies.
<table>
<thead>
<tr>
<th>Mode of Interaction (Refer to Appendix A)</th>
<th>Sectors Interacting</th>
<th>Industry/Government</th>
<th>Government/Higher Education</th>
<th>Higher Education/Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSIRO-AWCC Joint Committee</td>
<td>Early stage of development</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIRE-CSIRO Working Party</td>
<td>Early stage of development</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIRE-IUCR Joint Committee</td>
<td>Early stage of development</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development in Industry of DSTO projects</td>
<td>Very effective</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defence research groups</td>
<td>Early stage of development</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aust. Institute of Nuclear Science and Eng.</td>
<td>Highly effective (2500 man-days/year)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Service Board Interchange Scheme</td>
<td>Developing well, Limited number of technical changes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Use of Study Leave Joint Appointments</td>
<td>Very little interchange</td>
<td></td>
<td>Only a few known in the technical area</td>
<td></td>
</tr>
<tr>
<td>Research Associations</td>
<td>Very effective, Too few in the manufacturing area, Ideal for small companies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural Industry Research Funds</td>
<td>Very effective</td>
<td></td>
<td></td>
<td>Very effective</td>
</tr>
<tr>
<td>Australian Road Research Board</td>
<td>Very effective</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University consulting</td>
<td>Low level of activity</td>
<td></td>
<td>Low level of activity</td>
<td></td>
</tr>
<tr>
<td>University and college research companies</td>
<td>Effective but under-utilised</td>
<td></td>
<td></td>
<td>Effective but under-utilised</td>
</tr>
<tr>
<td>Public Interest Projects</td>
<td>Early stage of development ($4m in 1979-80)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 2.1 (continued)

**PRESENT INTERACTION ACTIVITIES IN AUSTRALIA**

<table>
<thead>
<tr>
<th>Mode of Interaction (Refer to Appendix A)</th>
<th>Sectors Interacting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Sectors</td>
</tr>
<tr>
<td>Pilot Enterprise Development Program</td>
<td>Early stage of development</td>
</tr>
<tr>
<td>Technology Transfer Council</td>
<td>Early stage of development</td>
</tr>
<tr>
<td>Australian Research Directory</td>
<td>Discontinued for present - did not cover activities of all sectors</td>
</tr>
</tbody>
</table>

**ABBREVIATIONS:**

- AVCC: Australian Vice-Chancellors' Committee
- AIRG: Australian Industrial Research Group
- IUCR: Inter-University Committee on Research
- DSTO: Defence Science and Technology Organisation
References to the Need for Greater Interaction

2.8 Several recent reports have made mention of the need for greater interaction in Australia. The OECD Examiners mentioned the low level of interaction between sectors in their 1974 report. They stated that:

the Australian authorities...might consider taking steps to...facilitate the transfer to industry of the results of research done by universities and government laboratories in case they contain know-how for making new products; and...the examiners found widely differing opinions in Australia regarding co-operation between industry on the one side and the universities and government laboratories on the other...as a rule...the contacts between these three sectors are still only sporadic and often confined to personal relationships [4].

2.9 The Report of the Independent Inquiry into the CSIRO, presented to the Prime Minister in August 1977, referred to the need to improve consultative machinery between CSIRO and other organisations and recommended that:

CSIRO should, in order to define adequately broad policies and objectives, establish a number of effective channels of communication with relevant policy areas of Government, users of research results (both Government and industry) and the community (Recommendation 34) [5].

The Report also considered exchanges and secondments. It noted that such activities are beneficial to CSIRO and to other research organisations, but that decreased promotional opportunities for the individual may outweigh organisational benefits. The report then recommended in general on interaction, that:

Exchanges and secondments from CSIRO to other institutions should be encouraged, accompanied by compensation for financial or other disadvantageous consequences (Recommendation 54) [6].

The report also contains a number of more specific recommendations on ways of improving interaction between CSIRO and organisations in other sectors.

2.10 The Report of the Committee of Inquiry into Education and Training, which was presented to the Prime Minister early in 1979, considered some aspects of the question of interaction and mobility between sectors - particularly in the context of maintaining 'innovation and freshness' in universities. The Report recommended, with particular reference to the Institute of Advanced Studies at the Australian National University:
that arrangements be negotiated with the civil service, CSIRO, industry and other universities for exchanges and secondments of staff (R5.41) [7].

2.11 The Report of the Senate Standing Committee on Science and the Environment, 'Industrial Research and Development in Australia' noted that:

A frequently heard theme during the inquiry was the need to improve liaison between government, industry and tertiary education institutions through the interchange of research and development staff... moves facilitating mobility of scientific and technical staff would do more to enhance and gain value from our R&D effort than almost any other single issue [8].

The Committee recommended that:

The Minister for Science and the Environment request CSIRO to explore the possibilities of an increase in joint project activities with universities (Recommendation 47) [9].

and that:

The Minister for Science and the Environment request CSIRO to give attention to considering all tertiary education institutions in any proposals aimed at encouraging secondment of staff (Recommendation 48) [10].

The Committee also recognised the need to encourage joint projects with industry; in particular it gave support to initiatives for an industrial fellowships program by recommending that:

The Government give full support to initiatives of the Department of Science and the Environment in awarding industrial fellowships (Recommendation 20) [11].

2.12 The evidence from submissions, and from Appendix A, suggests that interaction mechanisms between manufacturing industry and other sectors are least developed. For example, the Commonwealth Department of Productivity, in its submission, noted that:

There is evidence to suggest that a large part of manufacturing industry is either unaware of CSIRO's resources or, for various reasons, does not make use of these resources.
The Australian Academy of Technological Sciences noted that:

The number and the impact of joint projects between the CSIRO and the manufacturing industry offer scope for considerable expansion. The manufacturing industry is a major source of employment; it is the most research sensitive sector and is in need of technical support. CSIRO is by far the largest single national resource in R&D; an important role is service to industry and the agreed predominant role of "mission orientation" implies greater and more direct orientation to the needs of industry.

This gap also received attention in the report of the Independent Inquiry into the CSIRO, which made several recommendations for strengthening ties in this area, while noting that the problem does not arise entirely from within CSIRO [12].

GENERAL BARRIERS TO INTERACTION

2.13 Despite the abovementioned need for interaction, and the benefits to be expected from greater interaction, there are several constraints to increased activities in this area. Some of these are of a general nature, concerning basic attitudes, motivations and organisational arrangements, and these are discussed here. Other factors affecting levels of interaction, relevant to particular industry sectors (primary, mineral resources and manufacturing) are considered in other sections of this report.

Motivation and Attitude

2.14 As mentioned in 2.6, different sectors of R&D performance undertake different types of research. This influences the attitudes of researchers in the various sectors. Academic researchers tend to believe that Australian industrial R&D is largely derivative, short-term and tactical problem-oriented and therefore irrelevant to their activities, which are usually aimed more at understanding basic phenomena, either for their own sake or as part of strategic mission-oriented research. There is also a prevalent attitude that all industrial problems can be solved by application of existing knowledge; in fact there is ample scope for demanding original research on the technical problems of industry. Industrial researchers and managers, on the other hand, consider that much academic research is not relevant to their problems, and is on too long a timescale to help them with their difficulties.
2.15 These different attitudes are reflected in approaches to questions such as promotion and the allocation of resources. Promotion in tertiary education institutions, and to a certain extent in government research agencies, is determined primarily by research performance, generally measured by the number and quality of research publications. The contribution of staff in assisting industry may not be highly regarded as a criterion for staff advancement and, to the extent that confidentiality associated with industrial R&D may hinder publication, may militate against promotion. Similarly, some universities and university staff associations actively discourage the taking of study leave anywhere other than in overseas academic institutions.

2.16 Another attitudinal constraint is the so-called 'Not Invented Here' factor, which arises when a research discovery or invention needs to move from one sector to another as part of the process leading to commercial viability. There tend to be mismatches between the criteria of different sectors which adversely affect these transitions. An invention or research discovery is frequently treated with suspicion or uncertainty by those who may be asked to consider its commercial development. Often, the researcher may take the R&D process too far before calling on the expertise of those whose responsibility it will be to manufacture and/or market the product or process.

Institutional Constraints

2.17 At present, there is little incentive for government laboratories to engage in outside contract work. Any income received is necessarily viewed by the agency as part of its general appropriation. Entrepreneurial government research leaders, or research agencies, will thus not directly benefit their programs by contracting work in, and this reduces the incentive to participate in such ventures.

2.18 Present overall economic conditions, combined with the current policy of fiscal restraint, have reduced the latitude of researchers in all sectors of performance to interact outside their own institutions. The lack of personal time, and of support staff, resulting from these stringencies have been identified as two principal factors which reduce or prevent interaction.

2.19 A major constraint on the permanent transfer of R&D staff between higher education, industry and government is the non-portability of superannuation and associated entitlements. This tends to restrict mobility of R&D staff to short-term secondments or interchanges. While these may be beneficial to the sponsoring organisations, they may not be as attractive to staff involved, as they can carry the disadvantages of dislocation of lifestyle, and loss of opportunity for promotion in the 'home' organisation.
2.20 A final organisational impediment to interaction is the low level of exchange of information of mutual interest between sectors of R&D performance, for example on the availability of specialised equipment and expertise, and on problems which need R&D for their solution. Without this basic knowledge of what is going on, or is needed, in other sectors, even the first steps towards interaction become difficult.

BENEFITS TO BE EXPECTED FROM INTERACTION

2.21 Increased interaction between R&D sectors in Australia will increase the effectiveness of the nation's research. Research workers in government agencies, universities and colleges, and industry, have different viewpoints and expertise which, if they can be properly linked, can lead to more efficient setting of research priorities and increased conduct of R&D relevant to national needs.

Benefits to Industry

2.22 Most Australian business enterprises are too small to be able to undertake their own research. The need for these small enterprises to have access to relevant R&D activity is, however, considerable. In the case of rural holdings, there is a need for access to research results to allow breeding and introduction of disease-free stock, and to combat pests and diseases already prevalent. In manufacturing, the retention or development of a competitive position depends on innovation, including the ability to choose among new technologies. These needs can be met, at least in part, if small enterprises have open to them channels of communication with researchers and technologists in government agencies and in higher education; and if those workers are attuned to the problems and requirements of industry.

2.23 Larger firms, found mainly in mining and mineral processing and in manufacturing, have generally realised the need to conduct at least some internal R&D. The Australian Industrial Research Group (AIRG) is a group of research managers from those firms which operate identifiable R&D departments and divisions. The AIRG's recognition of the need for, and activities to encourage, interaction are described in Appendix A. Generally those firms with more substantial R&D efforts are likely to be involved with strategic research programs, and in so doing would have considerable overlap with the methods and approaches of academic and government researchers. Increased interaction is therefore likely to be directly, and mutually, beneficial.
Benefits to Higher Education

2.24 The principal advantage of interaction to higher education is the enrichment of teaching and research programs, especially in professional disciplines, gained from experience in industry or government laboratories. This would apply to both staff and students of higher education institutions. Another benefit, to both higher education and industry, would be the development of an awareness of the needs of industry, and in turn increased R&D on these problems in higher education institutions.

Benefits to Government R&D

2.25 Much of government R&D has been created to support the needs of industry. A high level of interaction with industry is therefore necessary to ensure that the resources devoted to R&D in government laboratories are being used as they are intended to be. Interaction with higher education is equally desirable, as some results of research in higher education can be translated, through government agencies, to the longer-term needs of industry, and vice-versa. This can, of course, be done without precluding direct interaction between industry and higher education.

Benefits from Interchanges of Staff

2.26 One mode of interaction particularly worthy of mention is that of interchange of staff between R&D organisations in the different sectors. It provides benefits to employers, who have made available to them a fresh outlook on, and new expertise in, their problems. It similarly benefits employees who undertake interchanges, in that they learn of new approaches, and of different research organisations and procedures, at first hand.

Studies and Specific Examples of Benefits

2.27 Some studies have examined the general benefits of interaction. For example the multiplier effect on business resulting from government support of industrial R&D through the contract mechanism has been the subject of three independent studies. All of these have shown that this type of interaction leads to benefits to industry, and in turn to government through taxation, well in excess of the amounts initially provided [13].

2.28 One study of industrial innovation shows that increased interaction may be of particular benefit to Australia. Utterback [14] has surveyed eight studies of the innovation process, which have variously estimated that between two-thirds and nine-tenths of innovations arise from market, mission or production needs, while the other one-third to
one-tenth arise from technical opportunities. In Australia, however, unlike most other industrial nations, the R&D effort is weighted strongly towards the basic research end of the R&D spectrum [15]. The appreciation of the market 'pull' so necessary to innovation (and generally resident in industry) therefore needs to be more actively aligned with the majority of Australian R&D resources (in government and universities), through increased interaction, if Australia is to take advantage of opportunities for innovation.

2.29 Some specific examples of innovations which have been made possible, or aided, through interaction between sectors are:

- development in industry of CSIRO inventions such as the self-twist spinner (export sales of $20 million, 1970-1975) and the atomic absorption spectrophotometer (export sales over $100 million);

- interaction between the Australian Atomic Energy Commission, mining companies, mineral industry research bodies, and manufacturers to investigate the use of, and develop, on-stream analysis techniques and instruments using radioactive isotopes;

- collaboration between a State forestry commission and an electronics firm to produce a computerised timber strength grading machine, which is in widespread use in Australia and overseas;

- joint R&D involving a hospital, a university department, a government research agency and industry on the use of wool blankets in hospitals; this involved specification by the hospital of problems believed to be involved with the carriage of infection by wool fibres, joint university-government research on this question, and joint government-industry development of a detergent suitable for repeated washing of wool.

INTERACTION ACTIVITIES IN OTHER COUNTRIES

2.30 An examination of schemes or programs operating in other countries provides valuable insights in respect of initiatives which might be considered in Australia. If reasonable provision is made for economic and social differences, the modification of overseas programs to fit the Australia situation may provide ways of stimulating interpenetration in Australia. A representative range of programs in other countries is described at Appendix B.
3. INTERACTION IN AUSTRALIAN AGRICULTURE AND MINERAL INDUSTRIES

3.1 Two Australian industry sectors have had reasonable success in interacting with the government and tertiary education sectors. These are agriculture, and mining and mineral processing. This section examines some of the interaction mechanisms used by these industries, and identifies the factors which have contributed to their success.

AGRICULTURE [16]

3.2 Australian agriculture is characterised by the large number of productive holdings, each operating on a scale which is small by the standards of other industry sectors. This small scale, coupled with unpredictability of returns associated with the industry, and the lack of opportunity to capture much of the return from any research results, means that the individual farmer is rarely in a position to carry out any research. At the same time, almost all of the problems of agriculture which require R&D for their solution are common to large numbers of rural holdings and, if not investigated and overcome, have the capability to cause significant damage to an important sector of the Australian economy. Finally, competition in agriculture occurs not between individual farming enterprises, but principally on world markets, where Australian-produced commodities must compete with those of other rural-product exporting nations.

3.3 For all these reasons, it has been necessary to maintain a significant effort in agricultural R&D in Australia, to centralise it to a large extent so as to ensure that worthwhile levels of effort can be realised and to ensure that results of research can be made readily available to producers. The mechanisms described below represent the expression of these needs.

Co-ordination

3.4 Commonwealth-State consultation on agricultural policy takes place between Ministers responsible for agriculture, meeting as the Australian Agricultural Council (AAC). The AAC is supported by a standing committee of officials, and a structure of 13 committees and 80 sub-committees working on a range of specific issues and problems. Co-ordination and review of rural research priorities and policies is undertaken by the Commonwealth Council for Rural Research and Extension (CCRRRE), which advises the Commonwealth Minister for Primary Industry. This includes advice on the nature and direction of rural research and extension in Australia, and on research organisation, including interaction.
Research Funding

3.5 Rural R&D is financed by a complex structure of Commonwealth and State government funds, together with substantial contributions from other sources, including the rural producers themselves, through levies on production. These levies, matched by government funds, are the basis of the Rural Industry Research Funds (RIRFs), which cover industries including wool, meat, dairying, wheat, tobacco, barley, poultry, dried vine fruit, and oilseeds. Since the producers provide significant levels of funds to the RIRFs they are entitled to, and have, a substantial say in what R&D is funded through the RIRFs. The RIRFs therefore provide a mechanism for making producers' problems known to the researchers.

Extension Services

3.6 Transfer of research results to primary industry is carried out mainly by the extension services of the State departments of agriculture, who also undertake most of the associated applied research work. Total extension activity amounts to the equivalent of about 1800 full-time workers [17]. In any year about one-third of rural producers are in close contact with the extension services, receiving information on practical applications flowing from R&D results, and at the same time describing current problems in need of solution. Finance for these services comes mainly from the States, supplemented by the Commonwealth Extension Services Grant (CESG). The CESG is also used to support teaching positions in agricultural extension at several universities, and training for State extension and research workers. These latter activities help complement, and expand, the already high levels of interaction which occur through extension services.

Minor Mechanisms

3.7 Joint research activities are undertaken by some State departments of agriculture on one hand, and agencies from other sectors (e.g. government research agencies, universities and private companies) on the other. There is only limited interchange of research workers between R&D organisations in the different sectors of performance, and this is an area where there would appear to be scope for improvement.

MINING AND MINERAL PROCESSING [18]

3.8 Mining and mineral processing industries in Australia have seen very significant growth in recent years.
This has been based on large-scale, capital-intensive mining and processing operations, to serve local and export markets. This growth is expected to continue for the foreseeable future. Australian mining companies recognise that there is a constant need to remain technologically advanced if competitiveness on the world scene is to be maintained, and these companies are in a position to fund research, development and exploration from profits of current activities [19]. As with agriculture, many of the problems requiring R&D are common to large parts of the industry, and (with the exception of the necessary secrecy over exploration activities) the need to remain internationally competitive is more important than competition between individual firms. Companies are thus willing to sponsor, or engage in, co-operative research. At the level of the individual firm, research staff need to participate in field and plant operations to understand essential priorities, and operating personnel need the assistance of researchers in order to define their problems in ways that enable successful research programs to be developed. The above factors have all led to a situation where considerable mining research is carried out 'in-house', and a successful mechanism for co-operative research has also evolved. This is the Australian Mineral Industries Research Association (AMIRA).

AMIRA

3.9 The work of AMIRA is outlined in Appendix A. AMIRA acts as a co-ordinating agent between interested companies and research agencies. The Association had also earlier provided the vehicle through which the minerals industry could channel its support for the conversion of the R&D Branch of the South Australian Department of Mines into the Australian Mineral Development Laboratories (AMDEL). AMIRA joined the Commonwealth and South Australian governments in providing a basic level of research contracts for AMDEL, and assisting with its management. This was the catalyst for AMDEL's formation. AMIRA's principal activity has since been the co-ordination and initiation of co-operative research projects for the industry.

3.10 AMIRA has enabled mining industry problems to be tackled on a scale not previously possible, particularly by the smaller companies. The key to AMIRA's success lies in its approach which involves regular reviews by technical people from sponsoring companies. In this way, strong relationships are established between the research group and the interested company people. A large number of contracts are let to government agencies (for example the CSIRO Division of Applied Geomechanics) and to universities. Although AMIRA's budget is small compared to total R&D expenditure on mining and mineral processing, it has played an important role as a catalyst of R&D through these mechanisms of interaction.
The Julius Kruttschnitt Mineral Research Centre

3.11 The Julius Kruttschnitt Mineral Research Centre (JKMRC), at the University of Queensland, had its origins in a small research group in the Department of Mining and Metallurgical Engineering at the University of Queensland, which began research into ore-grinding operations in 1962, with financial support from AMIRA.

3.12 Work in the early years was carried out in close co-operation with Mount Isa Mines Ltd, and in 1970 this Company agreed to provide the finances for the formal establishment of JKMRC. From the beginning, there has been very close co-operation with industry. The problems selected for research are of direct and immediate concern to the industry, and research programs are carried out in collaboration with many of the major Australian mining and mineral processing companies. An important objective of the research program has always been to train postgraduate students for employment in industry.

Other Organisations

3.13 Several other organisations are particularly active in R&D of direct interest to the industry. These include the Divisions within the CSIRO Institute of Earth Resources, the Mineral Chemistry Research Unit at Murdoch University, the Department of Mining and Metallurgical Engineering at the University of Queensland, the Bureau of Mineral Resources, several State Departments of Mines and the Australian Atomic Energy Commission.

3.14 With CSTRO, AMIRA makes available small groups of specialists who are technically competent to comment on and review CSIRO's mining and mineral-processing work. This arrangement has received strong support from member-companies, and has helped define areas of research considered to be important to the minerals industry. It has been a means of strengthening the relationship between the minerals industry and CSIRO, and CSIRO's collaboration with AMIRA has helped to determine the direction of its research in the minerals field, and accelerated the transfer of technology to industry once it has been sufficiently developed.

SUMMARY

3.15 The factors which have led to successful interaction in agriculture, and in mining and mineral processing, are:

- the need to establish, and maintain international competitiveness of the commodity produced;
the relatively limited number of products, and the commonality of problems to large parts of the industry; and

the fact that competition is mainly between Australian products and others in the international marketplace, rather than between individual firms within Australia, although some exceptions are recognised (see 3.8).

3.16 The differences between the industries have led to the various mechanisms for interaction. In agriculture, with its large numbers of small holdings, which cannot justify high technological expertise at first hand, there is a need for dissemination of R&D results on a large scale, and in a practical and useful fashion. This is provided by extension services, and is complemented by the activities of the Rural Industries Research Funds in making the producers' problems known to researchers. Mining and mineral processing firms, on the other hand, are large enough to undertake, or at least be aware of, R&D problems and processes. Their research, because of this and because of the commonality of their problems, is more active and co-operative than for agriculture. This type of research is ideally suited to a research association. The research association is a strong channel for making industry problems known to researchers, and can also act as a disseminator of information to the industry.

4. INTERACTION IN MANUFACTURING

4.1 The agricultural and mineral industry sectors, described in Section 3, have many similar characteristics which have aided a reasonably high level of interaction in R&D effort. The situation in manufacturing is somewhat different and, as noted in 2.12 above, this has led to a lower level of interaction among researchers engaged in manufacturing, or in disciplines relevant to manufacturing. This Section examines the reasons for the development of this relatively low level of interaction.

CHARACTERISTICS OF AUSTRALIAN MANUFACTURING

The Domestic Market Orientation

4.2 Australian manufacturing has developed largely to supply the domestic market, with less orientation to export than has been the case for rural products and, in recent years, minerals. Governments have supported manufacturing industry by a policy of protection when necessary, principally by introduction of tariffs, but more recently in a few instances by quantitative restrictions and occasionally by subsidies.
4.3 Production in Australia, and the prospects for manufacturing industry exports, have been affected by the small population, leading to small scale of the domestic market (usually an essential base on which to develop exports), the wide spread of centres of population, and the comparatively high wage structure. Changes in the exchange rate, the export incentives offered by competitor countries, and relative rates of inflation have also been important factors generally tending to inhibit exports of manufactures, although in recent times there has been increasing attention by industry and government to ways in which export of manufactures can be boosted.

4.4 Competition has therefore been principally in the local market, at the level of the individual firm, although import competition, even with the tariff barriers, is often important. Inter-firm competition is in contrast to the commonality of problems in agriculture and mining, and tends naturally to lead to less co-operation between firms. In particular, co-operative research efforts are less frequent, and a company conducting R&D does so mainly for its own products and processes.

4.5 In many areas of manufacturing, particularly those of higher technology, large international firms have been established in Australia. Some of these firms tend to concentrate their R&D activities in their home countries, and the opportunity for Australian R&D is lost. Sometimes, R&D transferred to Australia tends to be of a lower-grade, adaptive and testing kind.

4.6 The underlying reasons for the low level of R&D interaction between manufacturing industry and the other sectors are:

- much manufacturing is done by a large number of small firms (60% of employees are in firms with less than 15 employees, and 80% in firms with less than 100), each of insufficient size to support a viable R&D department;

- a very wide range of products is produced, compared with agriculture and mining;

- for small firms making similar products, competition for a share of the local market inhibits joint research on products;

- for small firms making dissimilar products there is seldom a common interest in research on products; and

- the fifty or so larger firms who do have research departments, have little interaction with higher education or government laboratories, because these firms wish to keep secure or patent their own or joint discoveries and because of the attitudinal barriers to interaction outlined in 2.14 above.

20.
These all contribute to making the situation in manufacturing quite different from that of agriculture and mining.

Publications, Patents and Confidentiality

4.7 Many research tasks in industry tend to be concentrated in sensitive industries such as electronics, chemicals and pharmaceuticals. In such areas industry may see a need to insist on assignment of patent rights and on constraints, or at least on delays, in publication of results, and some such agreements exist between companies and government agencies. This does not completely prevent a joint R&D effort with researchers from other sectors, but it may make such work less attractive to those who value the publication of research results in the scientific literature.

4.8 In joint programs with industry, involving consultants from government or higher education, there can be problems in the policy to be adopted in securing patent rights. Alternatively, if a product or process is developed in a university, companies may be unwilling to participate in subsequent developmental work if their investment is not properly protected by patents.

SCOPE FOR INCREASING INTERACTION

4.9 All the above appears to place formidable barriers in the way of interaction between researchers in Australian manufacturing, and their counterparts in higher education and government. Nonetheless, such interaction does occur, as documented in Appendix A. There appears to be further scope for such interaction to be increased, both to promote the transfer of existing knowledge to industry and (perhaps more importantly) to make academic and government researchers interested in the very real opportunities for original research offered by the technical problems of industry. It will be essential for such researchers to produce more results likely to be useful to industry. Industry has more scientific problems waiting to be solved than there are solutions waiting to be used by industry.

4.10 There is some common R&D needed by industries and individual companies within manufacturing that is not confidential and would not affect the competitive positions of firms. This typically involves process innovation, to reduce costs, rather than product innovation. Such R&D could be serviced by research associations. The Australian Welding Research Association is an example of one such, already operating successfully. It is also encouraging to note that research committees, with the potential to become research associations, have recently been established, covering the foundry, forging, and powder metals industries.
4.11 Agricultural extension services have been so successful as to suggest that there may be scope for the introduction of a similar mechanism in manufacturing. There is some similarity between the areas, in that they both include a large number of enterprises too small to conduct in-house R&D or to study and adapt new technology. Introduction of technology transfer into manufacturing may help to increase the technological awareness of small enterprises, although it is recognised that there will be difficulties associated with competition, and with the greater diversity of products and processes in manufacturing. These difficulties will include servicing the wide range of needs, and co-ordination of programs.

5. CONCLUSIONS AND RECOMMENDATIONS

GENERAL CONCLUSIONS

5.1 ASTEC believes that increased interaction between industry, government and higher education will bring with it considerable benefits to research workers, to the firms, agencies and institutions, and to the relevance and quality of Australian R&D. It is recognised that there are costs involved in any schemes which will promote useful levels of interaction, but the evidence presented to ASTEC, and its own considerations, suggest that the benefits of greater interaction will, in the long run, outweigh the costs.

5.2 There is particular need for increased interaction involving manufacturing industry. The situation in agriculture, and in mining and mineral processing is reasonably satisfactory, although agencies involved with these areas should not lose opportunities to maintain or increase interaction, particularly by secondments or interchanges of staff. The structure of Australian manufacturing is not so conducive to interaction and ASTEC believes that there is scope for government-sponsoring of increased interaction, which is likely to bring the sorts of benefits outlined in 2.22, 2.23 and 2.27 to 2.29 above.

5.3 Two major issues pertinent to the level of interaction between R&D sectors, although of considerable importance, are not the subject of specific recommendation here. These are the portability of superannuation, and the overall structure and environment of Australian manufacturing industry. These questions involve consideration of issues far wider than ASTEC's purview and it is realised that, although some changes in these areas may result in increased interaction, such changes need to be considered in a wider context.

22.
INCREASED INTERACTION INVOLVING GOVERNMENT LABORATORIES

5.4 Major government laboratories need to increase their level of communication with, and assistance to, the manufacturing sector. They also need to be encouraged to take steps to communicate more effectively their activities and scientific knowledge to industry, to meet with industry to determine R&D requirements, and to undertake a gradual re-organisation of their R&D activities to ensure that more programs are aligned with the needs of industry.

5.5 In this context, ASTEC notes that, following the Report of the Independent Inquiry into the CSIRO, which recognised the gap between CSIRO and manufacturing industry (see 2.12), CSIRO is undertaking a careful appraisal of its activities to improve its response to industry's needs. The Organisation recently established a Division of Manufacturing Technology charged with the responsibility of interacting closely with the metals, materials and metal-manufacturing industries. The Council believes that the outcome of this initiative should be carefully monitored; if successful, additional mission-oriented divisions should be established to assist selected areas of manufacturing industry.

5.6 ASTEC believes that several initiatives will encourage government laboratories to assist the industrial sectors. These include an increase in the number of independent advisory councils and committees, an increase in the level of contracting out of government R&D (on which ASTEC has already reported to the Government), an increase in the level of staff interchange to and from government laboratories, and the establishment of a regular series of Workshops.

Advisory Councils and Committees

5.7 Independent councils which advise on the overall R&D policy and direction of major government laboratories, are, in ASTEC's view, a simple and effective way of ensuring an overall R&D effort more in line with national objectives. ASTEC strongly supported the recommendation for an Advisory Council for CSIRO contained in the Independent Inquiry into the CSIRO [20], and made a recommendation for such a body in its report on the Bureau of Mineral Resources [21]. A similar recommendation is made in the recent report on the Australian Atomic Energy Commission's Research Establishment. The Council commends the establishment of advisory bodies and anticipates the introduction of similar bodies within other government laboratories. The Council stresses the need for such advisory councils to be constituted of members from all sectors (as a means, among other things, of encouraging technology transfer) and to be serviced by independent secretariats. ASTEC also commends the arrangements within CSIRO whereby any advice provided to the Executive by the Advisory Council that is not acted upon must be referred to and explained in the Annual Report.
5.8 ASTEC also sees merit in establishing specialist independent advisory committees to advise appropriate R&D units within major government laboratories. The Council appreciates that several such advisory committees already exist and commends, for example, the establishment of an Advisory Committee within the newly-formed CSIRO Division of Manufacturing Technology. ASTEC believes that all government laboratories should examine the advantages to be gained from establishing similar bodies to advise appropriate research units within their total organisations.

Staff Interchanges

5.9 There is a need to increase the level of staff interchanges to and from government laboratories as a means of ensuring better interaction. ASTEC sees great merit in the Public Service Board's Interchange Program. It notes that this is aimed primarily at management development; there is a relatively small number of scientists and technologists involved in this program. It believes that the program should be expanded to include more scientists from departments of government, and from laboratories staffed under the Public Service Act. It also believes that Statutory Authorities such as CSIRO and the Australian Atomic Energy Commission should, in consultation with the Public Service Board, examine the development of similar schemes involving research workers in their own laboratories.

Seminars and Workshops

5.10 Several submissions stressed the need for government laboratories to take a greater interest in the short- and long-term requirements of industry. The view was expressed that new approaches are required by these laboratories to publicise their research results, particularly in certain areas of manufacturing industry. One way for government laboratories to achieve this would be by increasing the frequency of one-day seminars or workshops. Similarly, workshops and seminars can be used to expose academic staff to the problems of government laboratories with a basic research content and to expose government R&D staff to the expertise and facilities available in universities and colleges. Such workshops should appeal to a wide variety of relevant organisations from all sectors. ASTEC sees particular merit, in many instances, in arranging for representatives from State Confederations of Industry to be present, as such organisations provide a direct contact with the many small business enterprises in the different States and could lead to successful liaison.
'Incubator' Schemes

5.11 ASTEC has examined the 'Incubator' program operating at the National Research Council (NRC) in Canada, whereby researchers from industry can have made available to them space and facilities in government laboratories, for use in their industrial research, (see Appendix B) and believes that a similar scheme would be beneficial in Australia. The viability of such a scheme depends primarily on the availability of suitable laboratory space in government laboratories; ASTEC is aware of areas where such space is available. The success of such a scheme would also depend greatly on individuals and administrators in both government laboratories and industry seeing substantial benefits in such a program but, as the cost would be minimal, ASTEC encourages an incubator program on the basis of it being a vehicle for staff interaction that would lead to a greater appreciation on both sides of the R&D capabilities, needs and requirements of the other sector; it would also encourage greater utilisation of major equipment facilities. A first step towards the development of incubator schemes might be discussion by those committees already established for purposes of contact between government and industry researchers.

Contracting of Government R&D to Industry

5.12 ASTEC has recently reported to the Government on a range of additional incentives for Australian industrial R&D [22]. That report included a series of recommendations aimed at increasing the levels of R&D contracted from government research agencies to industry. ASTEC recognises that, as well as stimulating industrial R&D directly these recommendations will, if adopted, necessarily lead to a greater degree of formal interaction between government and industry, in the specification of projects, the monitoring of their progress, and the presentation of research results to the government 'customer'.

THE AVAILABILITY OF RISK CAPITAL FOR DEVELOPMENT

5.13 One aspect of interaction involves the continuation (and financing) of a project as it passes from the initial research stage to the final marketable commodity. This often involves different sectors of the R&D community, starting perhaps in a university laboratory and finishing in the management and financing areas of industry. The costs associated with this process usually increase markedly as the project moves from research to development and beyond. One matter raised in several submissions to ASTEC was the need for finance, or risk capital, to enable the development and demonstration stages of new products and processes to be funded and assessed. The Council is aware that there are
some specialist sources for such funds (particularly schemes administered within the portfolio of the Minister for Productivity - see Appendix A), but believes that there is a need for the Government to institute a more comprehensive mechanism to promote the commercial development of research carried out in universities, colleges and government research organisations.

5.14 ASTEC has already indicated its support for a research development corporation similar to the National Research Development Corporation (NRDC) in the UK [23] and has given modified support to the proposal for an Australian Innovation Authority incorporating an NRDC-like body as recommended by the Study Group on Structural Adjustment [24]. The Council has examined the operations of the loan-insurance aspect of the Canadian Enterprise Development Program (see Appendix B). It believes that, irrespective of the final structure agreed to for a government development body in Australia, such a body should be constituted to include, amongst its responsibilities, a loan-insurance mechanism which will help make risk capital available to companies for development work.

ADDITIONAL STAFF INTERCHANGES AND SECONDMENTS

Industrial Fellowships

5.15 ASTEC is particularly concerned by the low level of staff secondments from universities and colleges to industry, and sees merit in a program of industrial fellowships similar to that operating in Canada. Such a program would have potential benefits to both sectors. Industry would gain access to skilled scientific and technical manpower and to a store of knowledge and expertise; the education sector would derive benefit from being able to match its teaching activities more closely to the future employment requirements of students, and through a widening of the research horizons of individual staff-members.

5.16 ASTEC is aware of a proposal developed by the Minister for Science and the Environment which would allow academic staff to spend periods of time working in industry. Such a scheme would be viable if the government contributed approximately half the salary and salary-related expenses of each fellow, and the host organisation covered the remainder of the fellow's salary and any other costs. This is in line with ASTEC's general principle of some degree of cost-sharing and the need for both sectors to support interaction and to be prepared to pay.
5.17 The proposal has received support from academics, industrialists and the Australian Academy of Technological Sciences; it is seen as a way to help break down the barriers between academic institutions and industry and, in the long term, open up significant employment opportunities in industry for Australian PhD graduates. The Council recommends that a program of industrial fellowships be instituted as a three-year pilot program to assess the viability and effectiveness of the scheme. The program should be funded jointly by the Commonwealth and by industry. In the first year, approximately 15 fellowships should be offered and this should rise to 30 in the second and third years; this would correspond to a cost to the Government of approximately $160,000 in the first year and $320,000 in the subsequent two years. ASTEC does not envisage a program of this size having a dramatic impact on the overall level of interaction, but believes that careful monitoring of the outcome of the pilot program would provide sufficient information to predict the desirability and viability of an expanded program in the future. In particular, it would allow an assessment of:

- the suitability of the scheme to small, medium and large companies;
- the number of potential host companies and their ability to offer the facilities, challenge and general R&D environment to attract suitable academics;
- the attitudes of all parties involved and the level of incentives needed to achieve active involvement by all parties;
- the most effective length of time for an industrial secondment; and
- the best approach in terms of the initial development of the work program.

5.18 Particular attention must be given to the extent of assistance provided by the Commonwealth. A realistic sum must be made available based on the real costs involved, including salary and related costs, travel costs, any assistance with accommodation etc. It is envisaged that the Commonwealth would typically contribute 50% of these costs but that the selection board (made up of members from both sectors involved and from government) might be empowered to pay considerably more than 50% in the case of fellowships taken up in small companies. However, the program would have greatest application to those larger companies having a substantial in-house R&D capability.
Although the assistance provided would need to be realistic, the host company should also make a significant contribution to ensure that subsequent reports on the exercise (and comments on the desirability of expanding the scheme) will not be influenced by the fact that the company received the assistance at no cost. At the same time, consideration would have to be given to the fact that, irrespective of any direct financial contribution by the company, resources (in the form of equipment and support staff) will undoubtedly be diverted from the company's day to day activities to support the visiting fellow. Some personal incentive must be provided for the individual. ASTEC considers that it would be appropriate for companies to negotiate suitable individual honoraria for visiting academics over and above salary and any dislocation costs.

**ASTEC recommends:** That a three-year pilot program of industrial fellowships be implemented.

The cost of this recommendation would be, as mentioned in 5.17, $160,000 in the first year and $320,000 in the subsequent two years.

**Changes in Study Leave**

Guidelines and incentives should be introduced to encourage more academic staff to spend some of their study leave either on secondment to Australian industrial or government organisations, or carrying out work for them in the home institutions (whilst freed of normal teaching, research and administrative responsibilities). ASTEC appreciates that this issue has been the subject of recent extensive investigation by the Tertiary Education Commission. If appropriate incentives are provided, some academic staff would spend periods of study leave working in (or for) industrial laboratories. ASTEC suggests that individual universities and colleges investigate ways to encourage this.

**Joint Appointments**

Action should also be taken to encourage scientists, technologists and engineers in industry to take up joint appointments in universities and colleges. The most viable form of joint appointment would involve an industrial scientist or engineer spending approximately 20% of his or her time as a visiting academic. The remuneration would need to be paid by the tertiary body in the form of an honorarium related to the salary of a full-time professor, reader, or lecturer in proportion to the time devoted to academic duties.
5.22 The government would not need to take an active part in promoting an increase in the level of joint appointments (although it may need to provide some small assistance for the payment of honoraria). ASTEC suggests that the most appropriate forum for discussion of this issue would be the Australian Industrial Research Group (AIRG) - Interuniversity Committee on Research (IUCR) (see Appendix A) and commends the issue to this joint body for consideration. A means of including the colleges and institutes of technology in these considerations needs to be found.

JOINT PROGRAMS, INCLUDING CONTRACTING AND CONSULTING

Research Associations

5.23 There is a range of operational mechanisms within the nine research associations that operate at present in Australia. These range from employment of permanent R&D staff and operation of substantial laboratories, to acting as a central contracting organisation (or broker), coordinating the customers' requirements for R&D with the capabilities of the various research-performing organisations (see Appendix A).

5.24 ASTEC has already indicated its support for research associations, based in particular on their unquestioned value to smaller companies which are unable to support in-house R&D [25]. The Council has again examined the role of research associations and is convinced of the need to increase their number, particularly those relating to manufacturing industry. ASTEC considers that research associations such as the Australian Mineral Industries Research Association (AMIRA), which operates as a central contracting broker (see Appendix A), are a most cost-effective and flexible form of arrangement for manufacturing industry. The Council recognises, however, that the success of such research associations depends upon the availability of suitable R&D staff and facilities in government laboratories or universities to accept contracts. Where such facilities do not exist, there may be a need to establish a research association which can conduct its own research.

5.25 One issue that has been considered in some detail is the question of whether research associations would be able to operate successfully in the highly competitive manufacturing sector with its attendant problems of confidentiality. Generally, they would need to tackle problems of common interest to groups within the industry although, as happens through AMIRA, contracts for a single company could sometimes be arranged on a confidential basis. In the context of this confidentiality problem and the likelihood of research associations being able to find problems of common interest to a particular manufacturing industry (or group of industries), ASTEC notes the success of the well-established Australian Welding Research Association.
and Australian Wine Research Institute. The Council is also aware of the recent establishment of research committees such as the Foundry Industry Research Corporation (FIRC) and the Powder Metals Industry Association (PMIA), both of which have been established under the auspices of the Metal Trades Industries Association.

5.26 ASTEC welcomes the recently-announced Government decisions on an active program to assist research associations, on the continuation of block grants to existing associations, and on assistance to new associations. The Council envisages that, in the interest of a greater degree of interaction, up to five new research associations could be established, at a cost to the Government of about $200,000 per annum each. The areas of operation of any new research associations would need to be chosen in consultation between government and industry, having regard to the considerations outlined above. The areas mentioned in paragraphs 5.25 and 5.28, where industry research committees have already been established, may be good starting points for establishment of new associations.

5.27 The Council is aware of an additional problem that serves to discourage the establishment of new research associations, a problem that has been evident in attempts to upgrade and expand the activities of the Australian Engineering and Building Industries Research Association Limited (AEBIRA). This is the administrative cost of establishing and maintaining a central co-ordinating office and employing a contracts manager. To overcome this, ASTEC believes that the Government's contribution to new research associations should cover administrative costs of operating the Associations, not just R&D costs.

Industry Research Committees and Panels

5.28 ASTEC welcomes the recent initiative of the Metal Trades Industry Association (MTIA) in establishing research committees and panels which provide a forum for discussion of problems associated with particular industries, and identify areas where research could bring benefits to the industry as a whole. As well as those mentioned in 5.25 above, panels have been established in areas including wear-resistant castings, non-destructive testing, pattern problems and materials, and environmental control. ASTEC believes that such committees, as well as being useful in themselves may serve as precursors to research associations, and that the above committees' development, and the establishment of further such committees, should be encouraged.
The Performance of Fundamental Research Projects of Interest to Industry and Tertiary Education Institutions

5.29 Initiatives by the Australian Industrial Research Group (AIRG) to generate enthusiasm in universities and colleges for research projects of interest to industry have been only moderately successful to date (see Appendix A). One reason is that no financial incentive is provided. ASTEC supports the proposed AIRG program as a means of aligning a proportion of academic R&D activities with industry, but suggests that some incentive is needed for the individual academic. The Council has examined the Special Co-operative Research Grants program operated by the Science Research Council (SRC) in the UK (see Appendix B); this is an effective mechanism for encouraging closer links between industry and higher education. Not only would this increase interaction between universities and industry, but it would also be an appropriate program for encouraging interaction with colleges of advanced education where staff should have a greater involvement in applied R&D.

5.30 After examining the most appropriate means of introducing the scheme into Australia, ASTEC has concluded that such a program would best be implemented as a grants sub-program of the Australian Industrial Research and Development Incentives (AIRDI) program, with any necessary amendment of the Australian Industrial R&D Incentives Act. The awarding of such grants might subsequently lead to program grants rather than project grants and could eventually have the effect of establishing industrial co-operative research centres, not dissimilar from the UK’s experience with the Marine Technology Directorate (see Appendix B). ASTEC believes that such co-operative research grants should be made relatively more attractive than the usual AIRDI project grant, and this could be done either by allowing companies involved to receive more than the 50% of total project costs currently met by the AIRDI scheme, or by setting aside a proportion of AIRDI funds for the co-operative grants. The Council believes that, following a study of the operation of the UK Science Research Council’s Special Co-operative Research Grants program, a pilot program needs to be established under the AIRDI Act. In the first instance, an amount of approximately $0.5million per annum is suggested, sufficient to support 10 to 20 major projects.

ASTEC recommends: That a pilot program of co-operative research grants be established under the Australian Industrial Research and Development Incentives Act 1976 (amended as necessary), taking into account the operations of the UK Special Co-operative Research Grants program.
5.31 More effective technology transfer is essential to the future viability of the Australian manufacturing sector. ASTEC has examined means of achieving this, and has concluded that one effective means is the establishment of a technology transfer network. Such a network would employ highly-qualified and experienced people, able to provide effective links between sources of technology in universities, colleges and government laboratories and potential users of technology in industry.

5.32 A recent initiative in this area is the Department of Productivity's Pilot Program in Technology Transfer (see Appendix A). This program, which has led to the establishment of a technology transfer network, is designed to gain practical experience on which future long-term government policies for the industrial application of technology can be based. An essential feature of this program is the involvement in its development, operation and evaluation of a broadly-based organisation, the Technology Transfer Advisory Council, which includes in its membership industry associations, technical and professional bodies and government departments and agencies. The program therefore ensures that a considerable degree of interaction actually occurs. As a further means of ensuring full industry participation in this program, a public interest company, Technology Transfer Council, has been formed by two major industry associations to employ staff and manage the operation of the network. Among other things, this approach provides the flexibility to offer appropriate levels of remuneration to attract suitable officers.

5.33 ASTEC has also examined the Technology Information Service operated by the Canadian National Research Council and notes that a cost-benefit analysis of this program indicated benefits to the Government considerably in excess of the costs (see Appendix B). Features of the scheme are relevant to the Australian situation. In particular, the field service operating from 16 offices across Canada would appear to have particular application in Australia in that the emphasis is on providing advice to small companies on methods improvement, new technologies and general procedures for upgrading productivity; help is given also in defining problems and advising on the hiring of specialist consultants.

5.34 A technology information service may partially overlap with the operations of research associations, but is more likely to offer a useful complement. The information service could be expected to take knowledge from researchers to users, whereas research associations take problems from users to researchers; the information service, to the extent that it solves problems at all, will only deal with
relatively simple ones, while research associations undertake more complex projects; and the information service would deal with company-specific problems, while research associations are more aligned to industry-wide problems.

5.35 A similar field service would be of value in Australia; this should be linked to an upgraded and broadened version of the Department of Productivity's program. ASTEC suggests that an initial program could involve 50 professional officers and support staff, at a cost of $2.5million per annum. This figure is based on the Canadian program, taking into account appropriate frequencies of visits by the professional officers to manufacturing establishments.

ASTEC recommends: That the activities of the Technology Transfer Council be upgraded and broadened in scope, including bringing a scheme similar to the field-service aspect of the Canadian Technical Information Service into the Program.

UNIVERSITY AND COLLEGE COURSES

Short Courses

5.36 Several universities and colleges in Australia run continuing education and retraining programs, often in the form of short courses; these often involve postgraduate training. Generally, a short course attempts to communicate effectively a body of new knowledge to those who can benefit; such courses usually last one to five days. In some areas, such as semiconductor technology, the rate of change of knowledge is so fast that short courses are, in many instances, the most efficient way to update the scientists' and engineers' knowledge of rapidly changing technical areas. As the Report on Education, Training and Employment [26] noted, the financing of these activities is a problem, unless the students formally enrol in masters or other postgraduate courses, even though such courses are not suited to the needs of all those who may seek further education.

Sandwich Courses

5.37 Sandwich courses, which combine periods of study for undergraduates with periods of professional training, operate in some institutions in the UK and Canada, and appear to give the student greater self-confidence, maturity and self-reliance and a better understanding of industry. In addition, they provide the university or college with closer links with industry, inputs to course content, and a better understanding of the graduate employment environment. Industry gains a cheap temporary employee, an influence over undergraduate course content, and access to students to assess them as potential employees. Sandwich courses are not common in Australian universities and colleges at present. Where they do operate, they have arisen because of a clear demand.

33.
NOTES AND REFERENCES


3. For example, Project SCORE 1973-74 (AGPS, Canberra, 1977) shows that basic research made up 73% of higher education R&D in 1973-74, 20% of government R&D, and 9.7% of business enterprise R&D.


12. Ref. 5, pp127-139.

13. ASTEC 'Industrial Research and Development: Proposals for Additional Incentives', AGPS, Canberra, 1980


15. Ref. 8, pp. 299-300.

16. For a description of overall organisation and operation of R&D in Agriculture, see 'Science and Technology in Australia 1977-78', Volume 2.
17. Information supplied in Department of Primary Industry Submission to ASTEC on interaction activities.

18. For a description of overall R&D organisation and activities in Mining and Mineral Processing, see "Science and Technology in Australia 1977-78", Volume 2.

19. There are problems of separating research, development and exploration in mining and mineral processing. See Ref. 3, Chapter 23.


22. 'Industrial Research and Development: Proposals for Additional Incentives' ASTEC Report to the Prime Minister, AGPS, Canberra, 1980.


APPENDIX A

INTERACTION ACTIVITIES IN AUSTRALIA

ARTICULATION BY JOINT COMMITTEES

Joint Committee of CSIRO and the Australian Vice-Chancellors' Committee (AVCC)

A.1 This Joint Committee comprises the four members of the AVCC Inter-University Committee on Research (IUCR) and the four members of the CSIRO Standing Committee on Inter-relationships with Tertiary Education Institutions. The CSIRO/AVCC Joint Committee first met in February 1979 and has met at approximately two-monthly intervals since then. The Committee's role is to examine possible co-operation and collaboration between CSIRO and the universities and it is studying information exchanges, collaboration in the form of joint projects, joint facilities, joint seminars, joint supervision of postgraduate students, joint sponsorship of visitors, staff interchange, study leave, staff mobility, CSIRO staff involvement in teaching, and contracting from CSIRO to universities.

Australian Industrial Research Group (AIRG) - CSIRO Working Party

A.2 This Working Party was established in 1977 to provide a forum for discussion between CSIRO and members of the AIRG. The AIRG is a group of industrial research managers seeking to improve the quality of research management in Australia; it was established in 1964. At present some 50 R&D managers from Australia's largest manufacturing and mining companies comprise the AIRG. Each year a conference is arranged at which CSIRO research leaders outline their proposed programs for the coming year and the industry R&D managers comment on their applicability and relevance to their own activities. There has also been considerable discussion on a range of issues including research associations, staff interchange, the setting of national goals and the dissemination of information (including the value of research directories). The Working Party recently began a technological forecasting exercise aimed primarily at establishing advanced techniques for forecasting which could be used by industry in a variety of ways.

36.
A.3 Regular meetings between these two groups began in mid-1976. The aim of such meetings is to encourage interaction between the industrial and academic sectors. In particular, the groups have examined the feasibility of secondments and short-term fellowships. The group has strongly encouraged the adoption by Government of some form of industrial fellowship program. One issue that has always been raised in any consideration of interaction between the two sectors has been the question of confidentiality and subsequent patent rights.

A.4 It should be noted that there is no such liaison activity involving smaller companies. This increases the difficulty of monitoring interaction activities involving such companies.

ACTIVITIES OF MAJOR GOVERNMENT LABORATORIES

CSIRO

A.5 CSIRO is a largely government-funded research organisation concentrating on strategic mission-oriented research. It has a variety of mechanisms for interacting with industry, higher education, and other government agencies. These include:

- CSIRO representation on a range of committees and councils concerned with research policy and planning, and with funding of research in specific areas (e.g. Rural Industry Research Funds);

- CSIRO membership of, and financial support for, research associations;

- interchanges of CSIRO staff and the staff of other agencies; for the period 1974 to 1978, 39 CSIRO staff were seconded to other organisations for periods of more than three months, and 69 staff of other organisations joined CSIRO for three months or longer;

- interaction with universities through joint use of equipment, joint supervision of postgraduate students, collaborative research and lecturing by CSIRO staff.

Defence Science and Technology Organisation (DSTO)

A.6 DSTO conducts research, development, testing and evaluation for the defence forces. It has a close interest in the defence capabilities of Australian technology, and
hence needs to interact with industry and higher education. This is achieved through the activities of the External Relations Branch of DSTO, and through the placement of significant amounts of development work arising from DSTO research with industry. DSTO is also increasingly encouraging secondments of staff between the organisation, and higher education and industry. Finally, small Defence Research Groups, comprising experts from DSTO, industry and universities, are being formed to consider areas of basic science of defence significance.

Telecom Australia

A.7 Telecom purchases about half of the output of the local electronics industry, which means that the industry is highly dependent on Telecom for its continued prosperity. Telecom's principal means of interaction with industry is through contracting of some of its R&D to industry ($133,000 in 1978-79, $200,000 in 1979-80). Telecom also supports R&D in higher education by research contracting ($53,000 in 1978-79), and is one of a number of government agencies which supports the Radio Research Board, which disburses about $180,000 annually to researchers in higher education.

Australian Atomic Energy Commission (AAEC)

A.8 The AAEC is involved in a range of research associated with nuclear energy, radioactive isotopes, and their applications. The AAEC interacts with industry, universities and medical establishments through collaborative R&D, consulting, contracting research, and scientific and technical services. The AAEC contributes strongly to the Australian Institute for Nuclear Science and Engineering which enables university and other researchers to use the research facilities of the Commission's Research Establishment. About 200 scientists visit the Research Establishment each year, and spend a total of about 2500 man-days there.

The Bureau of Mineral Resources, Geology and Geophysics (BMR)

A.9 BMR studies the geology of the Australian continent, its offshore area and the Australian Antarctic Territory as a basis for assessment and development of mineral resources. BMR's interaction activities include working-level involvement with State Geological Surveys, CSIRO, universities and industry; a proposed Advisory Committee to assist BMR in program formulation; some contracting out of, and support for external, research; and joint laboratories with CSIRO and the Australian National University.
ADDITIONAL STAFF INTERCHANGE AND SECONDMENTS

The Public Service Interchange Scheme

A.10 This program was introduced in 1977 to facilitate exchanges of personnel between the Commonwealth Public Service, other parts of the public sector and organisations in the private sector. Secondments may be for periods of up to two years, although periods of six to twelve months are usual. To May 1980, 127 exchanges had been arranged. Some 48 Commonwealth public servants had been placed in the private sector, 22 with other levels of government and nine with various other organisations. In return, 30 officers from the private sector, 13 from other levels of government, and five from other organisations, had spent periods of secondments with the Commonwealth Government.

A.11 Placements have usually been arranged as one to one exchanges, but exchanges are not necessarily simultaneous, at the same level, or for the same period of time. The arrangement is that the officer's home organisation pays normal salary and superannuation and all travel costs (except those directly associated with activities carried out for the host body). All forms of leave and entitlements accrue as if the individual were still with the home organisation. Sixteen exchanges (from a total of 79) have involved scientific and technical staff moving to other sectors, while 12 scientific and technical staff (from a total of 48) have spent periods of time with the Commonwealth sector.

The Use of Study Leave

A.12 Few academic staff spend their study leave in Australia. Still fewer spend time in either industry or government organisations. However, the recent report by the Tertiary Education Commission (TEC) on study leave [1] made recommendations which (particularly in the case of colleges) will strongly encourage the taking of study leave in Australian industry and government organisations. The Australian Industrial Research Group (AIRG) encourages academic staff to consider study leave programs which involve industrial R&D work.

A.13 Quantitative information on employment of academic consultants by industry during vacations, or while on study leave, is available as a result of a survey conducted by the Australian Industrial Research Group (AIRG) in October 1975. The results showed that only 25% of AIRG members had engaged academics during vacation or study leave periods; only 15 Australian academics have undertaken a period of time in industry of some months duration over a period of 20 years, and of these, nine were either chemical engineers or metallurgists.
University Secondments

A.14 Short-term transfers of university staff into the public service and government research institutions are sometimes used as a means of filling a need for expertise in a particular area. Little information is available, but there is clear evidence that secondments and transfers involving staff in Australian universities are small in number. The Federation of Australian University Staff Associations (FAUSA) has surveyed staff secondments from four universities for the period 1973 to November 1977. Fourteen secondments (for periods greater than one month) were made to CSIRO in this period, and nine to other government agencies.

Joint Appointments

A.15 Joint appointments (i.e. of visiting professorships or lectureships) are common and fairly successful in the USA, The Netherlands and the UK, but only limited use is made of them in Australia. CSIRO staff are active in providing teaching assistance for tertiary education courses and in jointly supervising higher degree students; in any one year, between 10 and 15% of the professional staff of CSIRO may have such teaching and training commitments. There are joint appointments of various special kinds by universities and hospitals in the medical area, the extent of which is difficult to document. Apart from these, there appears to be only a few 'visiting' Professorships in the scientific and technological area, mostly at the University of NSW.

The Australian Industrial Research Group (AIRG) Proposal for Study Leave

A.16 The AIRG has emphasised the need to achieve better interaction between the different R&D sectors. Recent proposals by AIRG include one aimed at increasing the number of academics who spend study leave in Australian industry. Two listings of research projects of interest to AIRG companies were compiled and circulated to universities and colleges in 1978 and 1979. Some ten projects have been taken up or are about to commence; these have mainly involved staff from colleges of advanced education.

Joint Programs, Including Contracting, Consulting and Applied Grant Schemes

Research Associations

A.17 The great majority of manufacturing companies in Australia employ fewer than 100 people. Slightly more than
half the value of manufactured goods is produced by some 30,000 small enterprises. This feature of the manufacturing sector makes it particularly important to assess the role played by research associations. These bodies are usually formed by groups of companies who see the need for R&D in their particular industry; the co-operative nature of research associations provides a mechanism for small companies to gain access to high quality R&D assistance.

A.18 Research associations keep their member-companies informed about progress in their areas of interest, and provide technical advice. They also delineate problems and research needs of their member companies to CSIRO Divisions or universities; they are able to act as the scientific and technological interpreters and advocates of the needs of the industry.

A.19 There are nine research associations in Australia. They employ a range of operational mechanisms, ranging from that of the Bread Research Institute (BRI), which employs permanent R&D staff, operates from substantial laboratories and receives funds mainly from industry (approx. 75%) with a subsidy from the Commonwealth Government (approx. 25%), to that of the Australian Mineral Industries Research Association (AMIRA), which carries out no in-house research but acts as a central contracting organisation.

Rural Industry Research Funds (RIRFs)

A.20 Funds for the RIRFs are generally provided on the basis of a producer levy with a matching Commonwealth Grant. Funds allocated from the RIRFs totalled $25.7million in 1978-79, of which $8.9million was provided by the Commonwealth [2]. In each instance recommendations for the allocation of funds are made by a committee comprising members of the appropriate producer group and representatives of the Commonwealth Department of Primary Industry, State departments of agriculture, CSIRO and universities. These committees ensure that projects are aligned to current needs. In 1978-79, the $25.7million allocated for research went to CSIRO (36%), State departments (22%), universities and colleges (20%) and other organisations (22%).

National Energy Research, Development and Demonstration Program

A.21 Over the last two years energy R,D&D support grants totalling $41.8million have been approved by the Minister for National Development and Energy under the above Program. Grants are approved on the basis of advice tendered by the National Energy Research, Development and Demonstration Council (NERDDC). All three research sectors are represented on the Council and its supporting committees.
A.22 In tendering its advice NERDDC is conscious of the need for interaction between the research sectors and many of the projects recommended are so structured that work is sub-contracted from one sector to another. NERDDC, in conjunction with the Department of National Development and Energy, has also sponsored workshops which provide an opportunity for researchers from all sectors to contribute to discussion on specific topics.

Fundamental Research Projects Proposed by the Australian Industrial Research Group (AIRG)

A.23 The AIRG has recently begun a program which involves the circulation, within universities and colleges, of a list of fundamental research topics of relevance to Australian industry. Over 1500 enquiries (more than 90% coming from universities) were made about individual projects and 90% of the enquirers made subsequent contact with the firms who had suggested the topic for study. AIRG see this as a very encouraging response.

The Australian Road Research Board (ARRB)

A.24 The ARRB is a private company established in 1970 and is directed, and largely funded by, Commonwealth and State government departments. ARRB's staff number about 130, of whom 38 are professionals; its 1978-79 Budget was $3.5 million, $3 million of which was spent in-house. At present 8% of the Budget comes from the Commonwealth and 92% from the States, who recover about half of this expenditure from the Commonwealth.

A.25 In general, the ARRB does research on subjects which do not fall within the purview of the States or which is better performed centrally, because it is of more general interest and application. About $0.5m is spent annually outside ARRB, mostly in universities under contract; contracts are also awarded to consultants and to industry. Industry also provides some funds for research by the ARRB.

A.26 Secondments between ARRB and universities are common. ARRB is also involved in a number of joint programs with industry. ARRB encourages long-term mobility and sees the non-portability of superannuation and associated benefits as the main constraint to long-term staff movement, although the Board has structured its own superannuation scheme to make it portable. Reciprocal arrangements with a number of organisations to permit transfer of superannuation and other rights have been negotiated.
University Consulting

A.27 Few academic staff are employed as consultants by organisations in either the government or industry sectors on a formal or permanent retainer basis; this contrasts with the situation in many overseas countries. In fact, consultancy activities (including many of those arranged through university companies - see below) are frequently restricted to requests for specific assistance in the form of trouble-shooting or access to specialised equipment.

University and College Research Companies

A.28 In recent years a number of universities and colleges have established companies which promote and manage research and consultancy services and develop small innovations. The companies were established primarily to 'market' academic resources. Their aim is to provide access by industry to particular services or resources of the university or college, for which fees are payable.

A.29 The first university company established in Australia was Unisearch Limited at the University of NSW, in 1959. Over the years, increasing use has been made of the company's consultancy, technical assistance and R&D services, the increased demand reflecting the growing needs of industry and commerce and the capability of the staff in meeting those needs successfully. The research companies are listed in Table A.1, with their respective turnovers for project fees for 1978-79.

<table>
<thead>
<tr>
<th>Company</th>
<th>$ million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unisearch (University of NSW)</td>
<td>1.23</td>
</tr>
<tr>
<td>Tunra (University of Newcastle)</td>
<td>0.16</td>
</tr>
<tr>
<td>Wait-Aid (WA Institute of Technology)</td>
<td>0.10</td>
</tr>
<tr>
<td>Technisearch (Royal Melbourne Institute of Technology)</td>
<td>0.15</td>
</tr>
<tr>
<td>Sard (Swinburne College of Technology)</td>
<td>0.15</td>
</tr>
<tr>
<td>Techsearch (SA Institute of Technology)</td>
<td>0.10</td>
</tr>
<tr>
<td>Insearch (NSW Institute of Technology)</td>
<td>0.15</td>
</tr>
</tbody>
</table>

43.
A.30 The Australian Industrial Research and Development Incentives Act 1976 provides for the payment of 'Commencement Grants' and 'Project Grants' to encourage industry to carry out R&D. Project Grants are made in support of specific projects; the work can be done 'in-house' or contracted out and this allows companies to make effective use of R&D capabilities which can be provided by other organisations. In 1979-80, $28million was allocated to Project Grants. A random sample of 100 applications for Project Grants received in recent months included only 12 projects in which the company proposed to contract R&D to an academic institution and two involving proposed contracts with CSIRO. These figures suggest that the interaction (in terms of contract research) is low. However, the contracting level is higher in the case of Commencement Grants.

A.31 Provision is also made for the support of Public Interest Projects. The Department of Productivity is actively encouraging the application by industry, of the results of research carried out in government and academic laboratories. Funds are provided to allow industry to develop such results in an attempt to demonstrate commercial viability. Strong interaction between public sector research workers and the companies undertaking the development work is required. Funds allocated for Public Interest Projects in 1979-80 totalled $4million.

The Pilot Enterprise Development Programs

A.32 The Pilot Enterprise Development Program initiated by the Department of Productivity in mid-1979 is designed to encourage and assist the creation of new companies to exploit significant developments in technology [3, 4]. The development of promising inventions often fails commercially for want of appropriate management skills and entrepreneurial ability and this program is intended to complement, to some extent, the Public Interest Grants (above) by providing support for new products and processes. This includes the use of specialists in management, finance, production, marketing and other relevant skills. The program is intended to assist the development of a new technological product or process to a stage where it will attract capital for the production and marketing process. Projects are usually overseen by a Guidance Committee, charged with formulating a complete corporate development strategy for potential investors. Funds allocated for this program in 1979-80 totalled some $0.35million.
INFORMATION TRANSFER

Technology Transfer Council; Technical Referral Network

A.33 The Department of Productivity established the Technology Transfer Council in August 1978, in recognition of the fact that the effective application of technology is one of the key factors in the development of an efficient manufacturing industry. This body at present concentrates its attention on the metal, metal products and machinery industries.

A.34 The Council has established a Technical Referral Network, which consists of a series of existing centres of technological expertise located in industry, academic institutions and government research organisations. These centres bring together the expertise from approximately 30 organisations from the professions, higher education, Commonwealth and State governments, industry associations and private enterprise. They operate with the assistance of specialist technical liaison officers, whose employment is arranged by the Department of Productivity, (through a new company) and who provide technical advice and problem-solving assistance. The Board of the company has representatives of the Confederation of Australian Industry, the Metal Trades Industries Association and the Department of Productivity. By may 1980, there were six technical liaison officers operating from a network of centres in most States.

A.35 The scheme operates through a telephone service for referral of problems, with answers being provided either from the network staff or by onward referral to appropriate experts. In addition, specialised short courses are organised in fields such as robotics, sheet metal forming etc. At this stage, there has been no consideration of the future of the program beyond the metals industry. There is authorisation and funding for a three-year pilot program and it is intended to commence a review of the program with a view to bringing forward proposals for expansion into other industries if warranted. Certain parallels may be drawn between the program and extension services which have been so successful in the agricultural sector.

The Australian Research Directory

A.36 A recent development intended to improve communication between sectors - the Australian Research Directory - was produced jointly by the Department of Science and the Environment and CSIRO. This Directory provided in an integrated form what is described as 'point of entry' information on research activities in Australia. The first edition, published early in 1979, covered research in the natural and selected social sciences in the higher education sector only.
A.37  A second edition had been planned. ASTEC has already indicated its general support for the program but has expressed reservations about its value unless it is made available in an easily-readable printed version. Moreover, ASTEC believes that, to achieve a usefulness commensurate with the effort involved in collecting and collating the information, it is essential that the data be stored in a simple computer retrieval system allowing access to selected data by subject, researcher, or category.

Compendium of Australian Energy Research, Development and Demonstration Projects

A.38  The first issue of this Compendium was produced by the Department of National Development and Energy in March 1980. It includes a synopsis of all projects which were funded under the National Energy Research, Development and Demonstration Program in 1978-79. An enlarged version of the Compendium which will include the bulk of Australian energy R&D activity is currently being prepared.

A.39  The Compendium assists in the dissemination of information throughout the research community. It is also important in achieving co-ordination of overall Australian energy R,D&D effort and in stimulating collaboration between laboratories in the various sectors.
REFERENCES


APPENDIX B

ARRANGEMENTS IN SOME OVERSEAS COUNTRIES

UNITED KINGDOM

Introduction

B.1 There are particular reasons why experiences in the UK are relevant to Australia. Australian academic institutions largely follow British patterns, and many large government research organisations in Australia were established along British lines. Moreover, in Australia, as in Britain, there has been a dichotomy between pure and applied research activities.

Sandwich Courses

B.2 These have been developed by universities to give undergraduate degree programs a greater industrial or vocational content [1]. Sandwich courses combine periods of academic study with periods of industrial or professional training thereby extending the traditional period for a degree by one year. Patterns of organisation vary, but there are two main forms: first, one in which the outside experience is in a single period of one year after two years full-time academic study and, secondly, a course in which the industrial experience is in smaller units (either two six-month periods or three four-month periods) spread over the four-year period.

B.3 Eight universities in England offer sandwich courses, in both science and engineering. These universities had all existed as some form of college of technology and became universities in the mid-1960's expansion. The percentage of students undertaking sandwich courses varies from institution to institution but is generally between 20 and 30% of the undergraduate enrolment in the science and engineering faculties.

B.4 Those universities engaged in sandwich courses and students who have experienced them are generally enthusiastic about the program. There is, however, little interest in the traditional universities in entering this field, the general argument given being that the demands of education and training would generate too much conflict. However Cambridge University actively encourages potential undergraduates in engineering to spend a period in industry before commencing their degree and approximately 70% of entering students have this experience.
Two clear conclusions emerge from an examination of the UK experience with sandwich courses:

- Keen staff interest in participation is a prerequisite for success; staff interest must extend to concern for the relevance and assessment of the industrial component of the course; and

- The success of sandwich courses depends on the availability of suitable and committed host companies for the industrial component.

**Research Consultancy Companies**

Companies similar to those existing within many Australian universities and colleges, have been established at almost all universities and polytechnics in the UK in the past few years. The decline in central government funding has undoubtedly created the climate where there is a greater concern to market university resources. The major function of these companies is to encourage and assist academic staff to develop commercially fruitful lines of enquiry and to attract industry to use particular services of the university.

**University Units**

Units whose prime purpose is to interact with industry, have been established in a number of universities in recent years, usually in response to a specific industrial need. Several have been established with assistance from the Wolfson Foundation which provides once-only grants on the basis of the units' becoming self-sufficient within five years. One of the most successful of these is the Wolfson Cambridge Industrial Unit. This Unit was established in 1970 with a grant of £220,000. It concentrates almost entirely on engineering problems and receives enquiries from around the country. Some work is done in the Unit and some is directed to departments. The unit encourages industry to become involved in the development of new lines of enquiry at the earliest possible stage and also encourages industrial R&D staff to work in the Cambridge engineering laboratories.

**Collaborative Awards in Science and Engineering (CASE) Studentships**

For ten years the Science Research Council (SRC) has influenced the orientation of postgraduate research by a scheme which relies on collaboration between university and industry. It was known as the Collaborative Awards in Pure Science (CAPS) scheme till 1972-73 and then became the Collaborative Awards in Science and Engineering (CASE). The basis of these awards is that the project should be jointly agreed by an academic and industrial researcher, that it should be approved by the relevant Panel or Committee of the
SRC, that the company should meet all extra costs to the participating student, and that the student spend at least six months working in the industrial firm on the project.

B.9 Despite the considerable growth in numbers of CASE studentships, they remain unpopular with some groups of academics. Some senior SRC officials take the pragmatic view that complaint by academic staff is a sign that the scheme is working in reorienting academic attitudes; opposition to CASE is present because it is in fact starting to achieve its stated objectives. Conflicting views on the value of CASE led to an independent review by a scientist from Shell International Chemicals [2]. The review concluded that:

- the success of any one award is dependent on all three people involved - the student, the academic supervisor, and the industrial supervisor;
- academic staff are now accepting the CASE scheme more readily; fewer staff are still hostile to any restrictions involved;
- the prejudice against CASE studentships by students is vanishing; and
- in general, there are no insuperable problems in relation to publication, confidentiality and patent rights.

R.10 However, discussions with individuals involved with the CASE program suggest that:

- the academic does nearly all the work in preparing the studentship application; industry initially has little interest and, despite the fact that the scheme appears to provide an inexpensive form of R&D for industry, companies generally have to be actively persuaded to participate;
- there is no documented evidence that CASE graduates have better employment prospects although the student often joins the staff of the co-operating company; and
- the academic does feel compromised in terms of the directions of research he may pursue; it can be frustrating not to follow up interesting sidelines and as a result fewer scientific publications generally result, to the detriment of the academic.
The Collaborative Training Awards (CTA) Program

B.11 The SRC has also introduced a scheme to complement CASE. This is better suited to smaller companies often presenting problems that do not warrant a full three-year study. In general, the projects involved require work over a 12-15 months' period. One problem is that few universities are prepared to award any formal qualification to a student carrying out research under the CTA scheme; the SRC hopes that potential employers will however come to consider involvement in a CTA program as a qualification in itself. CTA awards tend to be concentrated in engineering, especially design and manufacturing problems.

The 'Customer-Contractor' Principle

B.12 This approach to research definition was established primarily as a means to link the applied research programs of government research establishments to national need. A review of its operation [3] suggests that it has succeeded in linking university research programs to the interests of government departments, but that the linkage between government and industry has not been significantly affected. The major exception to this is the laboratories of the United Kingdom Atomic Energy Authority at Harwell which had already begun to operate as a contract research organisation, and now carries out more than 50% of its work on contract to industry.

B.13 In a number of government departments, but particularly in the Department of Industry, the determination of need has been passed to the Requirements Boards, a majority of the members of which are potential users of research results outside government, for example industrial firms and research associations. In these instances the contract is being used as a tool for ensuring that the research of departmental laboratories, funded by that department both directly and through the Requirements Boards, is in accord with the needs of the potential users of research.

Other SRC Initiatives Directed towards Specific Areas

B.14 In recent years the UK Science Research Council (SRC) has initiated a number of additional programs aimed at stimulating a greater level of interaction in certain areas seen as vital to Britain's industrial viability. These run parallel to, and complement, the funding program for fundamental research supported by the SRC.

B.15 The Teaching Company Program is a joint venture between the SRC and the UK Department of Industry. A university or polytechnic recruits Teaching Company Associates to work for a period in and for a chosen company, at government expense. The Associates work as teams on research projects,
that range from the development of new inventions to introducing new plant and technology into companies' factories. The emphasis is on production and the Associates' involvement with the co-operating academic institution is by way of seeking advice and access to specialised equipment. The gain to the academic is the opportunity to experiment in a factory situation with all its attendant problems; the manager in industry is able to discuss his technical and development problems with someone who has substantial knowledge and expertise and has, through the Scheme, the skilled engineers to put new ideas into practice.

B.16 The program is under the control of a director who has the overall responsibility for choosing the co-operating academic organisations and companies and overseeing each of the projects. The total cost per project is around $200,000 and some 20 projects are now operating or approved. The scheme has enthusiastically received by both sectors [4,5,6, 7].

B.17 The Polymer Engineering Directorate (PED) program was established by the SRC in 1976 to mobilise the engineering-oriented skills of universities and polytechnics to help improve the performance of the polymer fabrication industry in the UK. The program covers three facets of polymer production: materials and product properties, processing, and processing machinery.

B.18 The focus of the program's activities is on small polymer fabricators employing only 20 to 100 employees. Funds are provided in response to joint proposals from universities and industrial companies (in which instance the company contributes 25-30% of the total cost) or by contracting an academic group to carry out a proposal put forward by a particular company. All projects are assessed every three to six months by a committee of representatives from universities, industry, and the Science Research Council. A formal agreement on ownership of resulting patent rights is drawn up before work begins.

B.19 Academics and industrial managers have welcomed the scheme. Funding by the SRC is at present around £2 million per annum and an additional £0.5 million comes from industry and various manufacturers' associations. Over 80% of the program consists of joint projects.

B.20 The lack of co-ordination and communication between academic engineers and industry in the field of marine technology has been a recognised problem in the UK for many years. The Marine Technology Directorate (MTD) was established in 1977 to develop in the universities and polytechnics a co-ordinated program of R&D which would attract industrial support and enable academic staff to assume a role in the developing use of the oceans, and at
the same time to help provide the engineers and technologists needed in the industry. The scheme is being developed primarily through the establishment of multidisciplinary programs at a limited number of academic institutions or groups of institutions. These involve a substantial number of permanent staff who are encouraged by their parent institutions and the Science Research Council to establish marine technology as a long-term activity, and embrace a sufficiently wide range of interests to sustain coherent programs. The overall objective is to obtain a better knowledge and understanding of the marine environment in order to assist industry in marine ventures, particularly in exploration for, and exploitation of, natural resources.

B.21 At present, six centres have been established and they receive total funds of over £5 million p.a. These centres' programs are developed in consultation with industry although funds from industry are at present limited. As with the Polymer Engineering Directorate, the projects are reviewed by a committee which includes industry representation. Progress has been steady and industry's interest in the MTD program is growing; increased funding from industry is expected as this interest grows.

B.22 The Special Co-operative Research Grants scheme was initiated by the Science Research Council (SRC) in 1978 with the aim of fostering closer links between higher education and industry, through the support of collaborative research. The scheme provides that SRC supports a collaboration between an academic institution and an industrial partner by financing the institution's costs. The industrial partner must make a contribution, normally in the form of active participation. The amount of the SRC grant may be up to three times the industrial contribution. Any patent rights arising from the work are assigned to the industrial partner subject to a small royalty payable to the National Research Development Corporation.

B.23 Applications are assessed on the basis of their value to both sectors (as judged by specialist SRC Committees), and the degree of co-operation indicated by the company jointly proposing the program. Proposals which involve different aspects of the project being undertaken by the university and the industrial partner simultaneously are favoured. To December 1979, 25 projects (out of 49 applications) had been approved and were in progress. The SRC's contribution to these totalled £0.9 million. Experience has indicated that larger companies are best able to take advantage of the scheme.
The Canadian system of industrial fellowships has been operating since 1973. The scheme was initiated by the National Research Council (NRC), but is now administered by the National Sciences and Engineering Research Council of Canada (NSERC). The program has been welcomed by both sectors and 180 companies are at present involved. The company employing the industrial fellow maintains his normal salary; NSERC reimburses the company to the extent of a maximum of $Can12,000 p.a. The rights to any new developments arising out of the program go to the participating company.

Program for Industry-Laboratory Projects (PILP)

This program is administered by the National Research Council of Canada (NRC) and aims to assist in the application of the NRC's research results. It was introduced following studies that showed that research from government laboratories is usually not carried far enough to allow Canadian industrialists to determine whether commercial exploitation would be economic, or whether a specific Canadian opportunity exists. The program is designed to help overcome these barriers, allow better identification of the eventual products, expose the economic factors involved, and identify the possible place and position of the product or process in the market.

NRC scientists provide (sometimes part-time) assistance with this process. This sometimes involves the assignment of a project manager, from NRC, to oversee and manage the project. NRC scientists who become involved in PILP programs receive more generous grants for new equipment and may have enhanced promotional prospects.

There is a strong demand by industry for the PILP service, and potential collaborative development projects are carefully assessed. PILP has been so successful that five other Canadian government departments (through their associated R&D laboratories) have since arranged similar schemes, initially managed by NRC, called Co-operative Projects with Industry; they now run as separate programs spending a total of $Can2million a year.

Incubator Programs

The NRC uses this name for programs which allow individuals (or groups) of industrial R&D staff access to NRC laboratories (at no cost), and the expertise of the staff, for indefinite periods in order to develop a particular product or process. A similar scheme operates at the Institute for Materials Research at McMaster University. Companies pay an annual fee to become industrial affiliates which allows company R&D staff to use the apparatus of university laboratories and interact with university staff.
The Technical Information Services (TIS) Program

B.29 In Canada, small and medium companies (having less than 300 employees) account for about 95% of all manufacturing enterprises, 50% of employment in the area and 50% of the total manufacturing production; 92% of manufacturing companies employ no scientists and 97% employ no engineers. As a result, these companies are not able to identify or describe their technological problems and have real difficulty assessing and using technology.

B.30 The TIS Program, operated by the National Research Council, was established in 1945 to combat this situation. It aims to assist manufacturers to improve production operations, productivity and profitability through better use of existing technology. The basis of the program is that technology transfer can best be achieved by means of competent technical people making personal contact with the firms they serve, thereby overcoming small firms' reluctance to hire or employ expertise.

B.31 The TIS operates from sixteen offices. There are about twenty central office staff in Ottawa, and 80-100 'field officers' operating from other offices. All officers have had (usually varied) experience in industry which allows them to respond to requests and solicit work. In total, the TIS responds to about 25,000 enquiries per annum.

B.32 The strength of TIS lies in its provision of practical advice on methods improvement, work measurement, plant layout, materials handling, organisation, quality and cost control. TIS accepts that small businesses are usually concerned mainly with daily operations and are not in a position to assess potential longer-term improvements. The TIS therefore aims to:

- identify and define problems and needs and, if they are substantial, advise on private consultancy procedures (in general TIS limits its assistance to about 50-100 manhours per company);

- identify and locate specific technologies relevant to the problems (often through the Technological Awareness Service (see below));

- adapt, modify and/or interpret the information for the clients' special needs;

- assist in the practical use of the information; and

- follow up the advice by assessing benefits.
The value of this approach is undoubted; 52% of companies make repeat requests. The TIS accepts that few companies are in a position to introduce major changes immediately, but the idea is to provide a guide for future development. Nevertheless, many problems can be overcome immediately.

B.33 A 3% sample of TIS cases has been studied. It has been shown that $Can18.7 million in profits accrued and that the Federal tax return from increased profits represented a 136% return on government investment.

B.34 The Technological Awareness Service, a current awareness program, is part of the TIS program. It reviews some 800 books, journals and reports per year; translates them into layman's language, and files the information using a computer-accessible system. A profile of a company's interests is prepared by TIS officers in co-operation with the company's management, and is matched against the computer's records.

B.35 The Science and Engineering Student Program (SESP) is a recent addition to TIS, by which science and engineering students carry out short-term projects in industry, usually during the summer vacation. A TIS officer oversees the project and occasionally an expert-adviser is called in to assist as a paid consultant. As a result, many smaller companies have employed technical people after having gained, through the program, an appreciation of what a scientist or engineer can do.

B.36 Projects are prepared by TIS in conjunction with the company, which must have some commitment to technological improvement, and students are provided to the firm for up to four months, with their salary being paid by TIS. The annual expenditure on SESP is $Can0.75 million. In the first year, 1977-78, 260 such projects were undertaken and a cost-benefit analysis showed that 88 of them produced a profit (extrapolated over five years) of $Can15 million.

The Enterprise Development Program (EDP)

B.37 This program, administered by the Department of Industry, Trade and Commerce, to some extent complements the Program for Industry-Laboratory Projects (see above) and plays a role similar to the UK National Research Development Corporation. There are three aspects of the program. The first, and most important, centres around assistance for innovation, providing funds to assist companies to develop products or processes. It is more flexible than PILP in that it can provide support for a range of purposes including development, market analysis, and production engineering.
B.38 Applications for assistance are assessed by a central Board made up of approximately equal numbers of representatives of the business sector and government departments. Grants are provided to cover 50% of total costs. Some are as much as $Can0.6million; one grant totalled $Can8million over 5 years. Annual expenditure is around $Can55million on some 400 new projects, and about 1000 projects are current in any one year.

B.39 The technical assessment of the projects is carried out by relevant government officers (sometimes with the help of outside experts) while the Board lays emphasis on the level of risk (and bigger companies are expected to embark upon riskier projects when seeking assistance), the inherent viability of the company and its commitment to technological change. All patent rights go in the first instance to the company, reverting to government if not taken up in a reasonable time.

B.40 The two other aspects of the scheme are the provision of development capital when all other possible sources have been exhausted, by means of loan insurance ($Can1,000million is guaranteed in this way at present), and the Defence Industry Productivity (DIP) program, which aims at strengthening industries manufacturing defence materials. It provides funds for establishing new capabilities and modernising plant. Some $Can40million p.a. is provided under this part of the Scheme.

Centres of Advanced Technology

B.41 Several Canadian universities have industrial research institutes (or university companies) which operate in a similar way to those in Australian universities and colleges. In addition, several Centres of Advanced Technology have been established with initial financial support from the Canadian Department of Industry, Trade and Commerce; the Department provides up to $Can175,000 p.a. over a period of three to six years. Centres are based on an industrial demand for a specific R&D service and are established in a university or provincial research organisation which already has an appropriate capability. They are intended to develop technical competence in a specific area of technology, to assist in the evaluation and adaptation of new technology, to alert manufacturers to new products and processes and to advise on their applicability. In general, the area of specialisation of a Centre reflects a regional manufacturing interest, although some Centres focus on a nation-wide activity.

Innovation Centres

B.42 Industrial Innovation Centres have been established at the University of Waterloo and at the Ecole Polytechnique
with funds provided by the Department of Industry, Trade and Commerce; they are wholly owned subsidiaries of the academic institutions. Their objective is to stimulate and improve the quality of invention, innovation and enterprise. The Centres:

- promote invention, technological innovation and entrepreneurship;
- evaluate inventions and business proposals;
- advise inventors and entrepreneurs, in development and commercialisation of inventions and research results;
- assist clients in the development of technical ideas into new products, processes and businesses;
- link inventors and entrepreneurs with needed resources to assist development in all phases from research to venture financing;
- develop and provide educational programs for inventors, innovators and entrepreneurs; and
- sponsor and conduct research to provide useful new knowledge about the processes of invention, technological innovation and entrepreneurship and the persons performing such roles.

UNITED STATES OF AMERICA

Recent US Moves to Stimulate Innovation

B.43 Interaction is already at a reasonably high level in the USA. There are large national programs in defence, electronics, chemicals, aircraft manufacture, space technology and nuclear energy in the USA, and interaction in these areas between government and industry results from the large amount of R&D contracted from government to industry. There is also substantial interaction between industry and universities by way of joint appointments and consultancy arrangements.

B.44 Nevertheless, the US Government is clearly not satisfied with the present level of innovation and interaction. Following an 18 month study by the US Department of Commerce, the President presented the US Congress with 34 proposals for rekindling the innovative spirit in industry and increasing the commercial exploitation of scientific knowledge. Substantial funds are to be provided to ensure 'a more effective partnership among government, industry, labour and the academic community' [8]. These proposals, ranging from anti-trust legislation to technical information services, are not aimed directly at providing greater support for technological developments, but at making the technological climate more conducive to entrepreneurial activity.
The National Science Foundation's University-Industry Co-operative Research Centres

B.45 This program was introduced in 1975 to stimulate co-operative research for American industry. Funds totalling US $5.4 million were expended over five years (US $2.4 million from the National Science Foundation (NSF) and US $3 million from industry) to stimulate closer co-operation between academic and industrial researchers. The program was established as an experiment in evaluating institutional arrangements for stimulating technological progress in the industrial sector. Three centres have been established, at the Massachusetts Institute of Technology (MIT) (polymer processing), at North Carolina University (furniture industry), and at Mitre Corporation (electronics, radar and communications).

B.46 The program was reviewed in January 1979 and, with reservations, the experiment was judged to have been successful. The NSF believes that this success depends more on choice of director of the centre, and less on the area of activity focussed on, and that centres are more likely to be successful in universities than in companies. The review stated:

The results of this experiment indicate that university-industry co-operative research is a viable concept... Industry will fund such co-operation and believes the results are applicable to its needs. University faculty has found industry research to be challenging and within the purview of the academic environment...[9].
REFERENCES


APPENDIX C

WORKING PARTY ACTIVITIES

The membership of the ASTEC Working Party which considered interaction activities in detail, and formulated the earlier versions of this report for consideration by ASTEC, was:

Professor R. Street, FAA (convenor) Member of ASTEC until February 1980, and Vice-Chancellor, University of Western Australia.

Dr W.J. McG. Tegart, FTS. Member of the Executive of CSIRO; formerly executive assistant to the Chief General Manager, BHP Co. Ltd.

Professor P.T. Fink, CBE
Chief Defence Scientist

Dr P.N. Richards, General Manager, Research and Technology, John Lysaght (Australia) Ltd.

Following Professor Street's retirement from ASTEC, Professor B.D.O. Anderson, FAA, Member of ASTEC and Professor of Electrical Engineering at the University of Newcastle, joined the Working Party.

The Working Party advertised in the national press in June 1979 for submissions on the topic, and 103 were received. The Working Party met nine times, and consulted widely with interested parties.

The secretary of the Working Party undertook a study tour in March 1980 to examine programs for interaction in the UK, Canada and the USA.

Draft reports were submitted to ASTEC on four occasions. The final draft was edited and was submitted to the Council in September 1980.