Telecommunications Research and Development in Australia

1985
TELECOMMUNICATIONS RESEARCH AND DEVELOPMENT
IN AUSTRALIA

A REPORT TO THE PRIME MINISTER

BY THE

AUSTRALIAN SCIENCE AND TECHNOLOGY COUNCIL
(ASTEC)

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My dear Prime Minister

We have the honour to present to you a report by ASTEC on telecommunications research and development in Australia as requested by you in July 1984. The report reviews the nature and extent of Australian telecommunications research and development, the dependence of our telecommunications on imported technology, opportunities for development and export of our own technology, and the role of research in Telecom Australia. The report makes recommendations on an industry development strategy, Telecom's purchasing and regulatory policies, the operations of Telecom's research laboratories, and promotion of basic research in telecommunications. In addition, ASTEC believes that there is scope for the principal organisations in telecommunications service provision and equipment manufacture to co-operate to form an Australian telecommunications product development company. As part of this review, ASTEC convened a meeting of these parties to discuss the idea, and investigations of its commercial prospects are now under way.

Yours sincerely

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SUMMARY AND RECOMMENDATIONS

Telecommunications is a key world-wide industry, and one which is fundamental to national success in the increasingly important information technologies. Nations wishing to compete in financial markets and in the provision, processing and trade in information will require the most efficient and up to date telecommunications infrastructure.

At present, Australia's level of dependence on imported telecommunications technology is high and, as a result, Australia is missing out on opportunities to gain a valuable share in world and regional markets in telecommunications equipment and services. Moreover, while Australian public telecommunications enterprises are at present providing modern and efficient service, there are real dangers of a future deterioration in the standard of Australian services relative to the rest of the world, unless Australia becomes more involved in indigenous product development.

ASTEC has examined possible ways in which there could be greater efforts in domestic telecommunications product development. We believe that the most appropriate method would be through the formation of a free-standing company involving as shareholders some combination of the Australian service providers and the equipment manufacturing industry. Such an enterprise would have the roles of bridging the gap between research results and commercial production, and investigating market opportunities for local, regional and international sale of Australian products.

As part of the study leading to this report, ASTEC convened a meeting of the major telecommunications service providers and some locally-owned equipment manufacturers, to discuss the idea of such a commercial venture. This meeting agreed that the commercial prospects of the venture deserved further investigation, and this is being undertaken by the Australian Industries Development Corporation, in consultation with the interested parties. ASTEC believes that such a proposal deserves to be evaluated on its commercial merits alone, and that it would be inappropriate for the Government overtly to subsidise or directly support the venture. Hence no recommendation to this effect is made in this report.

Another important issue in promoting more dynamic telecommunications product development in Australia is the general environment in which the local equipment industry operates, including the influence of government in areas such as purchasing, offsets, technology programs, regulation and trade strategies. As a result of its response to a recent Industries Assistance Commission report on telecommunications and related equipment, the government is preparing an integrated development strategy for the Australian telecommunications equipment industry, taking full account of technology and innovation development issues. ASTEC fully supports the development of this strategy.

**Recommendation 1**

That the government continue with its proposal to develop an integrated development strategy for the Australian telecommunications equipment industry, in full consultation with industry interests and service providers.
Telecom Australia, through its purchasing, attachment and regulatory policies has a profound influence on the local equipment industry. To date, these policies have led to a substantial equipment manufacturing effort in Australia in order to supply Telecom, but have not been conducive to local development of telecommunications equipment. There are various areas in which Telecom could take actions, without prejudicing its overall role as an independent, well-informed and cost-effective purchaser of equipment, to increase the opportunities for local product development. Similar considerations apply to Telecom as a regulator and authority for approval of attachment of equipment.

**Recommendation 2**

*That Telecom Australia and the Minister for Communications give greater attention to the effect on innovation in the Australian telecommunications equipment industry of Telecom’s purchasing, attachment and regulatory policies and practices, especially at times when these policies or practices are under review.*

The work of Telecom Australia's Research Laboratories is closely integrated into Telecom's overall research, development and innovation program. ASTEC believes that the Laboratories' role, functions and methods of operation are appropriate to Telecom's needs as a service provider for research, technology and technical information. The effectiveness of the Laboratories could be improved through increasing flexibility in personnel structures, financial management arrangements, and conditions for overseas travel. Telecom should also, in ASTEC's view, make increasing use of the Laboratories in their planning and development of the communications network.

**Recommendation 3**

*That Telecom Australia consider ways to increase the flexibility of operation of its Research Laboratories, and interaction between the Laboratories and other parts of Telecom.*

Australia conducts basic research in telecommunications, including investigation of fundamental technologies. This work is, however, currently scattered over a number of laboratories and a wide range of subject matter areas. As a prelude to a greater degree of co-ordination and concentration of basic research in telecommunications, there needs to be an investigation of Australia's strengths in this area. The national research effort, and the supply of research skills, could also be enhanced by increased interaction among service providers, industry and higher education through contracting and the awarding of fellowships and scholarships.
Recommendation 4

(a) That the Australian Telecommunications and Electronics Research Board examine, and report to the Government on, areas of basic research and new technology in telecommunications which might be increasingly supported for national scientific and economic benefit.

(b) That telecommunications service providers and equipment industry consider ways to increase their R&D interactions with other performers of R&D, particularly through contracting out of R&D to industry and tertiary education, and the funding of scholarships and fellowships in disciplines where supply of skills falls, or is likely to fall, short of needs.
1 Importance of Telecommunications

1.1 Telecommunications is a key industry throughout the world. It is one of the largest and fastest-growing industries, with 1982 revenues of service providers at $US150 billion, growing at about 12% per annum and likely to reach $US200 billion by 1985[1]. The world equipment market in the same year was $US55 billion, expected to exceed $US100 billion by 1992[2]. Telecommunications forms a vital and growing part of the infrastructure of all developed and industrialising nations. The ever-expanding range of information industries are all increasing their dependence on new telecommunications services and technologies.

1.2 International competitiveness, particularly in information-intensive industries such as finance, commerce and computing services will increasingly depend on the qualities and capabilities, and the skilful use, of national telecommunications infrastructures. The changes in world financial markets provide a good example. These markets have decentralised from a few, dominant centres to a larger number of smaller ones, spread over a wider geographic area, and competing intensely. Much of this change has been brought about by the opportunities offered by new, international telecommunications services, and even the longest-established centres are increasingly recognising that they will lose their position unless they have available the most up-to-date telecommunications equipment, services and systems. Australia's ambitions to increase its importance as a financial centre in the south-east Asian region need to be seen against this background.

1.3 Telecommunications is also assuming greater importance as an element of international competitiveness through the increasing convergence of information technologies. Computing, data storage and handling, and communications are all becoming increasingly interdependent. There are now few natural barriers to the international flow of information by use of telecommunications, particularly with the growth in numbers and capacities of communications satellites and submarine cables. Data processing, computing services and associated control over acquisition, storage and access to information will all increasingly become the subject of competition among nations. Clearly, there are implications for both the economic well-being, and independence of any nation which cannot compete in this area.

1.4 These sorts of competitive pressures based on the quality of nations' telecommunications networks are being increased by recent trends in national and international regulation and standardisation. Deregulation has increased the opportunities for competition, in both services and products. This has been reinforced by the requirements for standardisation and compatibility across nations of networks.

1.5 All these changes can be seen not only as a challenge, but also as an opportunity. The range of equipment, systems or services available to be installed in, or connected to, the network has broadened significantly. While increasing technological complexity has raised the barriers to entry in areas such as major switching systems, there are substantial opportunities in more specialist markets.
Specialist network test equipment, terminal equipment, value-added services (such as videotex, data bases, and electronic funds transfer) and related equipment, local area networks, equipment for private networks and software associated with all of these are some examples. Smaller firms in Australia and overseas have made international successes in a number of these specialist areas. The growth and increasing diversity of possible services can only enhance these opportunities.

1.6 All the above general arguments apply to Australia as much as to any other developed nation. ASTEC believes, however, that there are other issues which have particular force in Australia.

1.7 Australia's level of dependence on telecommunications technology from abroad is inordinately high. Against some measures, Australia's performance is the worst in the developed world. This level of dependence represents a real economic threat to Australia, and means that, although Australia maintains a world-quality telecommunications service, opportunities for participation in world telecommunications product markets are being missed.

1.8 On the other hand, the telecommunications system and services provided to Australia by Telecom, OTC Australia and (in future) AUSSAT collectively make up one of Australia's largest and most valuable national assets, with revenues of over $A5.1 billion in 1984-85[3] and high growth rates. This size, and the range of skills they hold, make the service providers together comparable with substantial international firms. The companies and commissions making up this complex are also largely controlled by the Commonwealth government, thereby offering the opportunity (recognising other demands on the service providers) of developing a national initiative to improve Australian performance and competitiveness in a major area of industry and technology.

2 Problems to be Overcome

2.1 Australia's performance in international telecommunications product markets can be greatly improved, if certain barriers can be overcome. A co-ordinated, national effort should be mounted, bringing together the substantial expertise in telecommunications technology, industry and management in Australia.

2.2 One major difficulty limiting the further development of the Australian telecommunication industry is the lack of a mechanism to develop into valuable products the many ideas originating in various research laboratories and elsewhere. Telecom Australia, and various other laboratories and agencies have produced or identified new pieces of equipment or service technology which, if commercially evaluated, further developed and produced, may have had substantial market impacts. However, it is rare to see these ideas taken further. The organisations in which they originate often have neither the capability or the inclination to do so, or may be prevented from doing so by the specific roles given to them by government. It is encouraging that, more recently there have been some exceptions to this rule, for example the current joint Telecom Australia-L.M. Ericsson Pty Ltd development of a digital rural exchange. There are, however, many other areas of potential value to Australia where seemingly promising developments are unlikely to be further exploited. Network test equipment and development of satellite terminals suitable for use in developing countries are two examples. Naturally, it should not be expected that all such
inventions will be commercial successes. What is lacking, however, is a mechanism to evaluate whether they will or not, then to take them to the stage where they can be tested for technological and commercial competitiveness, and finally to manufacture and market them where profitable opportunities are found to exist.

2.3 Another major problem in Australia's performance in telecommunications is in knowledge of international markets. Most of the larger Australian-based manufacturers of telecommunications products, whether subsidiaries of multinational firms or indigenous, survive to a great extent on supply of their products to Telecom Australia, which takes some 75% of the output of the industry. As a result, there has been an inward-looking attitude on the part of these manufacturers, who show little interest in substantial research, product development and international marketing. Expertise in exploration, evaluation and consequent exploitation of international markets is lacking in Australian firms. It may exist in the parent companies of multinational subsidiaries located here, but there is little evidence that positive use is made of it in Australia, even if it is available to the subsidiaries.

2.4 The final issue which needs to be mentioned in relation to the state of Australian telecommunications technology is the perceived effect of various Telecom Australia policies and practices on the environment for innovation in the Australian telecommunications industry. Telecom, through its size and dominant position both as a purchaser and a setter of regulations, specifications and attachment policies, has enormous influence on all aspects of the Australian telecommunications product industry. Telecom's policies and practices have developed over the years to meet the wide range of demands made on the organisation. The basis of these policies is essentially the need for Telecom to conduct its business so as to protect the public interest, to be fair and equitable to all parties involved, and to provide and maintain services efficiently and economically. The observation and criticism has frequently been made that these same policies, whatever their original intention, have tended to reduce opportunities for product development within Australia in a number of ways.

2.5 Purchasing practices are seen by some as not providing sufficient incentive for local development or sufficiently encouraging local design, as are Telecom's monopoly rights in some equipment markets, (not least by placing Telecom in a position of potential conflict of interest as both the approving authority and a competitive supplier of the same products). Telecom, on the other hand, has noted the recent substantial moves to deregulation of terminal markets, and changes in its purchasing policies intended to increase local design and development.

3 Product Development and Service Provision

3.1 If Australia is to have a capability for development of telecommunications products which can compete on local and world markets, it needs to take advantage of the technological expertise and awareness of international developments resident in the major Australian service providers. The service providers alone possess the awareness of international telecommunications technology and industry necessary to apprehend adequately the range of technological and market prospects available for new products.
3.2 There would also be advantages to the service providers themselves in being involved in product development. Arrangements overseas, involving co-operation, joint R&D, and other joint ventures between service providers and product developers, have greatly encouraged innovation and new standards of quality in both services and products. A link with product development encourages service providers to anticipate new opportunities, and put them to use in the provision of new or better services.

3.3 To date, Australian service providers have survived well as competent and well-informed purchasers and operators of technology without any strong, direct link to product development. ASTEC believes, however, that this situation is unlikely to continue, particularly given the declining local content in telecommunications equipment provided to the network. Telecom itself has recognised the need for greater local product development, in its own interest. ASTEC would go further and say that the greatest overall benefit will be achieved if Telecom, and other service providers, themselves contribute to an increased Australian effort in product development in a commercially cost-effective way.

4 Difficulties with Product Development by Service Providers

4.1 The Australian service providers are not currently involved with internal product development to any great degree. Some items of network test equipment are currently produced on the scale of a "few-off" for internal use, and there has recently been the notable, and highly commendable initiative of a joint Telecom-L. M. Ericsson Pty Ltd development of a rural exchange. On the whole, however, the service providers, controlled by government, are subject to a wide range of pressures on their priorities for investment and action. Product development is risky and expensive, and needs to proceed at a significant level of investment of resources if it is to produce worthwhile commercial returns. There are also questions of conflict of interest should service providers themselves undertake product development.

4.2 Telecom Australia, in particular, is already simultaneously the technical approving authority for terminal equipment attached to the network, and a marketer of such equipment. It also needs to maintain its independence as a buyer of network equipment. This would be jeopardised by any commercial relationship with firms providing that equipment. These activities would only become increasingly subject to conflicts of interest if Telecom were to undertake product development itself.

5 Capabilities of Australian Industry

5.1 ASTEC's study of telecommunications R&D, and technological capabilities, in Australia has included extensive visits to, and consultation with, Australian and foreign-owned equipment manufacturing firms. There has also been considerable discussion with observers of the Australian industry. The Australian industry can be considered broadly as made up of three types of firms.
5.2 Subsidiaries of large, multi-national equipment suppliers, which mainly manufacture in Australia in order to meet Telecom's "local manufacture" rules. Firms in this category have mounted competent Australian manufacturing operations, to meet Telecom's stringent quality, price and local content requirements. They do not generally invest heavily in R&D in Australia, mainly concentrating on adaptive design to meet particular Telecom requirements and local conditions.

5.3 There is a small number of medium-sized Australian-owned firms, who demonstrate different degrees of innovation, ranging from original R&D, through adaptive design, to importation of equipment with minimal modification to meet local conditions. The overall level of innovative activity is not high, and only occasional attempts are made to seek out and exploit international markets.

5.4 Finally, there is a larger number of small Australian firms interested in using the latest technology available to them to produce original products, systems or services for export or specialist local markets. They often support this more original work with sales of imported, or locally-produced lines of more standard equipment.

5.5 Overall, the current indigenous technological capacity of Australian industry to develop products for international markets is not great. The larger, overseas-subsidiary firms rely on manufacturing in Australia based on technology developed overseas by their parent companies; those Australian firms of medium size make reasonable R&D efforts, but lack international marketing skills. Smaller firms, while making a creditable effort in using the latest technology and actively seeking export markets, face problems due to their small size and the need to concentrate on highly specialised and vulnerable "niche" markets. It is ASTEC's view that the Australian industry, in its present state, cannot be expected by itself to meet the challenges and opportunities which advances in telecommunications technology provide.

6 A National Initiative in Product Development and Marketing

6.1 A co-ordinated, national effort is required to address the problems inhibiting development of a more vigorous, export-oriented telecommunications product development industry. A better and more co-ordinated use needs to be made of Australia's considerable, but currently fragmented, resources in this area. This may be achieved by the simultaneous application of three principal groups of initiatives, involving establishment of an export-oriented product development and marketing organisation, government incentives for industrial research, development and manufacture, and a fresh look at relevant Telecom policies and practices.

A Proposal for an Australian Telecommunications Product Development Company

6.2 Without in any way advocating any reduction in assistance which should be given to Australian owned companies or joint venture companies in developing their business activities both within Australia and with products for export, ASTEC believes there is a clear opportunity for a new initiative to operate in Australia in the field of product development and marketing.
6.3 At present, Australian resources committed to telecommunications, concentrate on the provision of services and their R&D efforts are directed almost exclusively to that end. It is recognised that that statement is not true for the increasing number of small entrepreneurial companies but it holds good for the large organisations which are generally government-owned.

6.4 The opportunity exists for the formation of a new free-standing company with shareholders that could include the principal service providers (Telecom, OTC, AUSSAT), and those Australian companies wishing to participate. This company's aims should be determined by the initial shareholders, but should concentrate on the development and marketing (both locally and internationally) of products derived from indigenous R&D. ASTEC believes that a company structure is more appropriate than other possibilities (for example, a government trading corporation or statutory authority), in order:

- to provide a commercial/industrial solution to a commercial/industrial problem;
- to allow maximum freedom of operation, unconstrained by regulation other than that normally applying to corporate enterprises;
- to ensure that the company would not have unfair advantages over other firms operating in Australia, through any subsidy, guarantee of continuity, or special access to government which could apply to a statutory authority;
- to ensure that, by staying at some distance from the day-to-day operations of its shareholders among the service providers, it does not downgrade the quality and efficiency of the services they provide.

6.5 ASTEC does not intend to specify in any detail the size, equity structure, functions or methods of operation of the proposed company, except to say that fundamental to its concept is that it be not only free standing, but operationally entirely independent of its shareholders. The shareholders would deal with the new company as they see fit in their own interests. They would not be precluded from making their own arrangements with other parts of industry for development, manufacture and marketing of results arising within their own organisations, where they believe that it is in their own best interests to do so. Any transfer of technology, research results, etc from any shareholder to the proposed company would be at the shareholder's wish, and on a commercial basis.

6.6 The establishment of such a company represents the most practical, flexible and market-oriented way to overcome the problems of the Australian telecommunications product industry. The key features for its success will be:

- its size, sufficient to allow it to have a substantial effect on the Australian industry and to become established and effective quickly;
- the goodwill of its shareholders in setting its objectives and directions;
- the expertise, skills and entrepreneurship it can gather together, to allow it to operate as effectively and profitably as possible;
its freedom from any government or bureaucratic restriction or regulation (other than those normally applying to corporate enterprises), to allow its management to base decisions as far as possible on purely commercial criteria; and

its "arm's length" relationship with service providers and other product developers and manufacturers, to ensure no special favours or treatment, so that success or otherwise in the market is the true measure of the company's performance.

ASTEC believes that only these factors, in combination, can provide an adequate stimulus to the current condition of the Australian industry; without all of them operating together, any new approach will fail through lack of some crucial component or function. Such a company represents the mechanism which draws them together in the most effective and potentially successful fashion.

6.7 ASTEC has discussed this proposal for an Australian telecommunications product development company extensively with the Australian service providers and equipment manufacturers, and has involved financial institutions. This included a meeting of invited parties (see Appendix F) at which there was sufficient interest shown by participants to warrant further investigation. Through this meeting, the proposal for the product development company has been moved forward to the point of consideration of its commercial viability. These practical matters are essentially for resolution among those who may wish to invest in the company. The immediate role for Government may be that of ensuring that no barriers are placed in the way of the service providers' investing in the proposed company, should they decide that it is in their own interests to do so.

Government Assistance to the Telecommunications Equipment Industry

6.8 The Australian telecommunications equipment industry has recently been examined and reported on by the Industries Assistance Commission (IAC). The IAC's report covers all equipment of interest to ASTEC's study. The IAC has recommended that, for all equipment apart from data modems and multiplexers, tariff protection should be reduced from 35% to 20%. Modems and multiplexers should attract a value-added bounty of 25%. In doing so, the IAC recognised the pervasive influence of telecommunications services, and the convergence of telecommunications and data processing, requiring similar levels of assistance to both industries to avoid problems of substitution.

6.9 The Government has largely accepted these recommendations, agreeing to reduce tariffs to 20% over a four year period, and to replace tariffs on modems and multiplexers with bounties. The Government has also announced that it will, in consultation with industry, develop a package of industry development measures, aimed at addressing industry issues such as:

- the relatively small size of Australian companies;
- insufficient commitment to local research and development;
- fragmented market efforts; and
- restrictive regulatory procedures which act as a disincetive to growth.
This is to be done through improved co-ordination of existing government activities, particularly in the areas of government purchasing, offsets, technology programs, regulation and trade strategies[4].

6.10 ASTEC supports both the aims and the proposed mechanisms of the government’s industry development strategy, as such a strategy will help overcome many of the environmental factors inhibiting greater indigenous technology and product development. The strategy is also likely to be particularly effective in promotion of research and indigenous technology in combination with the government’s tax incentive for research and development. It would also provide precisely the sort of climate conducive to the success of the product development company mentioned above. The prospects of success of the industry development strategy will be enhanced if its development involves the fullest consultation with all relevant industry interests, including the service providers.

ASTEC recommends:
That the government continue with its proposal to develop an integrated development strategy for the Australian telecommunications equipment industry, in full consultation with industry interests and service providers.

Telecom Australia Policies

6.11 The effects of Telecom Australia purchasing, attachment and regulatory policies on the environment for innovation in the Australian telecommunications equipment industry have been mentioned above. Changes to these policies and practices which allowed readier access to the network for new products and services, which removed Telecom’s conflict of interest in being both the approving authority for, and a competitive supplier of, some products and which maximised considerations of local research, development and design in purchasing decisions, would all contribute to stimulation of Australian innovation. Such changes would have to be balanced against their costs to Telecom itself, to the efficiency, quality and coverage of the Australian network and services and to the requirement on Telecom to conduct its business in a commercially responsible fashion. ASTEC therefore does not propose major changes to Telecom’s legislation and a reorientation of its charter in order to bring about a more innovative environment for product development. ASTEC notes the steps Telecom has already taken in this direction, and considers it important that Telecom and the Minister for Communications, in considering further development of Telecom’s policies and practices, give greater attention than hitherto to the impacts of these practices on industrial innovation. Telecom could be assisted in this if its Research Laboratories were to take a more active part in informing other parts of the Commission of the impact of current and intended Telecom practices on innovation in Australian industry. Telecom’s user groups and the various high-technology equipment manufacturers can also contribute to this process of information sharing if appropriate channels for communications between parties with interests in the telecommunications industry are encouraged and actively used. In making these suggestions, ASTEC is seeking to encourage policy changes which lead to an overall growth in innovation in the Australian telecommunications product industry, not merely some selective redistribution from those who benefit from current practices, to those who see themselves as excluded from such benefits.
6.12 Some areas which Telecom Australia and government communications policy makers should consider in moving towards greater stimulation of the industry include:

- greater co-operation between Telecom and local industry in joint development of products prior to Telecom decisions on purchase of those products; the proposed new communications product development company could play a key role in this activity;
- greater advance notice by Telecom to the local industry of its network development plans and equipment needs, to allow local industry the opportunity to compete more effectively for Telecom orders;
- maximising the opportunities for small firms to compete for smaller orders by Telecom;
- increased recognition of the national importance (as well as importance to Telecom) of increased local intellectual content, and amendment of practices to reflect this;
- greater flexibility by Telecom in entering into commercial undertakings for local product development, without going to public tender;
- greater recognition by Telecom of the need for rapid consideration of proposals from industry for the attachment of innovative new technology to the network; and
- a separation of Telecom's regulatory and equipment marketing roles.

ASTEC recommends:

That Telecom Australia and the Minister for Communications give greater attention to the effect on innovation in the Australian telecommunications equipment industry of Telecom's purchasing, attachment and regulatory policies and practices especially at times when these policies or practices are under review.

7 Research and Development in Telecommunications

The Telecom Australia Research Laboratories

7.1 ASTEC's review of the Telecom Research Laboratories has included tours of inspection of the Laboratories, discussion of issues with staff and senior management, and gathering of views on the Laboratories' work from informed observers outside Telecom.

7.2 The Research Laboratories are responsible for research in, and awareness of, new science and technology. This is then used to enable Telecom to formulate and implement policies for the introduction of advances in science and engineering, and to solve problems requiring application of science and technology. It is ASTEC's view that the Laboratories discharge their role well, and are well attuned to the scientific and technological needs of Telecom as a
service provider. This is achieved through a well-developed and carefully-implemented program of research, development and innovation of which the Research Laboratories are an integral part.

7.3 ASTEC does not propose any substantial changes to the role of Telecom’s Research Laboratories, or their relationship to other parts of Telecom. The comments listed below are for consideration by Telecom as possible starting points in further improving the effectiveness of the Research Laboratories:

1. **Flexibility.** Telecom is formally free of public-service central co-ordinating agencies in setting its personnel structures, financial management arrangements, and conditions for overseas travel. However, largely for industrial relations reasons, arrangements and conditions in these areas are aligned with those of the Commonwealth public service. In ASTEC’s view, some of the arrangements currently applying in the Laboratories are unsuited to the most effective performance of research, and can even represent false economies. The Laboratories could function more effectively, and with at least the same degree of efficiency in use of resources as at present, if this alignment were relaxed. Telecom should investigate ways in which to implement a more flexible environment for research in the Laboratories, particularly in staff classifications and conditions for overseas travel.

2. **Interaction between the Laboratories and other parts of Telecom.** Awareness and appropriate use of new technology is already a key part of planning and development of communications networks, and can be expected to become increasingly important. Telecom needs to ensure that the most effective possible use is made of the valuable scientific and technical expertise within its Laboratories. This is already largely achieved by the research, development and innovation program, but increased interchange of staff at senior levels between the Laboratories and other parts of Telecom would enhance this process. Increased representation of Laboratories’ staff on appropriate planning, network development and other bodies within Telecom would also help ensure the necessary awareness of new science and technology in these vital Telecom functions.

ASTEC recommends:

That Telecom Australia consider ways to increase the flexibility of operation of its Research Laboratories, and interaction between the Laboratories and other parts of Telecom.

Other Issues in Research and Development

7.4 **Basic Research in Telecommunications.** ASTEC has been impressed by much of the basic telecommunications research being conducted in various Australian laboratories, including investigations of fundamental, “enabling” technologies. This work is, however, currently scattered over a number of government, higher education and other laboratories, and covers a wide range of subject-matter areas. A greater degree of co-ordination and concentration would increase the likelihood of both significant scientific advances, and consequent future economic benefits. This is not to suggest that basic telecommunications research should be rigidly centralised and controlled; rather, an
attempt should be made to survey current Australian efforts and to identify areas of greatest potential scientific and economic benefit. This could then lead to a proposal for some form of centre of concentration in a selected, key area, bringing together the research currently being conducted in different institutions. ASTEC believes that the Australian Telecommunications and Electronics Research Board would be an appropriate body to undertake this survey, and to report to Government on its scientific and economic prospects.

7.5 R&D contracting. ASTEC welcomes the recent initiative of the Overseas Telecommunications Commission (Australia) to establish a Research and Development Board, and to devote 1% of the Commission's turnover to R&D contracting through the Board. ASTEC sees such initiatives by service providers as valuable to research in other sectors, and indeed necessary to the providers themselves if they are to remain aware of, and capable in, the ever more complex telecommunications technologies, products and services. ASTEC encourages all service providers to increase their interactions with other R&D-performing sectors, especially through the mechanism of contracting R&D.

7.6 Education. ASTEC's investigations and consideration of submissions received as part of the preparation of this report have revealed that the supply of graduate skills to conduct research and product development in government and industry, while satisfactory in quality, is barely adequate in numbers. Moreover, there has been a substantial fall-off in recent years in the numbers of higher-degree graduates in telecommunications-related disciplines. Any increase in industrial research and development activity, as is believed necessary by ASTEC, will obviously place severe strains on the availability of research skills. This question is best addressed through greater interaction between the users of tertiary education research and research skills, and the education institutions themselves. Through such interaction, including funding by service providers and industry of research projects, studentships and fellowships, the supply of suitable skills can be improved.

ASTEC recommends:

(a) That the Australian Telecommunications and Electronics Research Board examine, and report to the Government on, areas of basic research and new technology in telecommunications which might be increasingly supported for national scientific and economic benefit.

(b) That telecommunications service providers and equipment industry consider ways to increase their R&D interactions with other performers of R&D, particularly through contracting out of R&D to industry and tertiary education, and the funding of scholarships and fellowships in disciplines where supply of skills falls, or is likely to fall, short of needs.
APPENDIX A

BACKGROUND TO THE STUDY

A.1 On 24 July 1984, the Prime Minister wrote to the Chairman of ASTEC, agreeing to an ASTEC proposal that the Council undertake a study of telecommunications research and development in Australia covering, inter alia, the following terms of reference:

- the nature and extent of telecommunications research and development in the public and private sectors in Australia;
- the degree of dependence of Australia's present and future telecommunications on imported technologies, and opportunities for the development and export of Australian technology; and
- the present and future roles of the Telecom Research Department, its capabilities and scale of operations, and the research and development inter-relations between Telecom (including its Research Department) and other relevant bodies.

A.2 Telecommunications, for the purposes of this study, is defined as any means of communicating at a distance by means of electromagnetic signals. This encompasses public and private telecommunications networks, broadcasting, cable television, mobile radio systems, and some security systems. The services carried on these networks and systems and the equipment making up, or attached to, them, are also considered. This study encompasses the research and technology associated with building, maintaining and upgrading networks and systems providing services (particularly new services) and providing the equipment which is either incorporated into networks/systems, or attached to them. In so doing, the study has necessarily touched on relevant government communications and industry policies, where these affect Australia's performance in telecommunications research, development and technology.

Other Relevant Studies

A.3 Telecommunications is one of the most significant of Australian economic activities, both in itself and as a basis for other economic activities, such as finance and commerce, involving the need for substantial amounts of instantaneous or near-instantaneous information transfer. As such, telecommunications activities and related technologies attract considerable attention from governments and policy-makers. Some of the recent reports to government which have touched on telecommunications, and which have been studied by ASTEC in preparing this report, include:

- the report "Cable and Subscription Television Services for Australia" (August 1982) prepared by the Australian Broadcasting Tribunal, examined the provision of cable television services and in particular the cable infrastructure as it related to present and future developments in
the telecommunications network. The government did not take up the report's recommendation to proceed with cable television.

the Report of the Committee of Inquiry into Telecommunications Services in Australia, October 1982 (the "Davidson Report"). The report was commissioned in 1981 to examine and report on possibilities for wider private-sector involvement in provision of services, and any consequential changes in the functions, etc. of the Australian Telecommunications Commission. The Committee made a large number of recommendations, covering networks, terminal equipment, services, manufacturing, Telecom's operational policies and effectiveness, and implementation of its recommendations. These recommendations, and the broad thrust of the Davidson report, were rejected by the Government in 1983.

the Report of the Inquiry into Commonwealth Laboratories, November 1983 (the "Ross Report"). This report covered work in Commonwealth technical and service research laboratories. It was commissioned by the government in March 1982. It recommended that ASTEC undertake an external review of the effectiveness, interactions and future roles, capabilities and scale of operations of the Telecom Australia Research Laboratories. Following discussions with Telecom and the Department of Communications, this was eventually translated into the third term of reference above.

the report "Information Technology in Australia, Capabilities and Opportunities", July 1984 (the "Scott-Little Report"). This report was commissioned by the then Department of Science and Technology in association with other departments. It was undertaken by the consultant firm of W.D. Scott Pty Ltd, in association with Arthur D. Little Inc. The report drew very broad, general conclusions across a wide range of information technologies and associated industries (including telecommunications), and presented an 'IT Strategy for Australia' in terms of actions, capabilities and opportunities. This is currently being considered by the government.

the Industries Assistance Commission Report, "Telecommunications and Related Equipment and Parts", October 1984. This report was prepared in response to a reference from government in November 1983, which asked the Commission to report on whether assistance should be provided to the industry concerned with the production of telecommunications and related equipment and parts. The IAC's report makes recommendations concerning the structure of tariffs and bounties to assist the industry, and is currently under consideration by the government.

ASTEC and its technological change committee have also produced a number of report on related topics. These include microelectronics, videotex, and forthcoming reports on electronic funds transfer and office automation.

A.4 ASTEC also sought submissions on the subjects within its terms of reference for this study, from a wide range of interested government, industry and academic organisations and individuals. Twenty-four submissions were received, and a brief analysis of the issues they raise is at Appendix E.
APPENDIX B

WORLD TELECOMMUNICATIONS

Service and Equipment Industries

B.1 The telecommunications industry is one of the world's largest, and also one of the most fundamentally important, due to the infrastructure role it plays in the economic, industrial and social well-being of every country. There were over 500 million telephones in use in 1982, about 85% of them in the OECD countries[1]. The revenues of the telecommunications service providers in 1982 totalled $US150 billion, growing at about 12% per annum (and so may have reached over $US200 billion by 1985)[1]. Investment in telecommunications networks in 1982 was $US60 billion, typically representing 10% of the value of the network[1], and from 0.4% to 0.9% of GDP for most developed countries[5]. These figures are for public telecommunications networks only, and do not include the various private networks which, due to various technological and regulatory changes, are growing more rapidly than public networks. The world market for telecommunications equipment, including public network, data transmission and business communications equipment was $US55 Billion in 1982, and is expected to exceed $US100 billion by 1992[2].

B.2 As well as these substantial rates of growth, several other factors have worked together in recent years to transform the telecommunications industry. In many developed nations, the market for basic telephone services has become saturated, and service providers have been looking elsewhere for growth opportunities. Advances in fundamental technologies, particularly in satellite communications, microelectronics, transmission media and new materials have provided opportunities for a greatly enhanced range and penetration of services; at the same time, the information technologies, including telecommunications, computing, business systems and data storage have all converged, creating new opportunities for the provision of services and equipment. Business and commercial users have simultaneously demanded a wider range of services, particularly as the information sector has assumed greater importance in developed economies. Finally, there have been government and legal developments in the regulation of telecommunications services, the relationships between service providers and equipment manufacturers, and the ownership of service-providing agencies.

B.3 All these changes have been so substantial, and their consequences so complex, that they cannot be summarised here. Some of the consequences of particular importance for this study are outlined below.

B.4 Service providers, and the equipment manufacturers who supply them, face a constant challenge to meet growing and changing market demands through selection and implementation of rapidly changing technologies. Research and development plays a central role in meeting these challenges, and massive investments in R&D are being made.
B.5 The increased availability and scope of telecommunications services has profoundly affected the operations, efficiency and competitiveness of the information-intensive industries, including finance, commerce and computing services. Firms in these industries have become much more open to competition, including international competition, and now rely crucially on the latest in telecommunications equipment and services to maintain their competitive positions.

B.6 With regulatory changes, shifting relationships between service providers and equipment suppliers, and in some cases the "privatisation" of service providers, markets for telecommunications equipment have become increasingly open to competition, particularly international competition. Equipment manufacturers are seeking to improve their export performance, either to compensate for the loss of guaranteed domestic markets, or to exploit emerging export opportunities, or both.

B.7 Changes in technology, and the growth in scope of services and equipment, have affected the barriers to entry to the various telecommunications product markets. In some areas, such as major public switching and transmission systems, increasing complexity of the technology has raised these barriers, with even the largest firms needing to combine to produce new generations of switching equipment. In many other areas, however, the growing diversity of products has opened up great opportunities for smaller firms or industries to enter valuable markets. A variety of terminal attachments and network test equipment, satellite terminals and software fall into this category.

Research and Development

B.8 There is no readily available figure for total world research and development expenditure in telecommunications. Some notional idea can be obtained from supposing that (as seems to be the practice in a number of OECD countries) service providers spend about 1 to 2% of revenues on R&D, and equipment manufacturers about 8 to 10%. This, together with the figures of paragraph B.1, suggest that world telecommunications R&D is of the order of $US7 to 9 billion in 1985. Certainly, it is not uncommon for a major equipment manufacturer to sustain R&D of the order of a few hundred million dollars per year. These figures are for service providers and telecommunications equipment manufacturers only, and neglect the major contributions to telecommunications research made by research in areas such as defence and space.

B.9 R&D by service providers has as its primary role the development of the network and the services it provides. Service providers undertake research to enable specification of equipment, and to ensure that such equipment can be effectively integrated into the network. There is thus a strong interdependence at the research level between service providers and equipment manufacturers. This is further reinforced by factors such as the market structure of the equipment industry, the rising costs of R&D in some areas, and the important role of fundamental research in telecommunications R&D. All these factors combine to make it necessary, in countries with a vigorous, innovative equipment industry, for mutual R&D interaction between service providers and equipment manufacturers.

B.10 The strong role of strategic basic research, the convergence of many different technologies and the large numbers of contributors to the research effort make it impossible to summarise easily the scope of R&D in telecommunications. In general, about 10% of budgets for R&D in service providers and equipment manufacturers go into fundamental research, "enabling" technologies or "capability
research", and the remainder into applied research or product development. Research efforts by service providers and equipment manufacturers are typically large (see B.8 above) and closely tied to the business of those organisations, typically by highly ordered processes of research program selection, justification and monitoring. So wide is the range of potential areas for research that even the largest research organisations are now finding it necessary to specialise in particular areas of potential value.

Demand and Trade in Telecommunications Products

B.11 Table B.1 shows imports and export figures for telecommunications products for OECD nations in 1980[6], and the shares of imports and exports in domestic consumption and production[5]. These figures show a range of trade patterns among OECD nations. Most of the major producer nations (Belgium, France, Germany, Japan, Netherlands, Sweden and the United Kingdom) have significantly positive trade balances, and overall there is a positive balance of trade of about $8 Billion per annum between the OECD nations and the rest of the world. The other three major producers (Canada, Italy and the USA) have trade balances ranging from just above even to moderately negative, although the negative result for the USA is negligible when compared with domestic production or consumption. Among the positive balance of trade countries, Sweden, and to a lesser extent Belgium and the Netherlands are interesting for their high export orientation coupled with small domestic markets, demonstrating willingness to allow external competition within their markets and to compete (successfully) on world markets. There is relatively little information available on the countries with substantial trade deficits, but it should be noted that they are all among the smaller and/or less developed OECD economies. Australia's performance is characterised by the second-worst of all ratios of exports to imports; moderate levels of imports and low exports; and the worst of all recorded shares of exports to domestic production. This indicates an essentially inward-looking domestic manufacturing industry, interested only in servicing domestic requirements within tariff and other barriers to imports.
Table B.1

OECD Nations - Trade in Telecommunications Products 1980
($US million)

<table>
<thead>
<tr>
<th>Country</th>
<th>Imports</th>
<th>Exports</th>
<th>Exports Imports (%)</th>
<th>Share of Imports in Domestic Consumption (%) (1975)</th>
<th>Share of Exports in Domestic Production (%) (1975)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>246</td>
<td>40</td>
<td>16</td>
<td>14(a)</td>
<td>3(a)</td>
</tr>
<tr>
<td>Austria</td>
<td>255</td>
<td>100</td>
<td>39</td>
<td>40</td>
<td>30.8</td>
</tr>
<tr>
<td>Belgium/Luxembourg</td>
<td>515</td>
<td>725</td>
<td>141</td>
<td>32.8</td>
<td>49.2</td>
</tr>
<tr>
<td>Canada</td>
<td>760</td>
<td>691</td>
<td>91</td>
<td>17.2</td>
<td>15.2</td>
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<tr>
<td>Finland</td>
<td>136</td>
<td>78</td>
<td>57</td>
<td>-</td>
<td>-</td>
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<tr>
<td>France</td>
<td>781</td>
<td>1154</td>
<td>148</td>
<td>4.6</td>
<td>12.1</td>
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<tr>
<td>Germany</td>
<td>1204</td>
<td>2222</td>
<td>185</td>
<td>3.5</td>
<td>13.7</td>
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<tr>
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<td>122</td>
<td>18</td>
<td>15</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Italy</td>
<td>593</td>
<td>596</td>
<td>101</td>
<td>8.9</td>
<td>9.3</td>
</tr>
<tr>
<td>Japan</td>
<td>209</td>
<td>3772</td>
<td>1805</td>
<td>1.4</td>
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<tr>
<td>Netherlands</td>
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</tr>
<tr>
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<td>6</td>
<td>18</td>
<td>-</td>
<td>-</td>
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<tr>
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<td>199</td>
<td>115</td>
<td>58</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Portugal</td>
<td>81</td>
<td>31</td>
<td>38</td>
<td>31.5</td>
<td>14.1</td>
</tr>
<tr>
<td>Spain</td>
<td>282</td>
<td>115</td>
<td>58</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Sweden</td>
<td>233</td>
<td>993</td>
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<td>83.4</td>
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<td>250</td>
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<td>114</td>
<td>-</td>
<td>-</td>
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<tr>
<td>UK</td>
<td>778</td>
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<td>159</td>
<td>8.5</td>
<td>13.9</td>
</tr>
<tr>
<td>USA</td>
<td>3212</td>
<td>2655</td>
<td>83</td>
<td>1.7</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Note: (a) From IAC report "Telecommunications and Related Equipment and Parts" AGPS, Canberra, 1984
APPENDIX C

AUSTRALIAN TELECOMMUNICATIONS

Service Provision

C.1 Public telecommunications services in Australia are provided by the Australian Telecommunications Commission (Telecom Australia) which is responsible for the domestic public network, and the Overseas Telecommunications Commission (Australia), responsible for international telecommunications traffic. Australia's first domestic communications satellite, to be operated by AUSSAT Pty Ltd, was launched in 1985. As in other nations, there has also been rapid growth in recent years in private telecommunications networks, including those used by news agencies and State governments. Growth in numbers of service providers, and in competition between them, will increase with the advent of the domestic communications satellite.

C.2 Both domestic and international telecommunications traffic are growing strongly, with consequent increases in the revenues of the service providers. Telecom's 1984-85 revenue was $4.76 billion, an increase of 12.9% over the previous year. In the same period, OTC's revenue reached $412 million, a growth of 21.4%. In 1984-85, the telephone traffic of Telecom and OTC grew by 5.9% and 19.1% respectively[3] Following international trends, the service providers are making large capital expenditures involving new technologies such as digital switching and optical fibres to expand the range of services available to private and business users. These include videotex, electronic funds transfer and the interconnection of computing networks for financial transactions and other uses. The long-term aim of the public service providers is for the provision of an Integrated Services Digital Network which will provide voice, text, data and graphics communication capability over a single network and with a single point of access by the user.

C.3 ASTEC has discussed the available services provided, and their technological status with the providers themselves, their suppliers and their users in Australia, and with informed international observers. From these views, and its own observations, ASTEC is satisfied that the public service providers are, at present, as close to the forefront of available telecommunications technology as could reasonably be expected, especially recognising Australia's demographic and geographic characteristics and the wide range of demands on the service providers. Whether this position relative to the technology can be retained in the future depends, in ASTEC's view, on the technological capabilities of both the service providers themselves and the equipment industry which supplies them.

Equipment Industry

C.4 As in all other nations, the nature of the Australian telecommunications equipment industry is closely linked with the needs and demands of the service providers, particularly Telecom Australia. Telecom's purchasing policies have been responsible for the continued presence in Australia of an Australian
communications equipment manufacturing industry. This industry is dominated by the provision of equipment to Telecom, which takes some 75% of the industry's output.

C.5 Most of the production of the local industry is accounted for by seven firms, only one of which, Amalgamated Wireless (A'Asia) Limited, is fully Australian-owned. The remainder are subsidiaries of foreign-based firms. All but one of these firms are heavily oriented to the needs of Telecom Australia, providing about 80% of the equipment for extension of the Australian telecommunications network. This includes switching equipment (currently changing from electromechanical to digital technology), line transmission equipment (with optical fibres being introduced), mobile telephones, standard and supplementary telephone handsets, modems and multiplexers, and other more specialised terminal equipment. The exception is Philips Industries Holdings Limited, which is 25% Australian owned, does not have Telecom as its dominant customer, and is responsible for about half of Australia's exports of telecommunications equipment.[7]

C.6 The standard of technology associated with this manufacture for Telecom is high (for the type of equipment produced), as it must be to meet Telecom's requirements of quality and cost. There is, however, little emphasis among the suppliers to Telecom on substantial product innovation. Most R&D by these firms is aimed at adaptive design of foreign-sourced technology, to meet Telecom specifications and local conditions. Similarly, there is little emphasis on exports, with only 3% of local production going to export. This should be compared with the overall figure for Australian manufacturers of 14%, itself low by OECD standards. R&D by the local industry as a whole averaged 3.6% of sales in 1982-83, about half the 1976 commitment[7].

C.7 As well as these larger suppliers to Telecom, there is also a number of smaller manufacturers, mostly Australian-owned, with some specialising in "niche" markets for high-technology products, either for sale to Telecom or to private networks or export. Such firms generally demonstrate reasonably high growth rates, re-investment of substantial amounts of revenue in R&D, and substantial export orientation. The markets they supply, however, can be volatile, highly competitive, and vulnerable to the entry of other suppliers with improved or more up-to-date products. These small firms therefore rely on continuing investment in innovation, and actively seeking out of specialised markets, in order to survive and grow.

Research and Development

C.8 R&D in telecommunications in Australia is undertaken in government establishments, facilities associated with higher education and industry. Precise figures on amounts of expenditure on R&D in recent years are difficult to obtain, as some telecommunications R&D (for example in the Defence Science and Technology Organisation) is collected and published under social and economic end-use classifications other than "communications".

C.9 Table C.1 presents such figures as are readily identifiable on R&D in telecommunications in Australia for the period 1976-77 to 1983-84. Notable features are the dominance of Telecom Australia (discussed in detail elsewhere in this report), the declining effort of industry as a proportion of sales, and the small, scattered efforts of other government and higher education organisations.
C.10 Table C.2 provides a notional estimate of the direction of identifiable telecommunications R&D expenditure in 1981-82, based on certain assumptions regarding objectives of research by various performers. Again, the dominance of the service providers, and of research aimed at improving the network rather than development of products, is evident.

C.11 The principal government support mechanisms for non-government telecommunications R&D in Australia are:

- the Australian Telecommunications and Electronics Research Board (formerly the Radio Research Board) which provided $307,000 in 1984-85, mainly for project research in higher education institutions; the Australian Computer Research Board also distributes a proportion of its $150,000 per annum funding for computer research, to projects related to communications;

- the Australian Industrial R&D Incentives Board which operates an incentive scheme to encourage industrial R&D in all sectors of Australian manufacturing industry; its support of telecommunications R&D in 1983-84 is estimated at $2.5 million;

- the Australian Research Grants Scheme funds research on the basis of the excellence of their researcher and project; its 1984 funding included 5 projects, valued at $85,000 under the category of Communications Systems;

- contracting of R&D from government (principally service providers) to industry and higher education to a value of $1.8 million in 1983-84; a recent initiative by OTC (A) to set up an R&D Board, to contract 1% of Commission revenue to R&D in industry and higher education, should be noted; and

- the recently-announced 150% tax premium for industrial R&D expenditures, to operate initially in 1985-86.

C.12 Comparisons between Australian R&D and that of other nations are hard to draw, due to lack of data and different systems of service provision, equipment manufacture and structuring of research efforts. Nonetheless, there is no doubt that, compared to other nations, Australia's performance in industrial R&D in telecommunications, particularly with the objective of product development, is poor. This is not unexpected, given the industry's concentration on adaptive design, lack of export orientation, and low level of product innovation.

**Principal Australian Performers of R&D in Telecommunications**

C.13 The work of the Telecom Australia Research Laboratories, which is by far the largest performer of telecommunications R&D in Australia, is described in Appendix D. Other major performers of R&D, and examples of R&D topics, are described below.

C.14 The Defence Science and Technology Organisation (DSTO) conducts research, development, trials and evaluation relevant to defence requirements. Telecommunications-related research is carried out primarily at two DSTO establishments – Electronics Research Laboratory and Advanced Engineering
Laboratory, both situated at Salisbury in South Australia. This work is undertaken to meet Australian defence needs, and generally results in the development of products or systems whose potential markets are different from those for civilian telecommunications products.

C.15 At the Electronics Research Laboratory, telecommunications R&D is conducted by the Radar and Electronic Warfare Divisions, with some contributions from the Optoelectronics Division. Substantial work is conducted in the following fields, which affect communications at a distance:

- radio propagation from Very Low Frequency (VLF) to millimetre waves, including the monitoring of the ionosphere for over-the-horizon radar;
- infra-red and optical propagation through the atmosphere at various angles; and
- performance and design of antenna systems over a wide range of radio frequencies.

C.16 The Advanced Engineering Laboratory's Communications Systems Engineering Group is responsible for most of the telecommunications work carried out by this Laboratory. Some relevant work is also done in other groups. Work on fibre optics is being done in the Laboratory's Underwater Systems Engineering Group due to its applications to hydrophone arrays and acoustic sensors. Work by the Communications Systems Engineering Group includes:

- the development of a Small Automatic Message Switch for use by the Army in the field;
- the enhancement of HF Radio Communications, especially with respect to:
  - ionospheric sounding and real time channel evaluation;
  - frequency management;
  - digital modem evaluation;
  - short and medium range communication; and
  - manmade background noise measurements.
- secure communications;
- satellite communications;
- dual band antenna feeds at ultra high frequency and super high frequency;
- propagation at super high frequency in the presence of rain; and
- consultations on communications for the Services, currently related to:
- the Parakeet Project - an integrated secure field trunk digital communications systems for Army and joint forces, providing voice, telegraph, data and facsimile services;

- the Raven Project - single channel radio system to be deployed in combat applications, for Army, RAN and RAAF;

- super high frequency broadband radio; and

- orbital positions and frequencies for satellites.

C.17 Other telecommunications research in the Advanced Engineering Laboratory includes:

- optical fibre transmission and sensor technology;
- signal processing;
- digital electronics techniques;
- electronics circuit and component design;
- electronics equipment fabrication; and
- quality assurance.

C.18 CSIRO conducts communications research in the Divisions of Radiophysics and Applied Physics, and the former Division of Computing Research (recently split into the CSIRONET computer network and the new Division of Information Technology). The Division of Radiophysics conducts research on signal processing techniques, antenna design (including communications antennae), and microwave circuits and components. The Division has particular strengths in antenna feed design, and has developed significant links with Australian industry. The Division of Applied Physics is responsible, in its National Measurement Laboratory, for maintenance of standards of time and frequency, which provide reference sources for local industry and others. The (former) Division of Computing Research conducts research on computer communications, including provision of interfaces to host computers, terminals and peripherals, development of national and international standards, and production of hardware and software. These activities involve collaboration with other CSIRO divisions, Telecom Research Laboratories, industry and a State government agency.

C.19 Telecommunications research is conducted in a number of tertiary education bodies, with the effort tending to be small-scale, and scattered across a wide range of topics and institutions. No overall summary of this effort is readily obtainable, but some significant initiatives should be noted. The Microwave Technology Development Centre (MITEC) at the University of Queensland is a national centre for the design and development of practical microwave components based on the latest microwave technology. It was established in 1980, and in 1983-84 had a staff of five, and expenditure of $225,000. The Centre is run on commercial lines, with strong interaction with industry, and intends to become self-supporting on projects income in 1984-85. Significant projects include a solid state power amplifier (for an antenna/terminal manufacturer), a communication link (Department of Defence), communications systems and repeaters.
(manufacturer and news service), antennae (television station and news service), and a variety of microwave components for other industrial and government users. Particularly notable is MITEC's development of a microwave system for the AAP-Reuter news service, for use on the services' private network in conjunction with the AUSSAT satellite system.

C.20 The Department of Communications and Electronic Engineering at the Royal Melbourne Institute of Technology has 28 full-time academic staff, 17 support staff, and 600 students including 30 post-graduates. The Department has a Microelectronics Technology Centre which conducts work in, among other things, VLSI design for digital circuitry, telecommunications switching, and optical/microelectronic device fabrication and circuit layout. More recently, a Centre for Industrial Microelectronic Applications has been formed. These Centres, and other activities by the Department, are aimed at increasing interaction with industry and government agencies in accordance with the applied research emphasis prevalent in institutes of technology.

C.21 Industrial research and development in telecommunications in Australia covers a wide range of telecommunications systems, and has a strong emphasis on product development, and adaptive design to meet Australian conditions and/or the requirements of telecommunications service providers and users. It is not possible to summarise the work of all firms involved in telecommunications R&D, but some representative examples are:

- Amalgamated Wireless (Asia) Limited spent about $7.5 million on development of telecommunications equipment in 1983-84. Areas of work include optical fibre communications, solid state devices, digital communications, antennas and propagation.

- Philips Industries Holdings Ltd undertakes research on data transmission, traffic controls, private automatic branch exchanges (PABX), mobile radio systems and rural telephone networks, and associated work on materials and components.

- Standard Telephones and Cables Pty Ltd conducts R&D on analog and digital public and private PABX equipment and systems, packet switching, optical communications and digital microwave systems. Eighty-five professional staff were employed in 1983.

- Codan Pty Ltd conducts R&D on high-frequency radio systems and equipment, and two-way ground terminals for satellite communications; about 6% of company turnover is devoted to R&D.

- Scitech Corporation Pty Ltd undertakes work on statistical and time-division data multiplexers for private communications networks. About $2 million, or 17% of sales, was spent on R&D in 1984, ranging from routine product improvement through new product development to more exploratory work.

Dependence of Australian Telecommunications on Imported Technologies

C.22 Dependence on imported technology can be measured in a variety of ways, for example through reference to foreign ownership and control, levels of R&D in Australia compared with that in other nations, and statistics on trade in
actual products and in technology. However, as the Industries Assistance Commission has noted, data on the Australian telecommunications industry is poor, due to confidentiality of much of the Australian Bureau of Statistics (ABS) data as a result of small numbers of manufacturers in each category. Moreover, the ABS has only recently produced statistics on foreign ownership and control of Australian manufacturing industry for the first time since 1972/73 and updated ABS data on foreign control of R&D in private enterprises will not appear until early 1987. As against these difficulties, there has been some study of Australia's dependence on foreign technology, for the Commonwealth legislative research service[8]. The results of this study contain much information on the dependence of Australian manufacturing on imported technology, and in some places separately identifies communications products, or industry categories which include communications products.

C.23 ABS statistics for 1982/83 indicate that 34.6% of Australian manufacturing (in terms of value added) was foreign controlled, little changed from 10 years ago. For those (unfortunately broad) industry categories which include communications equipment, foreign ownership and control figures are shown in Table C.1.

<table>
<thead>
<tr>
<th>Industry Category</th>
<th>No. Firms</th>
<th>Foreign Control (%)</th>
<th>Value Added $m</th>
<th>Foreign Ownership (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronic Equipment n.e.c</td>
<td>239</td>
<td>12.6</td>
<td>473.1</td>
<td>60.3</td>
</tr>
<tr>
<td>Electric and Telephone cable and wire</td>
<td>29</td>
<td>51.7</td>
<td>169.5</td>
<td>70.6</td>
</tr>
</tbody>
</table>

Source: Australian Bureau of Statistics

Foreign ownership and control, at least in terms of value added, is substantially higher in these industries than for Australian manufacturing as a whole.

C.24 With more specific reference to telecommunications products, the IAC has noted the extent of foreign ownership and control of the telecommunications equipment and parts industry in its recent report[6]. Seven firms account for most of the production of the goods studied by the IAC, and six of these firms
are subsidiaries of multinational telecommunications equipment manufacturers. Telecom's submission to the IAC inquiry estimated that

of the total business generated in the supply of telecommunications equipment for extension of the Australian telecommunications network...about 80% is handled by Australian subsidiaries of overseas companies.[7]

C.25 R&D is a good indicator of technological dependence, and its rate of change can be used to forecast, broadly, what is likely to happen to future levels of dependence. Again, due to the nature and method of collection of official statistics, the ABS figures do not separately identify R&D in communications equipment, which is lumped in to much broader product categories. Estimated total Australian R&D expenditure on telecommunications are given in Table C.2.

C.26 As an indicator of technological dependence, the level of indigenous R&D might be broadly compared with total world R&D. As mentioned in Appendix B above, world telecommunications R&D expenditure in 1985 is of the order of $US7 to 9 billion.

C.27 Future levels of dependence on imported technology might be indicated by trends in today's levels of R&D. In this context, it is disturbing to note that, in Telecom Australia, R&D as a proportion of revenue has declined slowly, but steadily over the period 1980-82 to 1984-85. Similarly, the IAC report on telecommunications equipment notes that R&D as a percentage of turnover among member companies of the Australian Electronics Industry Association has declined from an average of 7.5% of annual sales in 1976, to an average of 3.6% in 1982-83[7]. From observations made in the course of preparing this report, it seems that, if anything, major overseas service and equipment providers are increasing their R&D in order to explore, and make best competitive use of, the new communications technologies.

C.28 The ABS produces regular figures, as part of its R&D series, on payments and receipts for technical know-how by business enterprises in Australia. In the industry classification 'photographic, professional and scientific equipment and appliances and electrical equipment' which includes most communications equipment and also much else, for 1981-82, payments within Australia totalled $190,000, while payments made overseas totalled $11,476,000. Further, $8,842,000 of the grand total of $11,666,000 was paid to "related enterprises", that is companies in some way connected with those firms making the payments. Thus, roughly 75% of Australia's payments for technical know-how went to overseas companies related to local firms, most likely in a parent-subsidiary relationship; overall, more than 98% of technical know-how purchased by Australian firms came from overseas. Receipts for technical know-how to Australian firms for this industry classification in 1981-82 were $1.3 million.

C.29 Data available from the USA Office of Technology Assessment has been used to calculate"indices of revealed comparative advantage in invention" across several countries and product-groups, for the period 1970-79. This index is calculated by dividing a country's share in the total patents (in the USA) of a given product field by its share in the total patents in all product fields, and expressing the results in index number form. By this method, raw patent data are normalized for disparities in country size, and relative rather than absolute patent performances are highlighted. A figure of more than 100 shows a comparative advantage, while less than 100 reveals a comparative disadvantage. Table C.3
Table C.2
Research and Development in Telecommunications in Australia
1976-77 to 1983-84
($ million, current prices)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>COMMONWEALTH</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telecom</td>
<td>26.6</td>
<td>27.2</td>
<td>36.3</td>
<td>39.8</td>
<td>42.6</td>
<td>41.8</td>
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<tr>
<td>OTC (Australia)</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.4</td>
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<td>0.5</td>
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<tr>
<td>AUSSAT</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>1.6</td>
<td></td>
<td></td>
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<tr>
<td>Aust. Broadcasting Corporation</td>
<td>0.11</td>
<td>0.15</td>
<td>0.12</td>
<td>0.18</td>
<td>0.04</td>
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<tr>
<td>Aust. Broadcasting Tribunal</td>
<td>0.12</td>
<td>0.10</td>
<td>0.34</td>
<td>0.19</td>
<td>0.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSIRO (a)</td>
<td>1.96</td>
<td>2.02</td>
<td>1.48</td>
<td>1.03</td>
<td>1.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dept. of Defence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HIGHER EDUCATION</td>
<td>1.2</td>
<td>2.2</td>
<td>3.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Man-years</td>
<td>90.0</td>
<td>127.0</td>
<td>143.0</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>INDUSTRY</td>
<td>6.4</td>
<td>13.7</td>
<td>15.4</td>
<td>18.5</td>
<td></td>
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<tr>
<td>% of sales</td>
<td>7.5</td>
<td>4.3</td>
<td>2.6</td>
<td>3.6</td>
<td></td>
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</tbody>
</table>

Sources: Commonwealth Science and Technology Statement 1984-85
Higher Education Australian Bureau of Statistics, Catalogue No.8111.0
Industry IAC Report, Telecommunications and Related Equipment and parts

Notes: Blanks indicate lack of information, rather than zero entries
(a) Estimate by ASTEC
(b) No figure available; could be of the order of $3 million per annum
Table C.3
Indices of Revealed Comparative Advantage in Invention, 1970-79

<table>
<thead>
<tr>
<th>Product</th>
<th>Australia</th>
<th>Belgium</th>
<th>Canada</th>
<th>France</th>
<th>Germany</th>
<th>Italy</th>
<th>Japan</th>
<th>Netherlands</th>
<th>Switzerland</th>
<th>Sweden</th>
<th>United Kingdom</th>
</tr>
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<tr>
<td>Food products</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Textile products</td>
<td>119</td>
<td>84</td>
<td>100</td>
<td>74</td>
<td>54</td>
<td>82</td>
<td>160</td>
<td>190</td>
<td>101</td>
<td>85</td>
<td>89</td>
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<tr>
<td>Basic industrial chemistry</td>
<td>111</td>
<td>109</td>
<td>58</td>
<td>86</td>
<td>143</td>
<td>103</td>
<td>101</td>
<td>62</td>
<td>197</td>
<td>84</td>
<td>141</td>
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<tr>
<td>Plastics &amp; synthetic resins</td>
<td>70</td>
<td>136</td>
<td>73</td>
<td>124</td>
<td>150</td>
<td>164</td>
<td>102</td>
<td>114</td>
<td>252</td>
<td>38</td>
<td>108</td>
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<tr>
<td>Agricultural chemicals</td>
<td>86</td>
<td>150</td>
<td>57</td>
<td>85</td>
<td>138</td>
<td>149</td>
<td>152</td>
<td>96</td>
<td>88</td>
<td>277</td>
<td>94</td>
</tr>
<tr>
<td>Drugs &amp; medicines</td>
<td>115</td>
<td>112</td>
<td>70</td>
<td>170</td>
<td>135</td>
<td>152</td>
<td>130</td>
<td>81</td>
<td>271</td>
<td>84</td>
<td>150</td>
</tr>
<tr>
<td>Stone, clay, glass &amp; concrete</td>
<td>96</td>
<td>130</td>
<td>88</td>
<td>179</td>
<td>140</td>
<td>191</td>
<td>100</td>
<td>105</td>
<td>267</td>
<td>102</td>
<td>144</td>
</tr>
<tr>
<td>Primary metals</td>
<td>122</td>
<td>142</td>
<td>95</td>
<td>94</td>
<td>81</td>
<td>66</td>
<td>91</td>
<td>90</td>
<td>52</td>
<td>132</td>
<td>123</td>
</tr>
<tr>
<td>Fabricated metal products</td>
<td>163</td>
<td>158</td>
<td>161</td>
<td>126</td>
<td>100</td>
<td>100</td>
<td>130</td>
<td>74</td>
<td>89</td>
<td>191</td>
<td>114</td>
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<td>Farm &amp; garden machinery</td>
<td>130</td>
<td>81</td>
<td>122</td>
<td>90</td>
<td>81</td>
<td>78</td>
<td>64</td>
<td>77</td>
<td>72</td>
<td>133</td>
<td>95</td>
</tr>
<tr>
<td>Construction, mining &amp; material handling equipment</td>
<td>224</td>
<td>81</td>
<td>150</td>
<td>86</td>
<td>71</td>
<td>74</td>
<td>32</td>
<td>128</td>
<td>105</td>
<td>134</td>
<td>84</td>
</tr>
<tr>
<td>Metal working machinery &amp; equipment</td>
<td>136</td>
<td>77</td>
<td>94</td>
<td>101</td>
<td>122</td>
<td>110</td>
<td>79</td>
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<td>General industrial machinery</td>
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<td>99</td>
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<td>112</td>
<td>77</td>
<td>77</td>
<td>85</td>
<td>168</td>
<td>111</td>
</tr>
<tr>
<td>Electrical equipment except communications</td>
<td>61</td>
<td>53</td>
<td>91</td>
<td>99</td>
<td>90</td>
<td>88</td>
<td>100</td>
<td>122</td>
<td>81</td>
<td>95</td>
<td>102</td>
</tr>
<tr>
<td>Communications equipment &amp; electronic components</td>
<td>49</td>
<td>63</td>
<td>80</td>
<td>111</td>
<td>71</td>
<td>63</td>
<td>142</td>
<td>212</td>
<td>50</td>
<td>62</td>
<td>96</td>
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<tr>
<td>Transport equipment</td>
<td>97</td>
<td>58</td>
<td>107</td>
<td>127</td>
<td>118</td>
<td>76</td>
<td>92</td>
<td>54</td>
<td>52</td>
<td>125</td>
<td>124</td>
</tr>
<tr>
<td>Professional &amp; scientific instruments</td>
<td>107</td>
<td>175</td>
<td>67</td>
<td>83</td>
<td>92</td>
<td>62</td>
<td>136</td>
<td>74</td>
<td>93</td>
<td>94</td>
<td>90</td>
</tr>
</tbody>
</table>

shows the results of this calculation. Australia's performance in Communications equipment and electronic components is one of the poorest in the whole table, and is simultaneously the worst for Australia for any product group, and the worst of any developed country for the telecommunications product group.

C.30 OECD trade statistics have been analysed to provide information on imports and exports by the OECD countries of telecommunications equipment and parts in 1980. Appendix B discussed the results of this analysis, and as with many of the other measures above, Australia's export-import performance is one of the worst of all OECD countries, with an absolute trade deficit of $US206 million, and an export-to-import ratio of 0.16. More recent trade statistics show that this ratio has declined further, reaching 0.11 by 1983-84. (see Table C.4)

Table C.4
Australian Trade in Telecommunications Equipment
1979-80 to 1983-84

<table>
<thead>
<tr>
<th>Year</th>
<th>Imports ($ million)</th>
<th>Exports</th>
<th>Exports/Imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979-80</td>
<td>246</td>
<td>40</td>
<td>0.16</td>
</tr>
<tr>
<td>1980-81</td>
<td>247</td>
<td>35</td>
<td>0.14</td>
</tr>
<tr>
<td>1981-82</td>
<td>334</td>
<td>36</td>
<td>0.11</td>
</tr>
<tr>
<td>1982-83</td>
<td>370</td>
<td>68</td>
<td>0.18</td>
</tr>
<tr>
<td>1983-84</td>
<td>410</td>
<td>46</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Source: Derived from ABS Statistics

C.31 On all the above measures, Australia's dependence on imported technology in telecommunications is high, and indeed among the highest in all OECD countries. Further, given the trends in performance of R&D and trade, this dependence is likely to increase. These results are neither surprising nor controversial, and have been widely recognised, including by the IAC and Telecom. Given the importance of telecommunications products and technology to other industries and the balance of trade, they are, however, very disturbing. Finally, it should be noted that the above figures on dependence apply to telecommunications equipment. The situation regarding components is even more serious, as almost all components used to manufacture telecommunications equipment in Australia are imported.
APPENDIX D

THE TELECOM AUSTRALIA RESEARCH LABORATORIES

Role

D.1 Telecom Australia's Research Laboratories are an integral part of
Telecom, and are a key component of the Commission's organisation-wide program
of Research, Development and Innovation (RDI). The objectives of the
Laboratories are to:

. ensure that Telecom has available the necessary advice in relevant
fields of science and technology;

. provide expert participation in the formulation and implementation of
policies for the introduction of advances in science and engineering
relevant to Telecom Australia; and

. provide services to Telecom for solution of problems requiring the
application of specialised scientific and technological skills and
experience.

D.2 All these objectives require the Laboratories to endeavour to maintain a
position at the forefront of knowledge in communications science and technology,
which it undertakes by programs of basic and applied research, investigations into
developing technologies, maintenance of specialist resources to ensure that all
work is conducted with appropriate scientific and technical competence, and liaison
with other research establishments in Australia and overseas.

Research, Development and Innovation Program

D.3 Most of the investigations and problem-solving undertaken by
Laboratories' staff in the engineering and scientific disciplines are encompassed by
an annual corporate consultative process which yields a rolling 3-year Programme
of Research, Development and Innovation (RDI). The RDI Programme includes all
technical research, development and design activity performed throughout Telecom
which could lead to innovation in any of the customer services provided by
Telecom Australia or in the network systems and operational practices employed
by Telecom to provide these services.

D.4 By this process, 90% of the work of the Laboratories is determined and
co-ordinated with work performed elsewhere in Telecom, thereby ensuring that the
work is relevant to the priority needs of Telecom. The remaining 10% of the
Laboratories' work concerns the application of the Commission's technical and
scientific reference standards, technical information services and industrial
property consultancy.

D.5 While Telecom's RDI program determines 90% of the Laboratories' work, the work of the Laboratories makes up only about 27% of RDI. The total
size of the RDI program was about 1000 man-years in 1983-84[9], and, apart from
the Laboratories. RDI work is conducted in Telecom's Engineering and Commercial Services Departments, and State administrations. This non-research RDI work encompasses introduction of new equipment (including adaptation for local conditions) and enhancement of existing equipment for both terminals and the network. This can involve development of new installation techniques, trials of prototype plant, and modification of equipment design to improve performance or capabilities. Non-research RDI work is outside the scope of the current study.

D.6 The RDI program, from which flows most of the work of the Laboratories, is drawn up by a continuing process of interaction among those Branches, Departments and Directorates within Telecom with either the need for, or capabilities to contribute to, RDI. The process is co-ordinated by the Design Co-ordination Secretariat of the Headquarters Engineering Department, and considered by Telecom's RDI Select Committee under the oversight of the Chief General Manager. This process of interaction and co-ordination is intended to ensure that priorities are set appropriately, that levels of tasks are within available resources, and that all affected parts of Telecom (including, of course, the Research Laboratories) have a say in the scope and incidence of the program.

Resources and Research

D.7 The Research Laboratories have a staff of about 500, of which about 180 are professional engineers or scientists, 70 with postgraduate qualifications. The total resources devoted to the Laboratories for 1983-84 was $28 million, or about 0.7% of Telecom's revenue. The Laboratories work principally in well-equipped accommodation in Clayton, Victoria, and conduct a variety of field trials as necessary. In 1982-83, test equipment and facilities of the Laboratories was valued at $8 million, and $2 million worth of equipment (about 7% of total resources) was purchased in that year. The other major items of expenditure were salaries (about 50% of total costs) and consumables/laboratory costs (about 20%).

D.8 Research performed in accordance with the Laboratories' objectives and the RDI program covers a wide range of telecommunications problems and technologies, and includes work on:

Customer Services and Networks, including

- Human factors in communications and psychological research of individual and group behaviour in human communications
- Teleconferencing services
- Loudness ratings in telephone performance measurement
- Voice encoding, synthesis and analysis techniques
- Networking aspects of telematic services and computer-based messaging services
- Multi-service business communications networks
- Interworking of telecommunications services and networks

33
Studies related to the ISO/CCITT Reference Model of Open Systems Interconnection

Customer access protocols in the evolution of the integrated services digital network (ISDN) concept.

Switching and Signalling Systems, including

- Data communication standards
- Formal description techniques for communications protocols
- Circuit and packet switching techniques and networks for voice, data and other services
- Studies of the CCITT Common Channel Signalling System No.7
- Network interfaces, signalling techniques and control protocols in the evolution of an ISDN
- Traffic engineering, network and exchange dimensioning techniques for circuit and packet switched networks
- Software design methodologies and architectures for stored program controlled switching systems.
- Remote subscriber switching techniques and systems

Transmission Systems, including

- Transmission performance objectives for digital networks
- Digital transmission techniques in an ISDN local distribution network
- Synchronisation of digital networks
- Coherent/heterodyne optical transmission systems
- Transmission performance measurement techniques for single and multi-mode optical fibre transmission systems
- Cellular radiocommunications techniques and systems
- Microwave radio and optical fibre digital transmission systems for trunk, junction and local network applications
- Microwave radiocommunications system antennas
- Fading effects and channel parameters affecting digital radio transmission performance
- Multipath phenomena and rain attenuation effects in terrestrial and satellite radiocommunications system design
- Wideband services networks
Local area networks

Materials Science and Fundamental Technology including:

- Cost-effective custom logic circuit design techniques
- Microprocessor development systems in instrumentation
- Advanced optical fibre materials and optical devices
- Non-linear optical phenomena
- Growth of advanced, specialised semiconductors by molecular beam epitaxy
- Sputter-etching of microstrip components
- Thick and thin film circuit realisation techniques
- Polymer formulation and stabilisation for internal and external plant applications
- Physical, chemical and metallurgical properties of materials, components, etc., affecting service reliability of telecommunications plant
- Energy technologies for telecommunications
- Lead-acid battery design and performance evaluation
- Protection of users and plant from hazards due to lightning strikes and high induced voltages
- Service failure assessment of semiconductor devices and other components used in telecommunications plant
- Electromagnetic compatibility of telecommunications equipment and systems

Work on these topics ranges from quite long-term, basic research on emerging technologies, through to highly directed, short-term problem solving in response to problems more or less as they arise. Table D.1 summarises the Research Laboratories' involvement in the RDI program in 1983-84, showing principal areas of research, timescales, and types of research.

Interactions

D.9 The Research Laboratories maintain an extensive range of external contacts in connection with their work. These cover other government agencies, higher education, industry and overseas contacts. Some of Teleecom's interaction methods include:

- contracting R&D to industry through either significant procurement contracts or specific R&D contracts;
directly commissioning R&D in higher education through specific R&D contracts and indirectly through participation in the Australian Telecommunications and Electronics Research Board and the Australian Computer Research Board;

where appropriate to a particular topic, obtaining access to the special expertise/facilities of other research institutions (eg. CSIRO) through contracts or less formal agreements to collaborate in R&D, in the interests of work co-ordination and efficient resource-sharing;

operation of a Study Assistance Scheme which, inter alia, provides opportunities for selected staff to undertake postgraduate research or to gain work experience in local/overseas universities/industry. Telecom staff also undertake investigatory/consultative visits to overseas R&D institutions, telecommunications administrations and industry to stay aware of world developments;

provision, in special instances, for consultant visits by world experts in particular topics or for guest/exchange workers to work for periods in the Research Laboratories and elsewhere in the organisation;

through the significant involvement in international standardisation bodies impinging on telecommunications engaging in occasional R&D studies involving collaboration in field trials of new techniques or system specifications with overseas organisations such as British Telecom, Bell Canada and others.

D.10 The informal communications network which exists between groups of R&D workers in specialist disciplines ensures that some degree of continuing but informal interaction occurs in R&D. This type of indirect interaction occurs through publication of reports and papers; participation in the activities of learned societies, seminars and conferences; participation of research managers from Government and industry in the work of university faculty councils; consultations arising from commercial relationships, between Telecom and the Australian telecommunications industry; and joint participation by Government and industry research organisations in the activities of national bodies such as the Standards Association of Australia, and international bodies such as the International Telecommunications Union.

D.11 All of the above mechanisms contribute to a general "national awareness" among R&D workers in telecommunications of current R&D in various organisations and research sectors.

Contracting out of R&D

D.12 In 1984-85, Telecom's Research Laboratories will make payments of about $1.4 million against about 50 R&D contracts with Australian industry and higher education. About 20 of these are with industry, for about $800,000, and the rest with higher education. While this level of contracting has grown over the past few years, it is still small, and a typical industry contract is for the equivalent of about one man-year of work. In addition to this direct R&D contracting, there is an adaptive design component of Telecom procurement contracts of about $12 million per annum. This includes such projects as the joint Telecom-Ericsson development of a digital rural exchange.
Factors taken into account by the Research Laboratories in deciding whether to let R&D to contract, or to perform it internally, include:

1. R&D contracting is seen as a supplement to, and not a replacement for, Telecom's own R&D effort, and must be matched to Telecom's real needs;

2. Telecom must scale its program of R&D contracts to match budgets, and as importantly, to match the manpower and skills available to manage and assimilate the technical aspects of R&D contracts;

3. While many universities are content to receive a "part-payment" from Telecom as the contract price, as their overheads are met from other sources, industry often seeks payment on a "cost plus" basis. In some cases industry have also contributed additional resources of their own to meet the contract. Typical contract prices per annum are currently about $20,000 per university contract, compared with up to $100,000 for an industry contract;

4. Unless industry sees a continuing stream of R&D contracts being maintained by Telecom, it is reluctant to build up the necessary R&D staff and facilities; unless Telecom can see a need for and program funds for, and manpower to manage, R&D contract programs to the order of perhaps $5 million per annum, it seems that industry will view Telecom's R&D contracts as only an adjunct to their primary commercial objectives, and Telecom will correspondingly be deterred by its failure to attract widespread industry interest in its R&D contracts;

5. The structure, resources and commercial objectives of the Australian telecommunications industry currently appear to lead to some reluctance to take risks in product innovation, unless a local (Telecom) market for the product is assured in the short term. Telecom does not give such guarantees of future markets in the negotiation of R&D contracts in view of its open tendering policies, and is reluctant to tie itself to a single supplier for logistical and commercial reasons.
Table D.1
Summary of Research Laboratories Involvement in Telecom's 1983/84 RDI Program

1. TOTAL RESEARCH MAN-YEARS DIRECTLY ALLOCATED TO RDI = 270 MY
c.f Other HQ man-years allocated to RDI = 520 MY
All states man-years allocated to RDI = 200 MY

Total man-years allocated to RDI 990 MY

Note: Taking into account indirect RDI effort, the Research RDI activity comprises about 90% of total Research activity.

2. DISTRIBUTION OF RESEARCH EFFORT BY:

- Area of Application
- Time of Application

<table>
<thead>
<tr>
<th>Area of Application</th>
<th>% of Total Allocated to area</th>
<th>% of Area by Time of Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Short (0-3 yrs)</td>
</tr>
<tr>
<td>Local Transmission Systems</td>
<td>17%</td>
<td>56%</td>
</tr>
<tr>
<td>Trunk Transmission Systems</td>
<td>10%</td>
<td>44%</td>
</tr>
<tr>
<td>Telephone Terminal Systems</td>
<td>5%</td>
<td>94%</td>
</tr>
<tr>
<td>Telephone Switching Systems</td>
<td>10%</td>
<td>60%</td>
</tr>
<tr>
<td>Record and Data Systems</td>
<td>6%</td>
<td>54%</td>
</tr>
<tr>
<td>Advanced Services and Systems</td>
<td>23%</td>
<td>10%</td>
</tr>
<tr>
<td>Network Management and Services</td>
<td>4%</td>
<td>72%</td>
</tr>
<tr>
<td>Non-Network-Based Technologies and Techniques</td>
<td>25%</td>
<td>40%</td>
</tr>
<tr>
<td>TOTAL (ALL AREAS)</td>
<td>100%</td>
<td>43%</td>
</tr>
</tbody>
</table>
### 3. DISTRIBUTION OF RESEARCH EFFORT IN EACH RDI AREA OF APPLICATION BY RDI GUIDELINE OBJECTIVES

<table>
<thead>
<tr>
<th>Area of Application</th>
<th>RDI Guideline Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Existing Systems and Facilities</td>
</tr>
<tr>
<td>Local Transmission Systems</td>
<td>28%</td>
</tr>
<tr>
<td>Trunk Transmission Systems</td>
<td>7%</td>
</tr>
<tr>
<td>Telephone Terminal Systems</td>
<td>16%</td>
</tr>
<tr>
<td>Telephone Switching Systems</td>
<td>25%</td>
</tr>
<tr>
<td>Record and Data Systems</td>
<td>-</td>
</tr>
<tr>
<td>Advanced Services and Systems</td>
<td>-</td>
</tr>
<tr>
<td>Network Management Services</td>
<td>35%</td>
</tr>
<tr>
<td>Non-Network-Based Technologies and Techniques</td>
<td>40%</td>
</tr>
</tbody>
</table>

| TOTAL (ALL AREAS)         | 21%                       | 26%              | 53%                 |

Source: See [9]
APPENDIX E

SUBMISSIONS TO THE ASTEC STUDY

E.1. As part of its study, ASTEC wrote to a wide range of government, industry, academic, professional and trade-union bodies, seeking their views on the subject matter of the terms of reference of ASTEC's study. Twenty-four submissions of substance were received. Five of these were from Commonwealth government agencies, three from higher education, three from professional associations, two from trade unions, and eleven from business enterprises or industry associations.

E.2. Much of the material in submissions was descriptive, and ASTEC acknowledges the valuable contribution such material has made to the factual parts of its report. Even more valuable in helping ASTEC reach its conclusions, however, was the wide range of views on key issues involved in the study. The major matters dealt with in submissions were:

- the level of dependence of Australian industry on imported technology, the implications of such dependence, and ways in which it might be overcome;
- complementarily, the degree of technological capability of local industry, the value to be gained from an increase in local capabilities, and ways to achieve this;
- government, and particularly Telecom, policies, their effects on the local product industry, and ways in which they could be altered to improve the climate for local industrial research, development, design and innovation;
- potential areas for growth in development of Australian telecommunications products, and mechanisms for stimulating such growth;
- issues in basic research and higher education in telecommunications;
- incentives to increase industrial R&D;
- the role of Telecom's Research Laboratories.

Dependence, and the Capabilities of Australian Industry

E.3. More than half the submissions commented on either Australia's level of dependence on imported technologies, or the capabilities of the local equipment industry. All such submissions noted the dangers of excessive dependence, and the benefits to be gained from a greater local capability in product research, development and design. Suggestions as to ways of achieving this varied widely, including: development of national telecommunications strategies involving education, research, technology and marketing; greater Telecom participation in
product development; formation of a National Telecommunications Manufacturer; accreditation of firms' R&D capabilities; greater R&D interaction between service providers and manufacturers (including R&D contracting and joint ventures); increased support for export of telecommunications products; greater interaction between service providers and users of services; and 'picking winners' in high-technology industries.

Telecom's Influence on the Local Product Market

E.4. Just over half of the submissions made reference to the influence of Telecom's presence as a dominant buyer of equipment, and on the effect of Telecom's purchasing and other policies, on the Australian equipment industry. Strong views were expressed ranging from sweeping criticisms of perceived severely deleterious effects of Telecom policies, to constructive suggestions as to how Telecom policies could be used to improve the climate for innovation. Some typical comments from industry sources on Telecom and its role (slightly modified to preserve confidentiality) are:

1. ...(in general we ) support the concept of a common carrier and by inference the R&D establishment necessary to support that role. (We) look at the grey area between the nodes of communication systems and the end user and by and large would like to take over as much of that area as possible.

It would appear that under an Integrated Systems digital network (ISDN) the common carrier role of Telecom will dictate the interconnection between the user equipment and the communication node (the exchange). If this assumption is correct, then the R&D efforts of the private sector must be in the region of peripherals at the user end (this is the S and T interface of the CCITT recommendation). It would appear that this would be the most fruitful area for both the public and private sectors to:

- work in co-operation
- develop systems in terms of the Australian market
- from the expertise and experience gained from the above to tackle the export of the Australian technology

2. Under the Telecom purchasing policies the local manufacture of Telecommunications equipment is well established an a viable efficient industry exists and this would not and could not have been the case without the Telecom policy of establishing local manufacture. Moreover, a viable manufacturing industry is a stimulus to local R&D activities. R&D activities however are lower than desirable and lower than commensurate with the established level of local manufacture.

It should be remembered that Telecom absorbs some 70% of the local telecommunications industry output, consequently Telecom purchasing and R&D policies exert a very large effect on the local industry....

In overseas countries assistance is provided to the Telecommunications industry through large defence contracts that have spin offs in certain telecommunication developments. Many overseas telecommunications administrations enter into cooperative developments with their local
manufacturers and also purchase their equipment for the indigenous industry at price levels that allow the rapid recovery of the basic R&D costs and provide funds for expansion into other markets, i.e. export.

These necessities, are not enjoyed to the same extent by the local industry, where Telecom policy is to purchase equipment and technology on the world market, and not to enter into any commitment to purchase a product locally designed in accordance with Telecom's own technological forecast and, furthermore not to sponsor any particular development nor to absorb any of the design and development risk in designing a product for the Australian market.....

Australia, on the other hand, whilst making positive moves in terms of financing R&D through the IR&DI act and venture capital management investment companies, retains the very inefficient competitive purchasing system. This forces companies away from co-operation, both within the industry structure and between the three elements of R&D - industry, government and academia. Also, Government purchasing policies do not favour Australian technology and in fact due to the 'lowest price' selection preference in Government purchasing, Australian technology tends to fail as it is cheaper to buy technology than to create it. The greatest weakness associated with Technology purchasing is the export marketing constraints placed on the use of technology.

Telecom Australia in its annual report decries the lack of Australian developed technology, however, the commission has a history of rejecting Australian technology in favour of lower price imported technology development.

3. If our paper makes no other point of value to you, I hope to emphasise one particular matter concerning R&D. That is that the present tendency of Telecom to suddenly enter the terminal product market, with a product that is already being supplied from some other sector of the industry, is counter-productive to private R&D. No company is going to undertake R&D for a new product if that product survives only as long as Telecom allows it to compete. Instances of Telecom entering the market and using its regulatory powers to restrict approval or under-cutting the price of products already on the market, are not uncommon...

Part of the reason for the relatively small amount of private R&D in Australia is thought to be the high percentage of total product sales consumed by Telecom, since its purchasing procedure is to issue specifications for the equipment intended for purchase, thus restricting the benefits to the manufacturer from innovative R&D. More often than not, the standards for using the products on the national telecommunications network, based largely on overseas standards, render the value of producing equipment different from overseas products as minimal. There are some requirements of Telecom, however, which support one or two local manufacturers for a reasonable value of development (such as standard telephone handsets).

Since the benefit of Research and Development must, of necessity, depend on the size of the market and while the telecommunications terminal product market in Australia is authoritatively controlled and not market-driven, considerable growth of local R&D is thought to be unlikely.....
There are good reasons to move towards the liberalisation of the telecommunications terminal market in order to greatly stimulate user demand and the general need for new products. With assistance for the local industry, considerable benefits could accrue to local manufacturers from a freer terminal market. Given this liberalisation, private companies undertaking R&D could do so in the knowledge that their R&D effort could not be nullified by sudden imposition by Telecom of regulatory measures to prevent sale of the product developed. (This does occur at present.)

Opportunities for Growth

E.5. A little less than half the submissions attempted to identify areas where Australia had good prospects to develop or exploit export markets. These ranged widely, and included:

- hardware and systems for cable TV;
- participation in satellites, ground stations and terminal equipment for telecommunications satellite systems;
- antennas for fixed and mobile communications in HF, VHF and microwave bands;
- microwave materials, components and amplifiers;
- various telecommunications technologies (e.g. in switching, transmission etc), suitably modified to operate in Australian conditions or to meet Australian needs, which could then be exported to third-world and other markets, particularly in the Pacific region;
- software connected with any of the above.

Basic Research and Education

E.6. Five submissions dealt explicitly with issues on basic research and education in telecommunications. The general theme was that the quality, and extent, of basic research in this area had decreased in recent years, and that steps should be taken to correct this. The mechanisms most often suggested were establishment of an academic centre of concentration in telecommunications or some telecommunications technology, or increased interaction between government, industry and higher education R&D (usually with the Telecom Research laboratories taking a leading role). With regard to the supply of, and demand for, graduate and post-graduate skills, several agencies noted the fall-off in numbers and/or quality of post graduate students and higher-degree graduates in recent years. The numbers of graduate recruits of quality sufficient to undertake R&D work was seen as barely adequate. Possible remedies for an incipient crisis in the supply of research skills included establishment of a centre of concentration in telecommunications engineering, greater focus of tertiary-education R&D on user needs, and increased use of grants and studentships/fellowships to foster interest and focus research in areas of value. The vital role of industry inputs in setting the course of tertiary education teaching and research was often stressed.
Incentives for Industrial R&D

E.7. Five submissions noted the need for incentives to encourage Australian industrial R&D in telecommunications. These included taxation concessions for R&D, allowance of R&D as part of the offsets program (applying to overseas procurement by Government), Australian content rules, use of the Australian Industrial R&D Incentives Scheme, and additional export incentives for telecommunications products.

Role of the Telecom Research Laboratories

E.8. Only four submissions explicitly addressed the role of Telecom's Research Laboratories. In spite of this small number, views varied widely, from use of the laboratories as a national centre for telecommunications research with a consequent increase in its level of activity and range of research, to explicit and specific exclusion of the Laboratory from any product development activity.
APPENDIX F

WORKING PARTY ACTIVITIES

F.1 The Prime Minister requested ASTEC to undertake a study of telecommunications R&D on 24 July 1984, and a working party of Council members for this purpose was formed in August 1984. The working party consisted of:

Mr L S Zampatti (Convenor)
Professor J H Carver
Mr K H McLeod
Dr P D Jones
Professor G A Rigby

F.2 Secretariat support for the working party was provided by Dr M J Wardrop of the ASTEC Secretariat, and Dr R P Coutts, Section Head, Telecom Australia Research Laboratories. ASTEC wishes to thank Telecom Australia for its kind help in making Dr Coutts' services available, and Dr Coutts for the very substantial contribution he made to the study. Following Dr Wardrop's departure from the ASTEC Secretariat in early 1985, Mr I R Shortt of the Secretariat took over Dr Wardrop's tasks.

F.3 The working party made a number of visits within Australia in preparing this report. Visits were made to:

Amalgamated Wireless (A'asia) Limited
Philips Industries Holdings Ltd
Standard Telephones and Cables Pty Ltd
Codan Pty Ltd
Siemens Industries Ltd
L M Ericsson Pty Ltd
Scitech Corporation Pty Ltd
Overseas Telecommunications Commission (Australia)
AUSSAT Pty Ltd
Australian Telecommunications Commission (Telecom Australia) - four meetings involving senior management and Research Laboratories
Commonwealth Department of Communications
CSIRO Divisions of Radio Physics and Applied Physics
Advanced Engineering Laboratory, Defence Research Centre Salisbury

Professor A Karbowiak, Department of Electrical Engineering, University of New South Wales

Australian Telecommunications Employees Association

F.4 The working party met with senior executives of major overseas telecommunications service providers in November 1984, when they were in Australia for an international conference. They were:

Mr J Alvey, British Telecom
Mr R Fukutomi, Nippon Telegraph and Telephone
Mr H Kunze, Deutsches Bundespost
Mr J Segall, American Telephone and Telegraph

F.5 Secretariat members also visited a range of Australian government, industry and academic representatives on a less formal basis in the course of the study.

F.6 As mentioned in Appendix E, submissions on the subject matter of the working party's terms of reference were solicited from academic, professional, government, industry and trade union bodies as part of the study. Twenty-four substantial submissions were received, and are analysed in Appendix E.

F.7 Mr K H McLeod, working party member, took the opportunity while overseas on other business to visit a field trial for new telecommunications services in Biarritz, France in October 1984 on behalf of the working party.

F.8 Mr I R Shortt and Dr R Coutts made an overseas study tour in February-March 1985 to Canada, the United States of America, the United Kingdom, France and Sweden. Discussions were held with academic, industrial and government research laboratories, government regulatory and technology-development agencies, major telecommunications service providers, equipment manufacturing firms, and industry associations. Visits were also made to the Organisation for Economic Co-operation and Development, Paris, and the International Telecommunications Union, Geneva.

F.9 As mentioned in the text of the report, the proposal in the report for establishment of a product development company was discussed extensively with service providers, industry and other interests. This culminated in a meeting in Melbourne in October 1985 to discuss the proposal. Present at this meeting were:

The Minister for Industry, Technology and Commerce
The Minister for Communications

and representatives of:

ASTEC
Telecom Australia
OTC (Australia)
AUSSAT Pty Ltd
Amalgamated Wireless (A'Asia) Limited
Codan Pty Ltd
J. N. Almgren Pty Ltd
Datacraft (Aust) Pty Ltd
The Australian Industry Development Corporation
NOTES AND REFERENCES


3. (a) Telecom Australia Annual Report 1985, Telecom, Melbourne, 1984


