Department of Communications

Brief to the Senate Special Committee on Science Policy

Presented by the federal Department of Communications, July, 1976.

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Science really creates wealth and opportunity where they did not exist before. For this reason, I believe that the advent of modern science is the most important social event in history.

- R.A. Millikan

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INTRODUCTION

This brief is the concluding volume of a two-part response to a letter from Senator Lamontagne to the Deputy Minister of Communications in which he requested certain information about the research program of the Department and invited comments concerning the recommendations of the Senate Special Committee on Science Policy. The first volume, dealing with the Department's activities in the area of futures research, was submitted by the Minister of Communications on January 21, 1976.

The contents of this volume reflect the results of subsequent discussions between officials of the Department of Communications and members of the Senate Committee staff. It has three related objectives:

1. To present an explanatory overview of the Department's science and technology functions and activities, including their organization, scope and content;
2. To review our experience with the "make or buy" policy;
3. To comment upon the Senate Committee recommendations in the light of the Department's responsibilities for communications research and development.

In preparing this brief, the authors were aware that much of the material in the Senate Committee reports has broad application to the federal government as a whole. However, they have tried to confine their response to those aspects that apply mainly to the DOC and to its mission.

THE DEPARTMENT OF COMMUNICATIONS

DOC came into existence on April 1, 1969. Its creation consolidated a number of components from several departments that had a role in communications to provide a single responsibility for fostering the orderly development and growth of communications in Canada. In the domestic field, this includes the extension of existing telecommunications systems and services to obtain optimum benefits in the short and long terms; the development and introduction of new communications systems, facilities and resources; the management of the radio frequency spectrum to permit the development and growth of radio communications; and the development of telecommunications services for the Government of Canada. In the international field, it means the protection of Canadian interests in international telecommunications systems, services and undertakings. For a general perspective on these various aspects of the DOC functions, it is instructive to consider the size and diversified nature of the Canadian communications services and industry; Appendix 1, based upon available data for 1974, indicates gross annual revenues of the order of 4 billion dollars, or approximately 4% of the Gross National Product.

The 1969 amalgamation of the communications functions formerly under the Ministry of Transport with the communications and radar research and development capabilities that had evolved in the Defence Research Telecommunications Establishment to support military communications has provided a focus for the government's role in communications. Currently the Department is organized into four main groups -- Policy, Space Programs, Research, and Services -- as outlined in Appendix 2.

The bulk of research and development activities falls under the

Space Programs and Research Sectors and most of the associated personnel are located at the Communications Research Centre (CRC) near Ottawa. Currently, the CRC has a scientific and technical staff of some 150 scientists and engineers, supported by about an equal number of technologists and technicians. Details of the Department's budget for scientific activities in each of the last two fiscal years are shown in Appendix 3. As well, the major R&D program areas for the 1975/75 fiscal year are summarized in Appendix 4.

The social science activities of the Department are probably not quite as obvious since they are not concentrated in a separate location such as CRC. Nevertheless, DOC is concerned with society's needs for communications and with the effects of communications on society, as well as with the components, techniques and equipment that make up the various systems and services. The planning of new policies and services, the detailed assessment of social needs, the development of services and systems to match those needs, as well as the analysis of systems by operational research and computer simulations are multi-disciplinary activities. As such, they involve the social and behavioural as well as the physical, environmental and engineering sciences, though the statistical summaries of scientific activities may not represent the proper balance between the different fields. Appendix 3 summarizes the Departmental scientific activities to the extent that they have been identified.

Another way of describing the scope and extent of DOC scientific activities is to look at the scientific output. Appendix 5 shows the number of papers published in the scientific and technical journals and the laboratory reports produced at the Communications Research Centre for each of the past six years. These statistics, by themselves, do not adequately represent the scientific

and technological value of the output since not all papers or reports are of equal significance. By the same token, they do not include three important types of production that cannot conveniently be included here but which could significantly increase the totals: the first includes reports of a policy or proprietary nature and reports where military classified information is involved; the second includes a variety of miscellaneous reportings, such as by letter, memorandum, oral consultations, briefings, etc., which are employed extensively in the R&D work for other branches of DOC and in work for other government departments; and the third includes various ideas, inventions, devices, equipment, and computer software. It is also likely that an appreciation of the productivity in a particular area or program would require a more general overview or case study. Several of the Department's major accomplishments are summarized in more detail in Appendix 6.

THE ROLE OF SCIENCE IN DOC

The Minister of Communications is empowered to promote the establishment, development and efficiency of communications systems and facilities for Canada. As part of this general mandate the Department becomes involved in many matters related to the extension of both broadcasting and point-to-point communications services. This takes the form of determining needs, proposing plans and solutions and, in part, coordinating the plans of other departments and agencies so that the resulting communications configuration provides the needed reliable service to the public by the most economical means. It includes the formulation of technical policy, regulations, procedures, and standards as well as the associated licensing, certification, monitoring and control operations. It also includes a significant research and development activity since communications

and the associated electronic equipment for both terrestrial and satellite systems are in the forefront of a technology where change is exceedingly rapid and investment in exploratory research and systems development by public and private bodies in all industrialized countries is massive.

In Canada there are only two major communications R&D organizations, Bell Northern Research and the Communications Research Centre of the DOC. The DOC Research Sector, as the repository of the public-sector responsibility for communications R&D, is engaged in a variety of scientific and technological functions. These include the conduct of mission-oriented basic and applied research to advance the state of communications and computer-communications science and technology; the conception and evaluation of new and innovative systems and services arising from the application of advanced technologies and the projection of user needs for future services; the development of simulation and other planning tools; the identification, description and evaluation of future user needs with particular emphasis on the social impact of new communications technologies; operations research in support of new services and systems; and the provision of information, advice and research support throughout DOC and for other federal government departments and agencies, as requested by them.

While the foregoing comments are generally valid for all R&D carried out by the Department, satellite communication deserves special mention since it represents a new and major technological thrust in Canada. Because the cost of any satellite system must include large expenditures for launch and for the development and procurement of the spacecraft and ground stations, it has not been possible to develop satellite communications in the incremental fashion in

which many terrestrial systems have been developed. Commercial organizations are not always prepared to support such investments for long-range development because of the risks involved, although the systems are usually operated by commercial or quasi-commercial organizations. This has meant that, in general, governments have directed and supported the long-range development of satellite systems.

In Canada, the Department of Communications has played this latter role and, in recognition of its importance, created a separate Space Sector late in 1974. Telesat Canada operates the domestic communications satellite system and Teleglobe Canada is the operating entity for international satellite communications through Intelsat. In carrying out its responsibilities, the Department has made extensive use of contracts to industry and maintains only sufficient in-house expertise and capability to ensure that projects are developed in keeping with long-range government plans and policies. Indeed, as is described later in this report, it has been DOC practice, even before the adoption of the government "make or buy policy" to emphasize "buy" in all of its scientific activities. Consequently our in-house work in the space field involves principally such activities as the assessment of the suitability and likely performance of new technology for application in space; the definition of the probable nature of future satellite requirements; the identification of critical technical problems affecting satellite communications systems; component or system feasibility studies and demonstrations in speculative or difficult areas; and consultation with, and technology transfer to, industry.

Since satellite communication is a field in which strategies are strongly dependent on technological advances, the conduct of these activities does

require a technically informed core R&D activity with government. This core is particularly concerned with making early judgements regarding the nature of future satellite requirements. In the absence of a well-defined future requirement by government, the development of specific components is often too high a risk for Canadian industry to bear. Given the defined requirements, the development of components and subsystems by industry can proceed in order to prove feasibility in support of long-range planning or to provide hardware for specific programs. This process also gives focus to industrial capability and allows sufficiently rapid response by industry to meet schedule commitments inherent in large satellite programs.

In addition to generating information for long-range planning, the Department's R&D in speculative areas is intended to assist the establishment of commercially viable industrial capabilities which previously did not exist.* Such R&D also provides a technical base for consultation with industry and for the critical assessment of industrial capabilities and developments. Such assessments are essential elements in the development of long-range government and industrial strategies.

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* Some examples are the design of an improved scanning electron microscope which led to the creation of SEMCO, the development of a field-effect transistor amplifier at 12 GHz which was taken over by RCA Ltd., the phased-array antenna development for L-band satellite communications which has been taken over by Canadian Marconi Co., and the development of satellite ground station equipment for the Landsat satellite which involved SED Systems Ltd. and MacDonald, Dettwiler and Associates.

Turning now to some general questions of science policy it is appropriate to consider how the recommendations in the Senate Committee reports might apply to DOC. These reports dealt at some length with basic research: how much is being or should be done and where such activity should be carried out. Within DOC we have seen no requirement for this type of activity, nor are we able to identify in our current programs any basic research, or curiosity-oriented basic research as the Senate Committee termed it, that is being carried on in-house or supported by contract. We therefore hold no strong opinions regarding those recommendations other than to note the importance of this type of activity in the training of scientists, and the implications this must have for the role of the universities in the R&D processes since government departments such as DOC, as well as industry, will want to hire their graduates.

The Department supports a modest amount of mission-oriented basic research, some in-house and some through contracts at Canadian universities (see Appendix 3). Such work is usually closely related to some potential application, is an excellent means of reorienting, updating, and retraining staff in a new area of applied research, and can be a means of capitalizing on the unique expertise or facilities that exist at a university. Considering the small amount of such research undertaken by DOC, and its particular objectives, we do not believe that it can sensibly be handled in any other way. In particular, we do not think that there are any advantages in having this work done at a "national research academy" where it would be much more isolated from the other scientific activities of the mission toward which it is oriented.

There is no firm policy within DOC concerning the percentage of our scientific activities that should be devoted to oriented basic research. For the

current year this category includes only some 3% of our in-house R&D budget, plus perhaps an additional 2% in the form of university research contracts that pertain to both the social and physical sciences. We would note in passing that the Senate Committee recommendations concerning the social sciences did not appear to extend to the mission-oriented or applied activities and that, except in regard to basic research, the reports dealt mainly with the physical sciences. In consequence, we are made much more aware of an industrial productivity perspective than one concerned with science-based services and with the role of R&D for improving the process of social innovation. Apparently, the Committee recognized this imbalance and, in discussing possible future hearings and reports in Volume 3, notes its intention to address this subject in a separate report.

As must be apparent from the preceding description, and as may be seen from the statistics in Appendix 3, most of the DOC science activities are devoted to applied research and experimental development, with approximately 25% being in the former category. In the longer term we expect the balance between the two to shift back and forth somewhat depending on program priorities and requirements. For instance, the past several years have seen a large development activity -- the CTS satellite. With the recent successful launch into orbit of this satellite, the Departmental emphasis will shift somewhat from development activities to applied research while the satellite is employed in the conduct of various communications experiments. Essentially each program and each component of a program -- be it oriented basic research, applied research, or experimental development -- is considered on its merits, and budgeting and approval is based on the program objectives and on the Departmental requirements for that program,

not on the type of science or the type of scientific activity involved. Thus we use science and technology as means to some end, to a defined objective within the DOC mission, rather than as an end in themselves as is often the case with unoriented basic research.

It should be noted that our categorization of the Departmental activities in science has not always been entirely satisfactory since the Frascati Manual* does not include standards for the measurement of research in the social sciences. As is apparent in Appendix 3, the majority of the scientific activities are in the natural sciences and in engineering, where the standards are well established. Accordingly, most of the foregoing discussion pertains to those R&D categories, rather than to our activities in the human sciences.

To a certain extent the pursuit of the primary DOC objectives carries with it an implicit follow-on role for industry in regard to the production, implementation, and promotion of the new systems and services. As well, industry has a role to play in the applied research and experimental development activities through contract work under the "make or buy" policy. In neither case, however, do we have a primary mandate to support Canadian industry in such endeavours; the primary Departmental mission is concerned with communications and the support of industrial productivity is only a secondary consideration. Nevertheless, if the results of our research are to benefit Canada, the Department must be intimately involved with industry and with its problems and needs. DOC scientists and their counterparts in industry must understand and

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* "The Measurement of Scientific and Technical Activities" OECD Document No. DAS/70.40.

appreciate each other's roles and capabilities so that they can work in close cooperation, as a team.

THE LEVEL OF SCIENTIFIC ACTIVITY IN DOC

By nature R&D is forward looking; research to uncover new knowledge for some subsequent application, development to make available systems and services for future use, or studies to elucidate the possible impact of communications on a community are all concerned with the future. One of the most fundamental of all questions is how to allocate sensibly today's resources for R&D toward a future requirement which, at the moment, may be difficult or impossible to define properly. Our present standard of living is directly related to our progress in harnessing the potential benefits of science and technology, and that Canadians have available to them the excellent communications they do is no accident. Certainly, in the case of telecommunications, the healthy state of the Canadian industry is no small measure the result of substantial R&D investments.

In this connection we note that the Senate Committee has advocated a national expenditure on worthwhile R&D that should grow to 2.5% of the GNP by 1980. We are unable to suggest arguments that would lead to any other percentage, and would be happy to see implemented, as a matter of national policy, an objective goal of this sort. However, a 2.5% national average across all sectors, some of which are low in relevant research investment (e.g. road building), some of which are very high (e.g. aircraft or computers), is not particularly meaningful as a yard stick in any one sector. The all-important consideration is the rate of innovation in the associated industry. Communications is a field in which internationally the rate of innovation is very high. Consequently if Canada is to be competitive in the field the Canadian contribution to this process must

be correspondingly high. This necessarily implies an important role for communications R&D, which should probably be maintained at a level somewhat higher than the national average.

Here it might seem desirable to seek some objective criteria that link the research outlays to the revenues and gross productivity in the Canadian telecommunications industry. As discussed previously, and as summarized in Appendix 1, estimates based on available data for 1974 indicate that total annual revenues are of the order of 4 billion dollars, being somewhat greater or smaller depending on whether broadcasting is or is not included. The corresponding R&D expenditures are somewhat more difficult to arrive at, but on the basis of available data for 1974 we have been able to identify annual expenditures in the private sector that total about 70 million dollars, most of which is accounted for by the durable goods manufacturers. However, this figure is probably too low since it appears not to include such factors as R&D in other sectors and in borderline classification cases, hard-to-categorize activities of many small companies and engineering costs of others, and large uncertainties in social sciences activities. If these are taken into account, it is estimated that the 70 million dollar figure should be increased substantially, perhaps by as much as $50 million. Taken as a whole, then, the private sector is estimated to have R&D expenditures that approach $120 million, or some 3% of the gross revenue in the industry. Considering that part of Canada's technological innovation is imported from other countries, not too much significance can be drawn from this percentage. The identified manufacturing R&D of about $70 million is almost 6% of the identified revenues from that sector, which may be a better indicator of the health of the Canadian manufacturing industry for communications.

A corresponding total for the government R&D and other related scientific expenditures in telecommunications and such closely related fields as radar, navigation technology, microwave remote sensing, and certain upper atmospheric studies associated with radio-wave propagation is of the order of $50 million. These are largely incurred by the DOC, but include contributions from DND, MOT, EMR, DOE, and NRC. The $170 million for all communications R&D is approximately 4% of the total contribution of the industry to the Gross National Product. At first glance this does not appear abnormal when compared to the communications picture in other developed nations. However, on considering such factors as the uncertainty of some of the industrial contributions to the total, the nature of the Canadian environment, the extensive communications requirements to be served in the remote and rural regions of the country, and the high technological content and international competition in the industry, this percentage appears more modest. Furthermore, close inspection reveals that there are parts of the discipline (for example, satellite broadcasting and millimetre wave propagation) in which little or no R&D is going on in Canadian industry and that much gap-filling is required if the public interest is to be adequately served in the longer term. Thus there may be justifiable reasons for increased R&D expenditures to maintain a capability in most areas of communications. There are probably also reasons for questioning the relative levels of support in the different areas, or in the government as opposed to the private sector.

A manufacturer, to be successful, must seek to develop products that can give an acceptable or superior return on capital investment at minimum risk. In Canada, as in most other nations, products which industry develops are determined, in the first instance, by the domestic market. Left to itself industry seeks

those products and services that are likely to be profitable, which means that unprofitable or doubtful developments, no matter how necessary or desirable they might appear from the social or long-term economic point of view, usually can only proceed with government support. In the communications field there are areas in which Canadian industry has and will continue to be very successful on its own. There are also areas in which the risks are such that products and services likely can only be developed and introduced with the support of the federal government. Considering the high degree of innovation associated with communications it is unlikely that the domestic market alone will be sufficient justification for all-Canadian industrial developments in the near future. It is also possible that the introduction of new technology and new systems may require some expansion of government support in order to help Canadian industry become more competitive in world markets. Consequently, if there is to be a lasting impact, government R&D expenditures in industry may have to continue for some time at a level that is no lower than the present and possibly significantly higher.

We believe that the approach being pursued by DOC is a sound one. Over the years we have built up a competent team with considerable systems knowledge of communications. This team can provide advice to the policy sector as to technical developments and their impacts in the near, medium and long terms. The policy arm is then able to recommend policies which can make optimal use of new and existing technology. This approach, supported by an adequate level of in-house and contracted R&D and aided by the close cooperation with both the telecommunications manufacturing and service sectors, can result in telecommunications developments that are not critically dependent on short-term commercial

viability. In fact, in a sparsely settled country like Canada where the industry cannot, unaided, justify development of many new products and services, the public sector must play a role in order that new communications systems, which are for the more general and longer-term economic benefit of the country, can be developed in Canada rather than imported.

THE "MAKE OR BUY" POLICY

In its reports on science policy the Senate Committee made a number of recommendations related to industrial R&D and government assistance to industry. One response by the government was the "make or buy" policy which formalized an approach to R&D procurement already in practice in some departments, including DOC. Funds were also provided, under the subsequent Unsolicited Proposals Program, to assist industry in taking advantage of this policy. This Department has been heartily in favour of such measures and in the past several years has contracted out a significant portion of its applied research and experimental development work, as indicated in Appendix 3. Our space-related expenditures in industry have been dominated by the development and procurement of the CTS satellite. Since 1972 these expenditures have averaged about $15 million per year, compared to about $5.5 million per year to support the related in-house activities on space. The Research Sector also has made good use of R&D contracts, although the percentage contracted out has not been as large as for space. These Research Sector contracts have included advanced radar processors, mobile radio data systems, advanced high-frequency equipment developments, studies of the potential of optical-fibre communications, and studies of data communication needs, to mention only a few current examples. In these activities, DOC staff work closely with industry to ensure both a maximum public benefit and an

opportunity for a longer-term benefit to the industry.

Because of its importance, somewhat special procedures apply for the Space Sector. Canadian space (satellite) activities are carried on with government programs and by commercial corporations such as Telesat Canada. Telesat procures its satellites and earth stations by contract and DOC programs are structured to ensure that, insofar as possible, satellite communication systems will be designed, developed, and constructed in Canadian industry. This has already been the case for most of the major sub-systems of the CTS satellite. Over the past decade the Canadian space manufacturing industry has developed, through participation in programs sponsored by DOC, a considerable capability in the design and manufacture of satellite sub-systems and earth-terminal equipment. It has been able to obtain substantial sub-contracts for satellite systems manufactured for use in Canada and abroad. The Department, along with IT&C and MOSST, is presently engaged in discussions with representatives of Canadian industry concerning the possibility of establishing in Canada a prime contractor for complete satellite systems. If such a prime contractor can be found for future communication satellite systems, the DOC role in space is expected to become one of acting as the design authority for experimental and developmental satellite systems purchased by government and of continuing to work with industry to ensure that the required technology is being developed.

As already noted, the main thrust of our industrial program is to promote technological developments in industry which will meet DOC planning objectives by demonstrating the feasibility of critical components and techniques, and which will put the industry in a better position to develop marketable products. The Department supports the Unsolicited Proposals Program as well as using its

own funds to carry out development of components and equipment important to communications applications. This plus shared-cost programs such as PAIT and IRDA are important tools in enabling industry to carry out development projects that otherwise might not go ahead. Our experience with such programs has been most satisfactory. In space technology alone this type of expenditure has resulted in industrial contracts since 1974 that total about $500,000 per year and we expect to make greater use of this mechanism to increase the Canadian content in our space systems. We strongly support the objectives of the "make or buy" policy and are confident of our ability to continue to meet its goals.

An important in-house capability which the department must retain, concerns the validation and supplementing of the information bases used by industry. This is particularly important with respect to regulated industries such as the federally regulated telecommunications carriers. For example, the department must have the necessary expertise and data for analyzing the relevant cost and effectiveness of alternative communication systems in order to monitor the performance of the carriers, particularly where the public interest is being served by a complex of institutions, as is the case in Canada.

The Department does not have a granting responsibility and essentially is not affected by the Senate Committee recommendations concerning grants to industry under IT&C. However, we are very much in favour of the Senate Committee recommendation that personnel exchanges between government laboratories, industry and universities be facilitated. In fact, DOC has such an industry-exchange program and our experience with it has been very favourable.

Finally, it should be noted that the Department contracts out some oriented basic and applied research to Canadian universities. In 1975/76 some $720,000

was expended in this way, almost half of which was for projects in the economic, regulatory and social areas.

THE SUPPLY OF QUALIFIED SCIENTISTS AND ENGINEERS

The Senate Committee recommended a MOSST task force to examine the needs for and qualifications of qualified scientists and engineers for industry. This is a commendable step but, in view of the complementary roles of government and industry mentioned earlier, we would also like to see the needs of the government laboratories included.

Within DOC we have experienced considerable difficulty on occasion in hiring suitably qualified personnel in computer communications and data systems, radar technology, space mechanics, and communications systems engineering. We have also had difficulty in hiring operational research scientists, management scientists, and social and behavioural scientists. In part this arises because the hiring practices of the government service differ from those of industry, especially when there is an imbalance between supply and demand. It is also partly attributable to the fact that university training programs in Canada have not been closely matched to the needs of government and industry. One consequence has been a very real requirement for on-the-job training to bring personnel to a level where they can contribute effectively. In addition, we have been forced to recruit some essential specialists from outside Canada.

A primary and probably the paramount resource of an industrialized nation is its scientific and technological know-how. However, science and technology are continuously growing and expanding, so that special efforts are required to maintain the capabilities and up-date the skills and knowledge of scientists and engineers. In fact, in rapidly evolving technological areas, such as tele-

communications, a particular expertise requires renewal after only 3 or 4 years. Accordingly, any organization or agency engaged in scientific activities must provide for appropriate up-dating and retraining of its technical staff. Within DOC the provisions for up-dating have included projects in oriented basic and applied research, visits to other centres and laboratories, attendance at scientific conferences, the sponsoring of conferences and workshops on specific topics of interest, and university courses which may on occasion be extended into a "sabbatical year".

In the past several years there has been a noticeable trend in CRC toward system and feasibility studies at the expense of laboratory or experimental studies. If this trend continues it is likely to require increased reorientation of many of our scientists and engineers into different avenues. This could require training in new techniques, such as economic analysis, optimization, and social and behavioural evaluation which have not hitherto been included in the training of the majority of our scientists.

SCIENTIFIC AND TECHNICAL INFORMATION

The Senate Committee underscored the importance of an effective scientific and technical information (STI) organization and its recommendations in this connection were considered in the formation of the Canada Institute for Scientific and Technical Information. That organization appears to satisfy a large part of the requirement for published scientific and technical information. Considering that Canada contributes less than 2% of the new STI produced in the world, the Institute performs a very important function indeed.

In a field of rapidly expanding technology, such as communications, the timeless of technological information is all important. The description of new

techniques in the scientific journals usually occurs some time after their initial discovery, and often well after they can be exploited to advantage. Anyone engaged in development must take steps to import technical know-how early enough to enable it to be used to commercial advantage. There are no tidy procedures that can be invoked for this, since experience indicates that the most successful channel is personal contact between scientists. Accordingly, government departments that are involved in R&D should be encouraged to take measures that could improve their importing effectiveness. Such measures include visits, attendance at international scientific conferences, joint R&D projects, exchanges of scientists and of scientific liaison officers, the sponsoring of symposia and meetings on identified subjects, and negotiated international scientific and technical exchanges.

WORK FOR OTHER DEPARTMENTS AND AGENCIES

Each year DOC undertakes a significant amount of R&D work for other Government departments, a large portion of which is for the Department of National Defence. The latter is in accordance with an understanding reached when CRC was separated from DND in 1969. Its terms required DOC to continue to fund, on its own initiative, certain research of interest to the military and, in addition, to carry out an agreed R&D program under direct DND funding. It also commits us to support DND in international R&D activities and commitments and to provide general back-up and advice in areas related to communications. The accepted basis for that understanding was that DOC had responsibility for planning and executing a communications research program adequate to meet the national need. Where another department required assistance with a particular task, the project undertaken would be paid for by them and there was to be no joint funding of

projects by DOC and the other department. As a consequence, DND and other departments have made and continue to make specific requests for advice and assistance or for R&D to their programs, for which they usually provide at least partial funding. See Appendix 7 for a listing of work for other departments and agencies during the current fiscal year. These various requests arise because of the particular expertise and facilities at CRC which are not available elsewhere in the country.

It is perhaps worth noting that, in addition to our capabilities in communications and satellite technologies, a large percentage of the national competence on microwave remote sensing and radar, particularly that pertaining to synthetic aperture techniques, resides at CRC. Probably the main reason why this expertise resides in the government service is that the essential requirements for it have been and still continue to be in the government. Although this unique capability does not fall specifically within the mandate of the Department, it is closely related to the communications technologies and to the DOC interests related to the propagation of radio waves.

Applying the expertise within CRC to the requirements of other departments and agencies is not always a simple task. There is not too much of a problem in cases where the projects have been planned sufficiently far in advance for inclusion in our program forecast and for a proper allocation of man-year and financial resources. Responding to large numbers of unforeseen requests is another matter, however, since even though the resources needed for a particular task may be small, the cumulative impact can constitute a significant drain on our resources that is difficult to budget for in advance. In order to deal with these situations we try to maintain a certain flexibility for a portion of our

program, which includes the ability to augment the scientific staff on a term or contract basis.

GENERAL COMMENTS ON THE SENATE COMMITTEE RECOMMENDATIONS

Without a doubt the Senate Committee's examination of Science Policy in Canada has been of real value. The reports have been widely read and discussed at great length. Some of the recommendations have been implemented, at least in part, while others have prompted action along related lines. On balance, the exposure that the Senate Committee reports have given to science and to its role in society would seem to have been highly beneficial. In the present climate of restrained spending, science can only gain favour if it is prepared to expose itself to the public and to pay more attention to explaining the relevance of what it does.

However, relevancy is not the only aspect of science that concerned the Senate Committee. The quality of science is also important. Quality depends on many factors, including the qualifications of the scientists and engineers; how those qualifications are maintained and up-dated; the nature of the research facilities; a stimulating research environment within which ideas and concepts can be developed that are of benefit to Canada; a degree of flexibility that permits visits and cross-fertilization with industry, university and scientific colleagues in other countries; and a mutual understanding and close cooperation between the scientific and policy sectors of the Department.

Much of the merit of the Senate Committee reports rests in their advocacy of constructive measures, not in any implicit or explicit arguments for destructive change. Two of their main considerations concerned the provision of an adequate level of fundamental science and the potential of science for increasing

industrial productivity for the benefit of all Canadians. To a considerable extent these two considerations bypass a mission-oriented department, such as DOC, whose primary responsibilities do not specifically include support for basic research on the one hand or support for industry on the other. Nevertheless, both these considerations are of fundamental importance to the Department. On the one hand, we maintain close working relations with Canadian universities in order to benefit from the basic research that takes place there, to learn of new developments, ideas and concepts at an early date, and, through our University Research Contract Program, to encourage new research ventures in areas of interest to DOC. On the other hand, we spend a large portion of our budget in industry, and now have a five-year program for support to the space industry. Accordingly, we can identify with much of the intent, if not the specifics, of the Senate Committee recommendations.

We are engaged in many scientific and technological activities, a number of which border on or are connected with related activities in other departments. With respect to our relations with industry there is considerable coordination with IT&C and also with MOSST. Because technology is so vital to the DOC mission, logic calls for a close relationship of all aspects of communications R&D with such industrial activities as manufacturing, marketing and the implementation and operation of services. Accordingly, the responsibility boundaries with IT&C may need to be somewhat more flexible than the Senate Committee envisaged. Similarly, the review processes that the Committee recommended for MOSST in regard to industrial R&D programs need to be adapted to fit particular circumstances.

One area in which the DOC approach seems to differ from that recommended by

the Senate Committee concerns the separation of the different R&D sectors. Rather than isolating the different sectors, as the Senate Committee seemed to favour, we try to provide only enough isolation between researchers and those concerned with applications to prevent too much distraction by one another's routine problems. Not all policy needs or all applications can be foreseen accurately enough so as always to define in detail the research program. As a result some oriented basic and applied research must be undertaken in both industry and government as a learning process and as a stimulating breeding ground for new ideas and devices, without necessarily always having an obvious pay-off. This unexpected nature of discovery and invention sometimes makes research difficult to justify. In the R&D processes one knows and can justify very well a particular development. But basic research is usually undertaken because of a lack of knowledge. In such cases the scientific methodologies are invaluable for enhancing the chances of success, provided there is a policy to support such investigations in the first place.

On balance, then, we recognize that science is fundamental to the Departmental mission and that we must pay attention to the quality of our R&D so as to be able to promote that mission credibly and successfully. However, our policies regarding science and its uses are still evolving, and are likely to continue to adapt to fit the changing needs of the discipline.

Much of the preceding discussion has been for the purpose of illustrating how, within one department at least, science is being used for the attainment of national goals. Over the years our scientists and engineers have built up an enviable reputation, both at home and abroad. We are endeavouring to retain and nurture that expertise and to make the best use possible of it to ensure that

future Canadians will have available to them communications systems and services that are suited to their needs. We are confident that the associated Canadian industries can and will be encouraged to thrive because of such programs as "make or buy", or because of deliberate industrial strategies worked out in combination with IT&C and MOSST aimed at supporting designated industrial sectors or aimed at the transfer of in-house technology to industry.

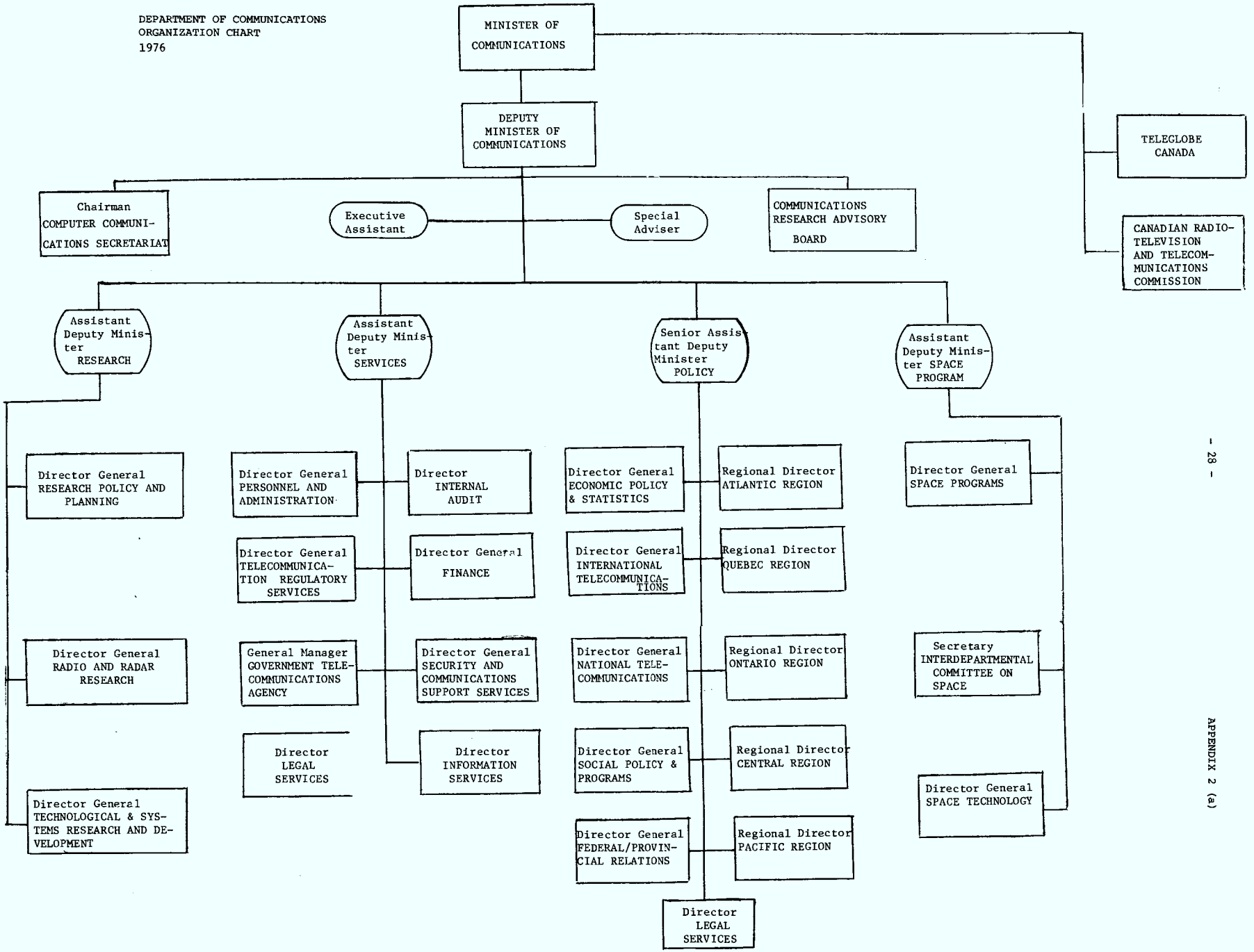
APPENDICES

Estimates* for 1974 of revenues for the Canadian telecommunications industry (in millions)

Telecommunications carriers	$2,600.
Broadcasting	500.
Manufacturing industry	1,200.
TOTAL	$4,300.

* Based on Financial Statistics on Canadian Telecommunication Common Carriers, 1974 (DOC Report), and on data from Statistics Canada.

DEPARTMENT OF COMMUNICATIONS
ORGANIZATION CHART
1976



APPENDIX 2 (b)

FUNCTIONS OF THE DEPARTMENT'S BRANCHES

The Department is organized into four main groups: Policy, Space Programs, Research and Services. The budget for the 1975/76 fiscal year has been set at $55,442,000.

POLICY

The first group, under the Senior Assistant Deputy Minister, is responsible for formulating and recommending international and national policies in the field of telecommunications, and proposing legislation for consideration by the Government. This sector also coordinates federal-provincial relations in matters of interest to the Department, develops social policy for the utilization of communications technology, and interfaces with Teleglobe Canada, Telesat Canada, and the Canadian Radio-television and Telecommunications Commission.
The Department's field organization, headed by five regional directors (Atlantic, Quebec, Ontario, Central and Pacific), also reports to the Senior Assistant Deputy Minister.

SPACE PROGRAM

Under the Assistant Deputy Minister, Space Program, this group is responsible for the Communications Technology Satellite (currently the department's single largest budget item); relations with Telesat Canada and other agencies and departments concerned with space; development of new space systems and applications; and important planning and international functions in this rapidly growing area of communications technology. Reporting to the Assistant Deputy Minister are three directors-general, responsible for space programs, space applications and space technology.

RESEARCH

This third group under the Assistant Deputy Minister, Research, carries out research in the complex field of communications, both in-house and through a system of university research contracts. It aids in the development of new communications systems, manages the overall departmental R&D program, provides scientific advice to aid in the foundation of departmental policy and seeks to ensure that a level and quality of research and development capability is maintained in Canada sufficient to reflect the importance of communications to the country and to keep Canada at least abreast of other technologically advanced nations. The Department's principal research facility is the Communications Research Centre, just west of Ottawa. Reporting to the Assistant Deputy Minister (Research) are three directors-general, responsible for research policy and planning, radio and radar research and technological and systems research and development.

SERVICES

Within the services group, the Telecommunication Regulatory Service establishes technical certificates and radio operating licences and manages the radio frequency spectrum. Another branch, the Government Telecommunications Agency, provides consulting and centralized telecommunications services for federal department and agencies.

The Assistant Deputy Minister, Services, is the Department's principal adviser on organization, personnel, financial management, administration, bilingualism, information, legal matters and security.

COMPUTER COMMUNICATIONS SECRETARIAT

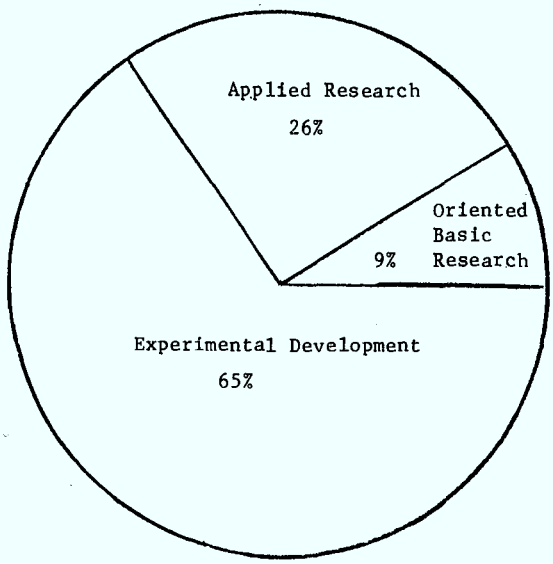
The Computer Communications Secretariat, which reports to the Deputy Minister, serves an interdepartmental committee within the federal government which coordinates policies and analyzes alternatives on an ongoing basis to ensure the development of computer/communications for the benefit of Canadian society. The Department provides the chairman as well as the secretariat for the interdepartmental committee.

APPENDIX 3

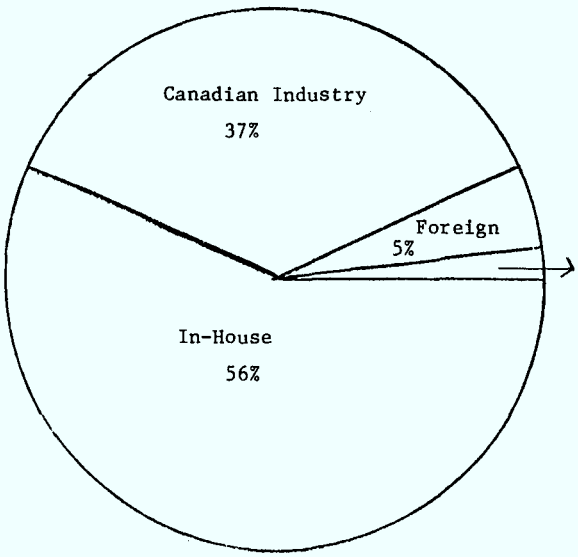
TOTAL DOC BUDGET IN SCIENTIFIC ACTIVITIES

74/75 $36,481,000*

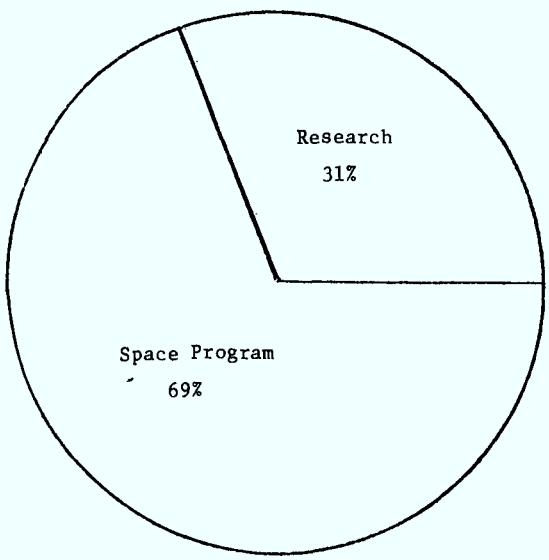
*Includes - $1,942,000 for human science activities,
- $34,539,000 for natural science activities, of which $5,226,000 is for construction, and administrative and other support services at CRC.



Fraction of in-house R&D by type of scientific activity



Fraction of scientific activities budget carried out in-house and by contracts

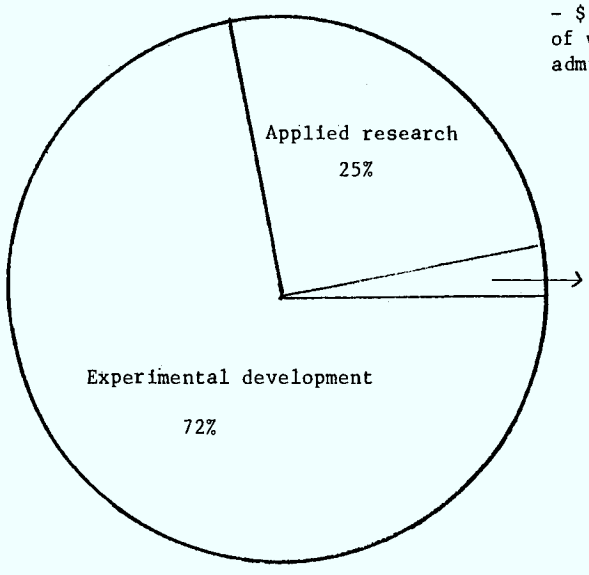


Relative fraction of scientific activities budget in Space Applications and Telecommunications Research

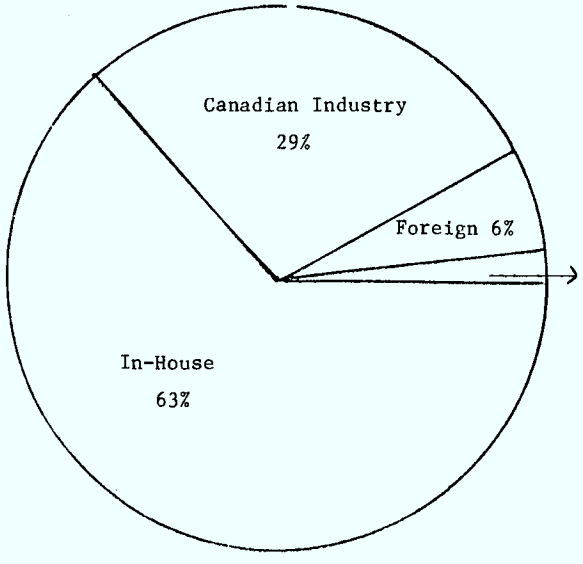
TOTAL DOC BUDGET IN SCIENTIFIC ACTIVITIES

75/76 $37,116,000*

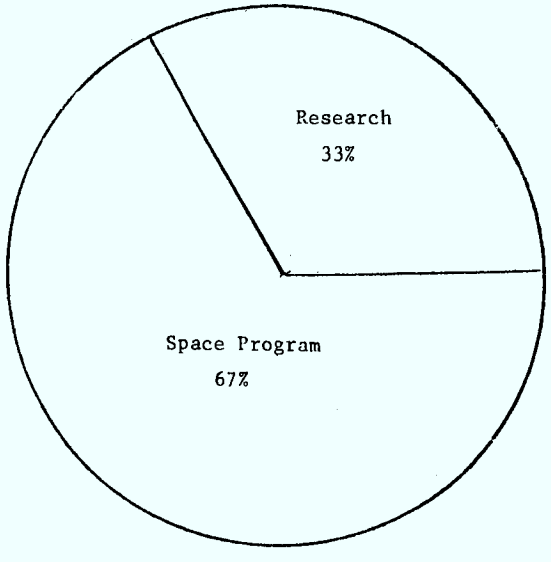
*Includes - $2,094,000 for human science activities,
- $35,022,000 for natural science activities, of which $5,810,000 is for construction and administrative and other support services at CRC.



Fraction of in-house R&D by type of scientific activity



Fraction of scientific activities budget carried out in-house and by contracts



Relative fraction of scientific activities budget in Space Applications and Telecommunications Research

APPENDIX 4

A. MAJOR PROGRAM AREAS OF THE RESEARCH SECTOR 1975/76

REMOTE COMMUNICATIONS PROGRAM

This program aims to strengthen communication links (telephone, data, radio, live television for education and entertainment), among communities in the North and between people of the North and fellow Canadians in the South. Current research activities directed towards the achievement of this objective include mainly an overall system study of the intra and inter community communication needs, a detailed system study of an integrated HF/VHF communication system, and an investigation of the use of very high power beams of radio energy to create localized regions of dense ionization in the ionosphere.

RURAL COMMUNICATIONS PROGRAM

The Canadian rural networks are among the worst of developed countries. This high priority research program aims at exploring alternative means for rectifying this situation. Activities this year include studies of technical options with particular emphasis on radio and guided-optical systems, detailed examination of the current situation and needs, and the identification of opportunities for government stimulation of industrial electronics development.

URBAN COMMUNICATIONS PROGRAM

Research and development activities in this area strongly support the following departmental objectives: a) to foster, develop and introduce new communication systems, facilities and resources, b) to foster, develop and extend telecommunications services to obtain optimum benefits for Canada in the short and long term.

The activities for this program are concentrated on Image Communications, Broadband Communications and Computer/Communications.

RESEARCH RELEVANT TO MANAGEMENT OF THE RADIO FREQUENCY SPECTRUM

The major objectives of this year's program are to study radio interference and noise in the HF, VHF and lower UHF bands; to provide information and advice to support DOC spectrum occupancy and management and to assist other user departments in this area.

RESEARCH IN SUPPORT OF OTHER DEPARTMENTS

In response to its public sector responsibility for communications research and development, the DOC research program also contains an important set of activities on behalf of other federal government departments and agencies. DND is the largest customer and accounts for about 75% of the current effort. The remainder is divided among the Bureau of Staff Development, the Canadian Centre for Remote Sensing, Teleglobe Canada, Telesat, the RCMP and the Ministry of Transport.

B. MAJOR PROGRAM AREAS OF THE SPACE SECTOR

THE COMMUNICATIONS TECHNOLOGY SATELLITE

The Communications Technology Satellite (CTS), begun in 1970, was launched on January 17, 1976. The CTS is intended to test concepts of broadcasting for satellites, and to develop new technology in Canadian industry and an industrial competence in Canada.

AEROSAT (AERONAUTIC COMMUNICATION SATELLITE)

AEROSAT is an international program involving Canada, the U.S., and a group of European countries represented by European Space Agency (ESA). The aim is to investigate the use of satellite communications technology in the management of international air traffic. The proposed investigation will be conducted over the Atlantic.

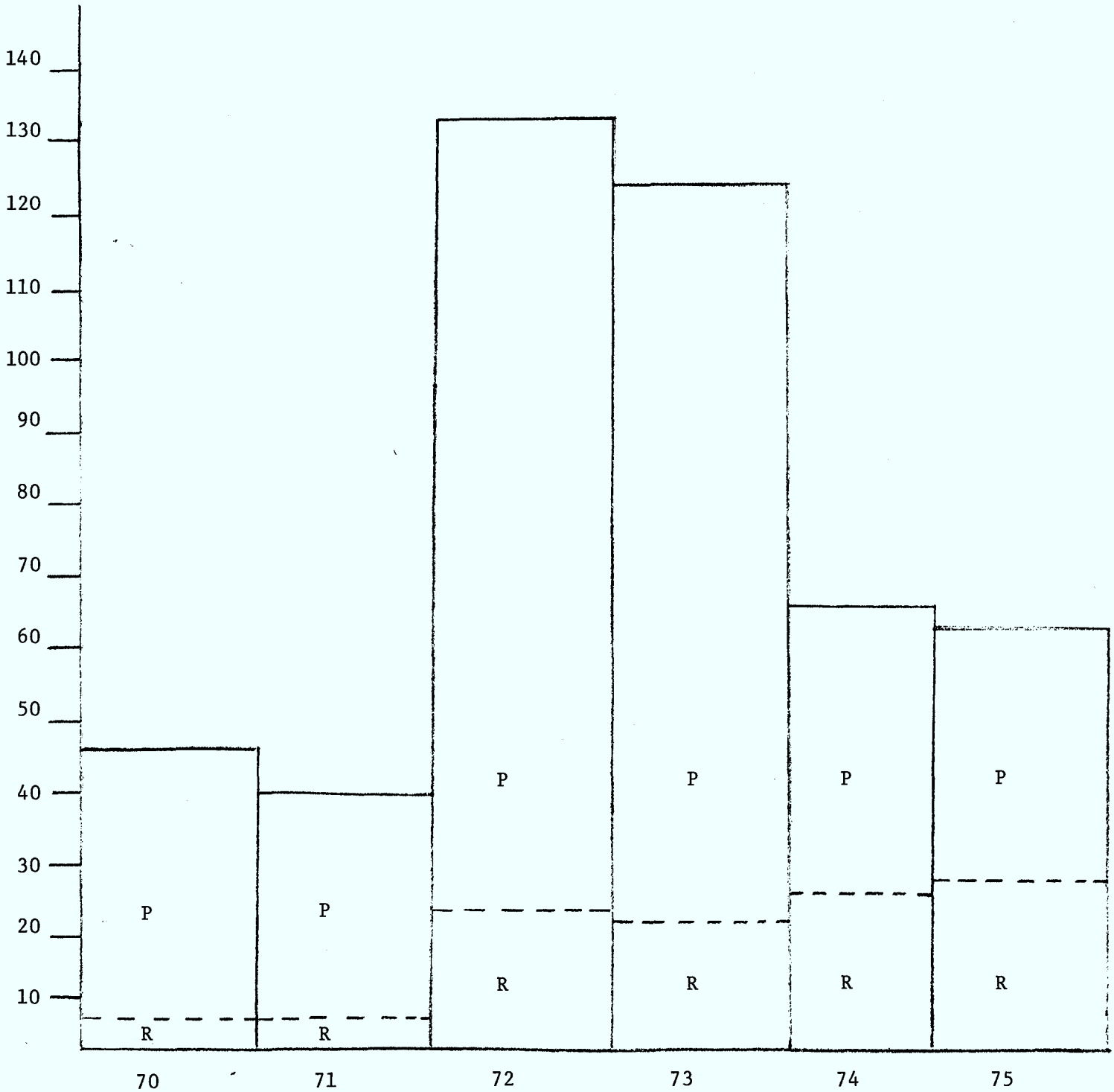
THE SPACE DIVISION OF THE CRC

Approximately half of the technical staff of the Communications Research Centre are occupied in the Space Program. Their responsibilities are the CTS program, operation of the David Florida Laboratory for integrating and testing spacecraft, the earth station facilities for operating the Alouette and ISIS Satellites, and supporting research in space electronics and space mechanics.

APPENDIX 5

PUBLICATIONS ISSUED FROM CRC

1970 - 1975



P- Papers published in the open scientific literature
R- Publications issued as CRC Reports and CRC Technical Notes

THE COMMUNICATIONS TECHNOLOGY SATELLITE

On January 17, 1976, Canada's Communications Technology Satellite (CTS) was launched from the Kennedy Space Centre in Florida. It is now in a geostationary orbit and tests have shown that the on-board systems are operating well. This is a most satisfactory conclusion for a six-year development program and represents a significant step toward "direct-to-home broadcast" type satellites.

The CTS program was a joint undertaking of the DOC and the National Aeronautics and Space Administration (NASA), in which Canada undertook to design and build the spacecraft and to control and operate it in synchronous orbit. The United States undertook to provide the launch vehicle, a high-power travelling-wave-tube amplifier, pre-launch test support, and to carry out the launch. The European Space Agency also participated, through a bilateral agreement with Canada.

The primary DOC objectives of the program are: to demonstrate high-powered television and other transmission to small, low-cost earth stations; to explore by means of communications experiments the social, cultural and economic impact of the eventual introduction of services that might be provided; to flight-test major advanced technology subsystems of the spacecraft itself and; to further develop and demonstrate the abilities of Canadian industry in the design and fabrication of sub-systems and components for the space/communications systems of tomorrow.

The satellite was designed and built by DOC at its research centre near Ottawa. Spar Aerospace Products, Ltd. of Toronto supplied the spacecraft structure and mechanical subsystems. RCA Ltd. of Montreal built the electrical and electronic systems. as well as the spacecraft's antennas and 18 small ground stations. SED Systems Ltd. of Saskatoon built two self-contained three-metre ground stations, housed in trailers and capable of providing a full range of communication services from remote locations in Canada; the company also played an important part in providing the computer software for the orbit manoeuvers. Bristol Aerospace Ltd. of Winnipeg supplied electrical units.

In all, about 80 percent of the value of the industrial contracts let for construction of CTS has gone to Canadian industries. In addition to this, the CTS program has provided a means of encouraging Canadian manufacturers to develop capabilities for the design and manufacture of advanced components and sub-systems for spacecraft -- both for use in Canada and for export -- in accord with one of the objectives set out in the government's recent statement on space policy.

The DOC will use the CTS to study the effectiveness of satellite technology for meeting Canada's growing communications needs in the 1980s, its capability for expanding and improving communications services to

isolated areas, especially the North, and the potential use of small earth terminals for community or direct home reception.

In the next two years, a number of groups from provincial governments, industry, universities and federal agencies will conduct communications experiments using earth terminals operating in the 12 and 14 Gigahertz frequency bands reserved for satellite communications by international agreement and which will be used in Canada for the first time by the CTS.

Present day commercial satellites operated by Intelsat and the three Aniks share the already crowded four and six GHz frequency bands with the microwave networks of the telephone and telegraph companies. The risk of interference from signals relayed to and from the commercial satellites has been a major factor in determining the size and limiting the suitable locations for the ground antennas. It has also placed an upper limit on the power that could be transmitted from these satellites.

The transmitter in the CTS will be the most powerful used up to now, permitting use of earth terminals with antennas as small as one metre in diameter. The CTS may point the way to a new era of low cost communications, for broadcasting and for two-way communications.

THE MOBILE RADIO DATA SYSTEMS PROJECT

In "Branching Out"* it was recommended that computer communications should be recognized as a key area of industrial and social activity, and that, in this field, steps should be taken to strengthen Canadian industry, to identify user needs, and to evaluate the impact of such systems on society. While it was thought unlikely that Canadian industry would support large computer mainframe manufacture, it seemed possible that it might support the development and manufacture of data terminal equipment. Accordingly, studies were undertaken by the Department through industrial contracts to ascertain the current status of data terminal development and production, and to identify latent needs in society that could be developed as market opportunities for industry. If a suitable market opportunity could be found, a follow-on program could be expected for the development and manufacture of data terminal equipment in Canada.

The initial studies revealed that the Canadian market was supplied with terminal equipments that were either imported from the USA or manufactured in Canada by American subsidiaries; in the latter cases the Canadian contribution amounted to only some 10% of the cost of the terminals. A further study indicated that the standards and protocols in use were largely American, and that almost no research on data terminals and related components was carried out in Canada. Our data-terminal industry was found

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* Branching Out: Report of the Canadian Computer/Communications Task Force. Department of Communications, May, 1972.

to be limited in scope, highly concentrated, and dominated by two USA-controlled manufacturing companies.

Among the many terminal opportunities examined, mobile radio data systems appeared to be a likely viable market opportunity for industry. In particular, the Canadian Police Forces were identified as potential lead users in the area of computer aided dispatch and data retrieval. Other potential users were ambulance and fire services, taxi companies, ready-mix concrete companies, transit authorities, railways, etc.

Subsequently a decision was taken to develop a police system as a joint undertaking between DOC and the RCMP. The primary objectives of the project were to develop and define detailed system specifications, to demonstrate by means of a pre-production prototype that the approach was valid and would meet requirements, to maximize the efficient use of communications in this application, and to encourage the development of industrial capability to produce such systems with a maximum Canadian content in both hardware and software.

R&D FOR OTHER DEPARTMENTS 1975/76

	PROGRAM	DESCRIPTION	DEPARTMENT OR AGENCY
(1)	MILITARY PROGRAM	Recoverable and supplementary funding on-going	DND/CRAD
(2)	HF PREDICTION	On-line access to the HF prediction program	DND/CFCC, External Affairs, DOC Regions
(3)	MICROWAVE LANDING SYSTEM (MLS)	Technical consultation to MOT for the Canadian participation in the International Civil Aviation MLS program	MOT
(4)	CIVILIAN RADAR/REMOTE SENSING PROGRAM	Provide assistance and consultation on the following: i) Airborne Scatterometry ii) Development of Ice Thickness Radar iii) Soil Moisture Measurements iv) Radar Permafrost Measurements v) Microwave Properties of Materials	DOE, CDA, DEMR
(5)	INTEGRATED AIR SURVEILLANCE	Provide consultation on the radar aspect of the project	DND, MOT
(6)	SEASAT	Preparation for a possible cooperative CANADA/USA microwave remote sensing satellite program	DEMR, DOE
(7)	SITE DIVERSITY	Experimental measurement program designed to obtain the statistics of precipitation attenuation for the 11 and 14 GHz bands	Teleglobe
(8)	INTERACTIVE IMAGE COMMUNICATIONS	Image Communications (Graphics, Common Working Space, Facsimile)	DND, DOE, NHW
(9)	DATA TERMINAL	Development of a mobile radio digital data communications system for the Police Forces of Canada	RCMP, DOC

	PROGRAM	DESCRIPTION	DEPARTMENT OR AGENCY
(10)	HF AIR-GROUND DATA LINK STUDY	Provide equipment and technical assistance to MOT for an OTTAWA-DALLAS HF circuit	MOT
(11)	EUREKA	Evaluation of a wide-band data link from Eureka to Ottawa using the TELESAT-ANIK satellite	DND, DOC
(12)	DEFENCE INDUSTRIAL RESEARCH	Provide assistance and advice on the defence industrial research program	DND
(13)	UNSOLICITED PROPOSAL	Provide assistance in the evaluation of unsolicited proposals	DND
(14)	NORPLOY	i) VLF/LF Communications and Propagation Research ii) Sounder Calling System for Ship-shore-ship communications	DND
(15)	COMPUTER-CONFERENCING RESEARCH PROGRAM	Study of technology and of behaviour and attitudes to various new systems	BSDT, DOC
(16)	REFRACTIVITY ATLAS	Preparation of two climatological atlases for Canada dealing respectively with rainfall attenuation and refractivity	Canadian Radio Technical Planning Board
(17)	HF COMMUNICATION STUDIES	Study of ionospheric Faraday rotation	NRC