Department of Communications

Communications Systems
Research and
Development Branch

CONCLUDING REPORT
RURAL COMMUNICATIONS PROGRAM

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April 1981

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May, 1981

To All Who Have Expressed An Interest In The Rural Communications Program

I am pleased to send you the Concluding Report on the Rural Communications Program. The Program was a major research undertaking by the Department of Communications. We have benefited throughout not only from what we have learned but also by the contacts resulting from the widespread interest it has aroused.

As a research activity, it has been a success. While no single, all-encompassing or revolutionary technological solution has been found, and this is not surprising given the diverse and sparsely populated nature of rural Canada, we have nevertheless concluded that certain broad areas of technological solutions are feasible. It is our hope that our conclusions will be of value to all those authorities, in both the public and private sectors, whose responsibility it is to make decisions on the implementation of rural services.

Mai 1981

A tous ceux qui se sont montrés intéressés au programme de communications rurales

Il me fait plaisir de vous faire parvenir le rapport final sur le programme de communications rurales. Ce programme s'est avéré, pour le ministère des Communications, une entreprise importante et l'expérience nous fut très profitable, non seulement par l'information qu'elle nous a apporté mais aussi par les relations établies grâce au grand intérêt qu'elle a suscité.

Notre enquête fut certes menée à bonne fin. Bien sûr, aucune solution globale ou révolutionnaire sur le plan technique n'a été mise de l'avant qui aurait pu résoudre nos problèmes de communications; mais il fallait s'attendre à cela compte tenu du caractère varié et dispersé de la population rurale du Canada. Nous avons cependant pu nous rendre compte des immenses possibilités que nous offre la technologie.

Nous comptons que les conclusions auxquelles nous sommes parvenus seront un apport précieux pour les différents intervenants,

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I trust that the Report will be of interest to you. My staff and I would be pleased to discuss any points with you or to provide you with additional information.

Yours sincerely,

tant du secteur privé que du secteur public, qui ont pour tâche d'orienter la réalisation de services dans les régions rurales.

Aussi nous espérons que le présent rapport saura vous intéresser. Il nous fera grand plaisir d'en discuter avec vous ou de vous fournir des informations supplémentaires.

Veuillez agréer nos sincères salutations.

Recherche & Développement
Systèmes de Communication,
Directeur Général,

Roger Kaye
Director General,
Communications Systems
Research & Development

CONCLUDING REPORT

RURAL COMMUNICATIONS PROGRAM

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1. INTRODUCTION

The Rural Communications Program was a research program that began in 1976 with a scheduled termination by April, 1980. Its initiation was based on a recognition of the significant disparity between communication services provided to rural areas and those available in urban areas.

This is the concluding report of the program. The report will first state the original objectives, and then highlight the research findings and measure them against the stated objectives. Finally, it will present the conclusions.

2. DOC OBJECTIVES

The objectives originally stated for the Rural Communications Program are as follows:

(a) To provide an engineering/economic framework for the development of federal policies on rural communications,

(b) To foster federal-provincial cooperation in the improvement of rural services,

(c) To stimulate Canadian product design for rural communications,

(d) To provide the basis for a coherent domestic market for equipment used in improving rural services.

The first objective, which is in support of the Department's role in developing federal policies in communications matters, constitutes the main objective of the Rural Communications Program.

3. MEETING ORIGINAL OBJECTIVES

Objective (a) was tackled in two parts:

- Studies to quantify rural communications problems;
- Studies to evaluate potential technological/economic solutions.

The rural communications problems were quantified by finding answers to the following questions:

(i) What is the nature of the rural environment in terms of population distribution, existing telephone service, TV and radio broadcast services, etc.?

(ii) What are the levels of telephone, TV, radio and other communication services desired by the rural people and what is their willingness and ability to pay for what they want?

(Note: With regard to TV and radio services our concern in this research program is only with the number of channels or stations that could be delivered and their quality of reception and not with program contents.)

Objectives (b) and (c) are to be met as natural outcomes of the activities related to Objective (a).

Objective (d) essentially calls for the establishment of national standards for rural communication equipment and systems.

The following sub-sections discuss the extent to which the above objectives have been met.

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3.1 Quantification of Rural Communications Problems

3.1.1 Nature of Rural Environment and Existing Services

This aspect of the Rural Communication Program has been addressed in great depth with satisfactory results. A large number of reports were completed which resulted in the availability of an excellent data base on rural statistics - See References 1, 4-13, 18-22, 24, 27, 29, 39, 41 and 51.

(a) Demographic Characteristics

(Ref. 5 to 8, 19 to 22, 27, 29, 39)

Remote areas are defined as those areas beyond the limits of continuous population distribution (where the population density is less than 1 person/sq. mile).

Rural areas are defined as those non-remote areas which are outside communities of more than 2500 people, as indicated in Figure 1.

The rural areas of Canada identified by applying this definition are shown in Figure 2.

Table I gives 1971 population statisitics for the three groups classified as remote, rural and urban.

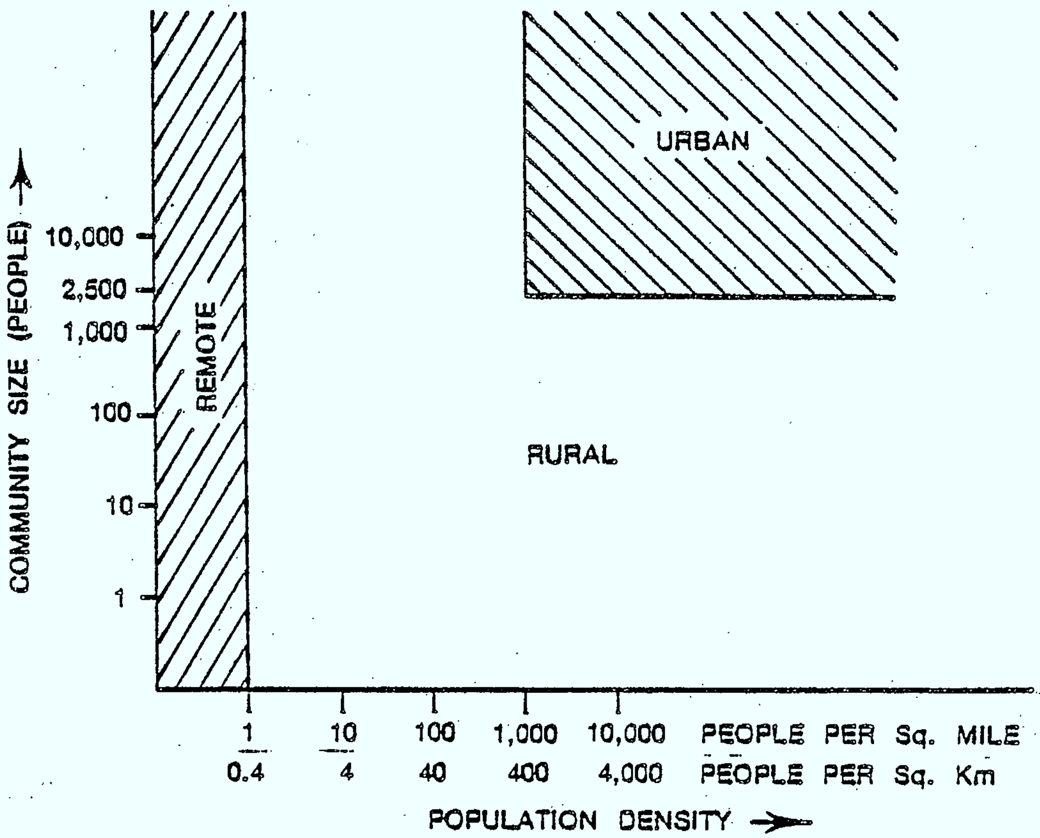

Fig.1 THE POPULATION DENSITY DEFINITION OF RURAL

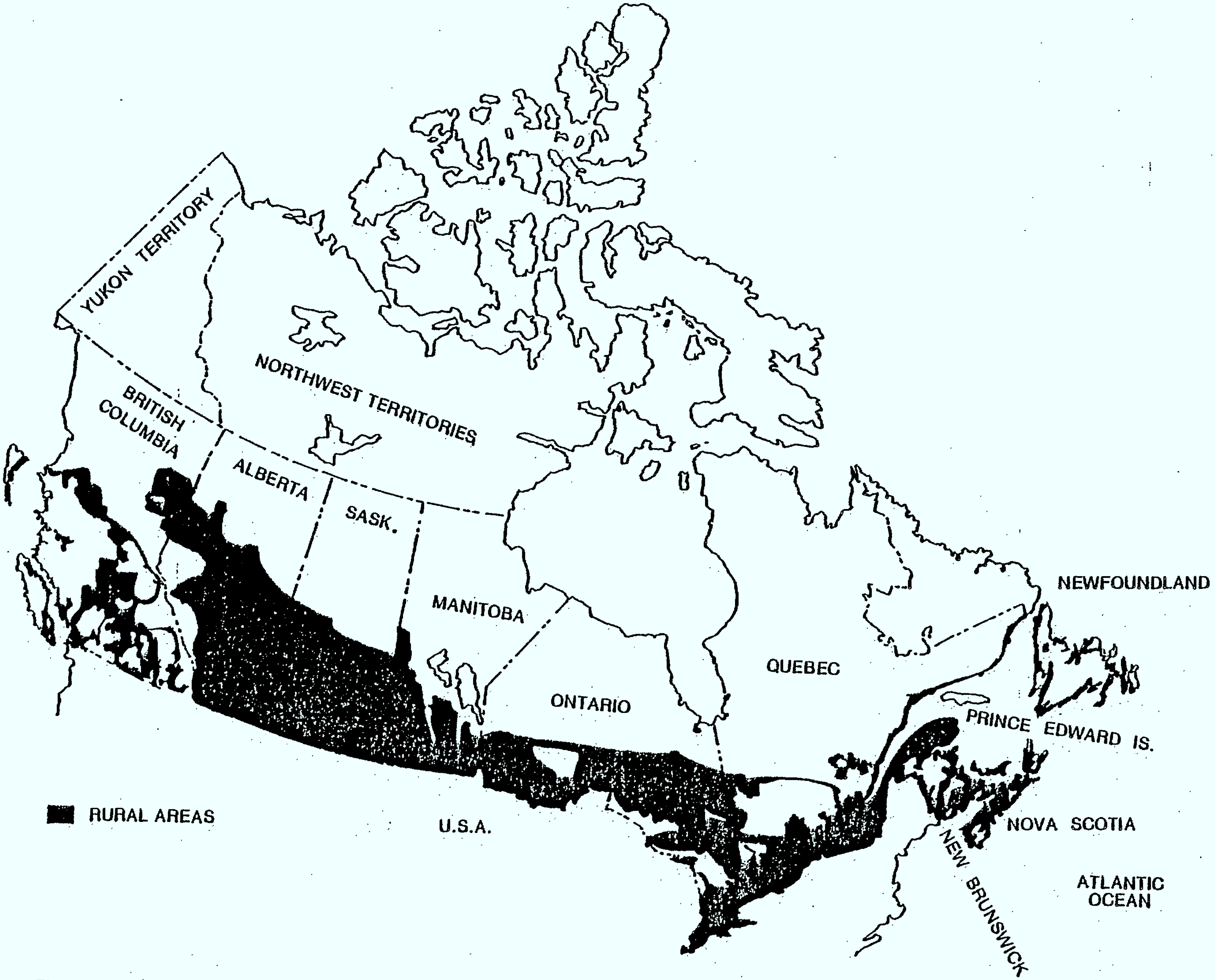

Fig.2 THE RURAL AREAS OF CANADA

TABLE I

1971 Population Statistics in Canada

	Urban	Rural	Remote	Canada
Land area (sq. miles)	*	606,666		3,560,238
Population	15,066,300	6,239,600	262,400	21,568,300
Average density (people/sq. mile)	1,640	10.3	0.1	6.1
Households		1,592,100		6,041,300
Average Household density (Households/sq. mile)		2.6		1.7

*Very small (less than 1% of the total)

The statistics contained in Table 1 indicate that 17% of the land area in Canada can be classified as rural; this area contains 29% of the population and 26% of the households. The bulk of the land area of Canada is classified as remote and contains only one percent of the population. Conversely the urban area accounts for 70% of the total population but occupies less than one percent of the land area. In terms of average population density, there are two orders of magnitude between the rural group and other population groups.

The demographic statistical distributions by Provinces are as shown in Figures 3 and 4.

(b) <u>Telephone Service</u>

(Ref. 1, 27, 30, 36, 37, 38, 49, 53, 54)

Details of average telephone exchange area and average number of communities per exchange are given in Figure 5.

Details of the level of rural telephone service are given in Figure 6. It can be seen that one-third of the rural population have 4-party service or worse based on 1976 statistics.

Also at the time when the rural study was conducted in 1978, about 4.5% of the rural population had no telephone service at all. The common carriers have spent or will be spending a total of approximately $1 Billion to up-grade the rural service to 4-party lines or better. This process should be completed by 1983.

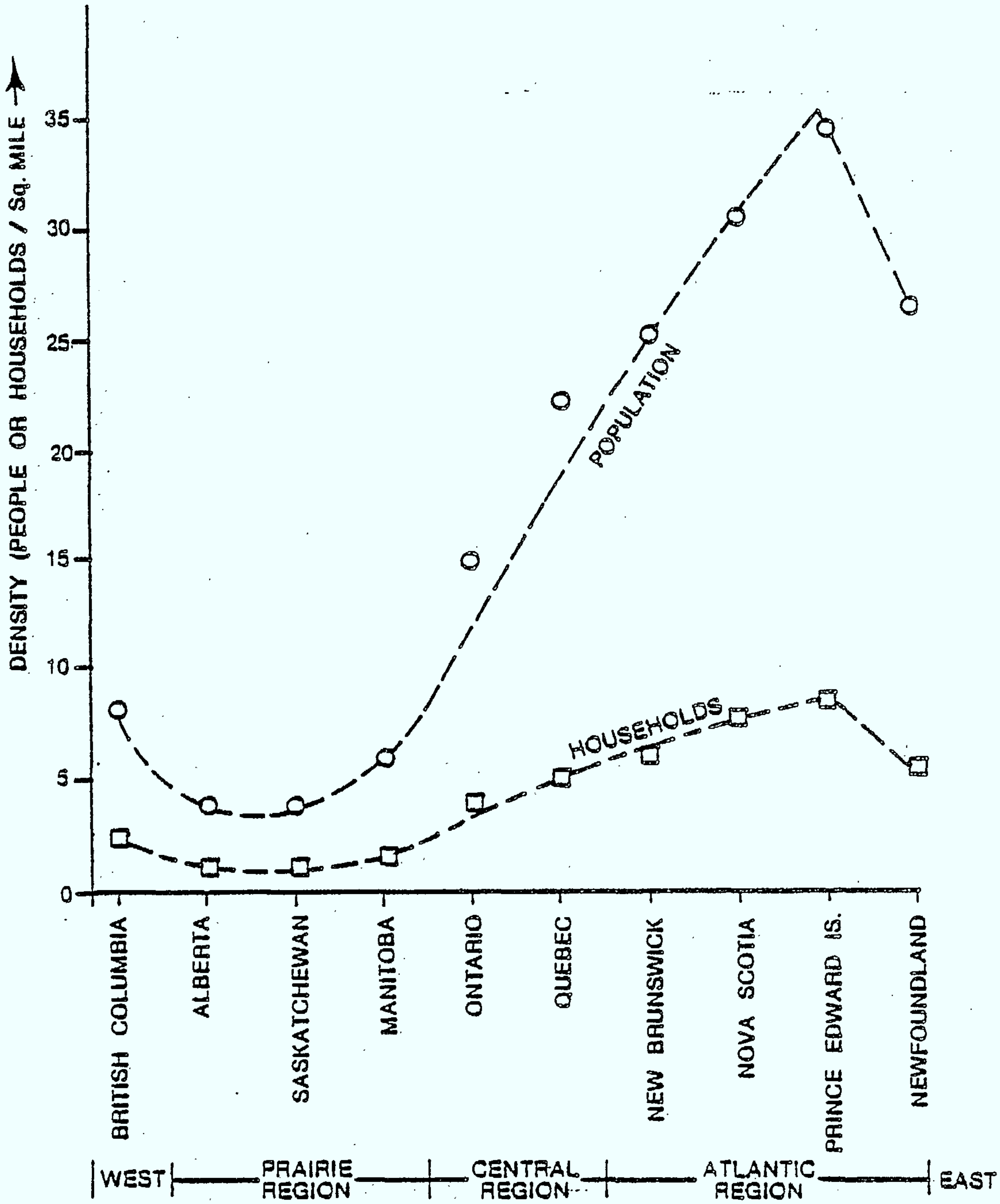

Fig. 3 RURAL POPULATION AND HOUSEHOLD DENSITY BY PROVINCE

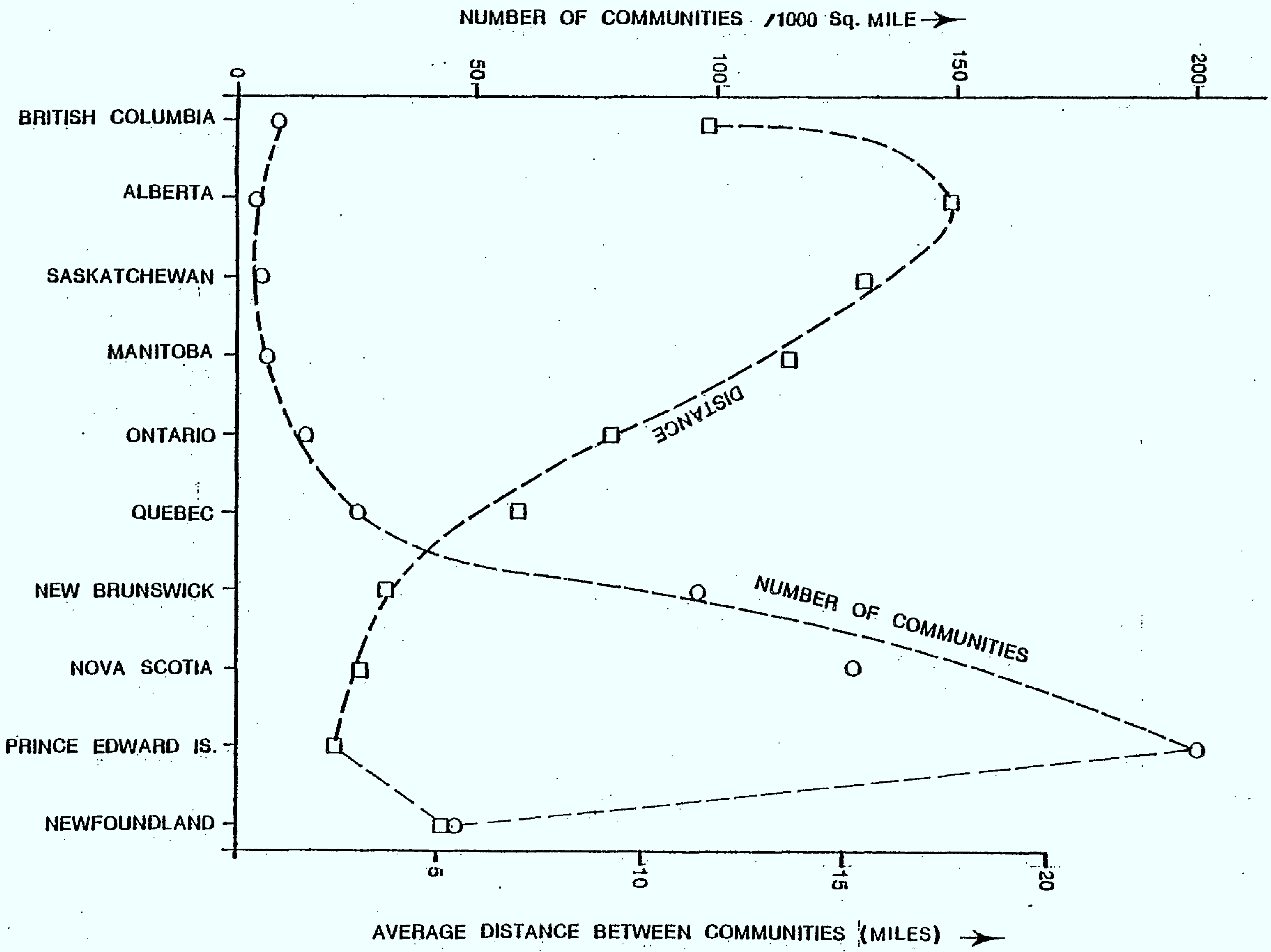

Fig. 4 COMMUNITY DENSITY AND SPATIAL SEPARATION BY PROVINCE

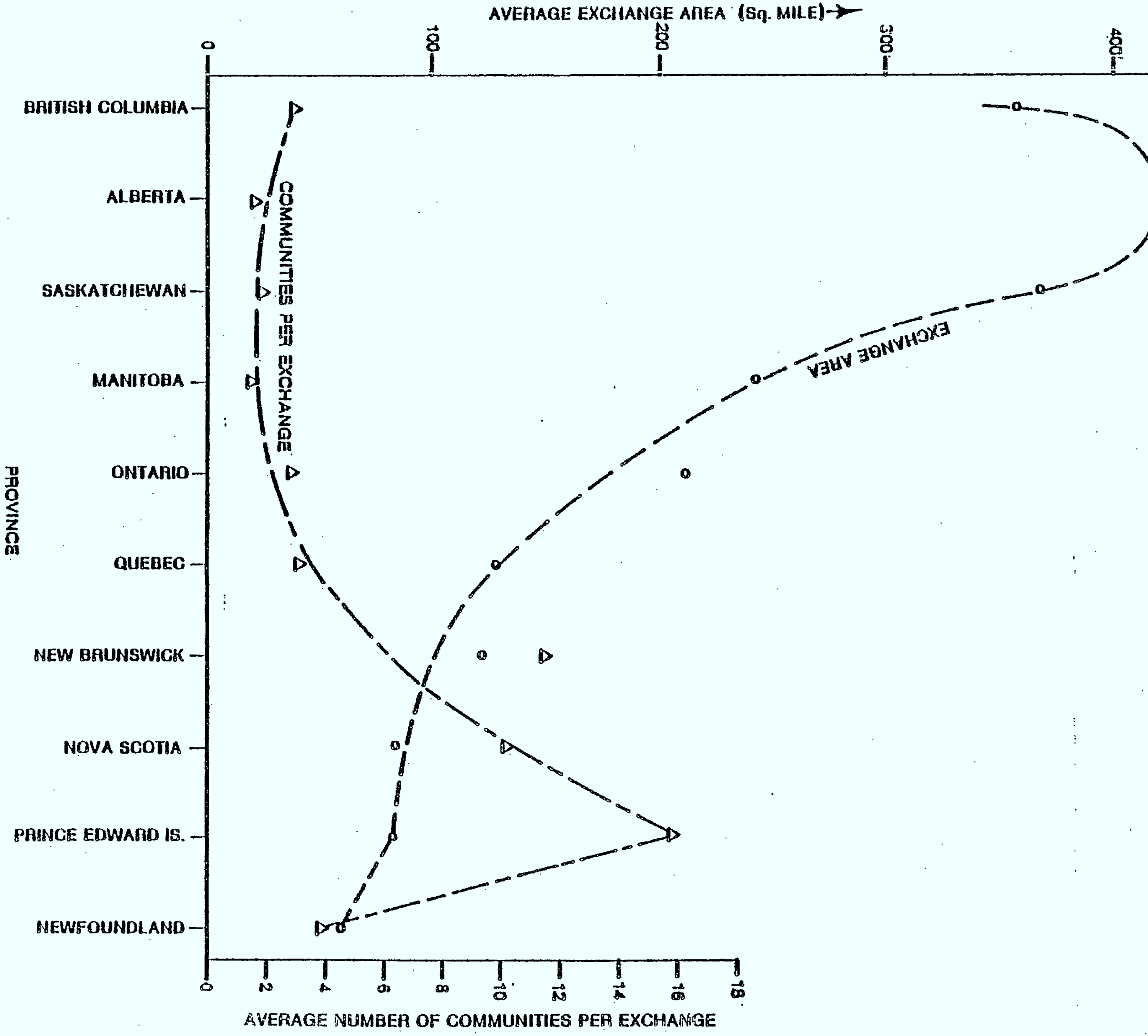

FIG. 5-VARIATION OF EXCHANGE SIZE AND NUMBER OF COMMUNITIES SERVED BY PROVINCE

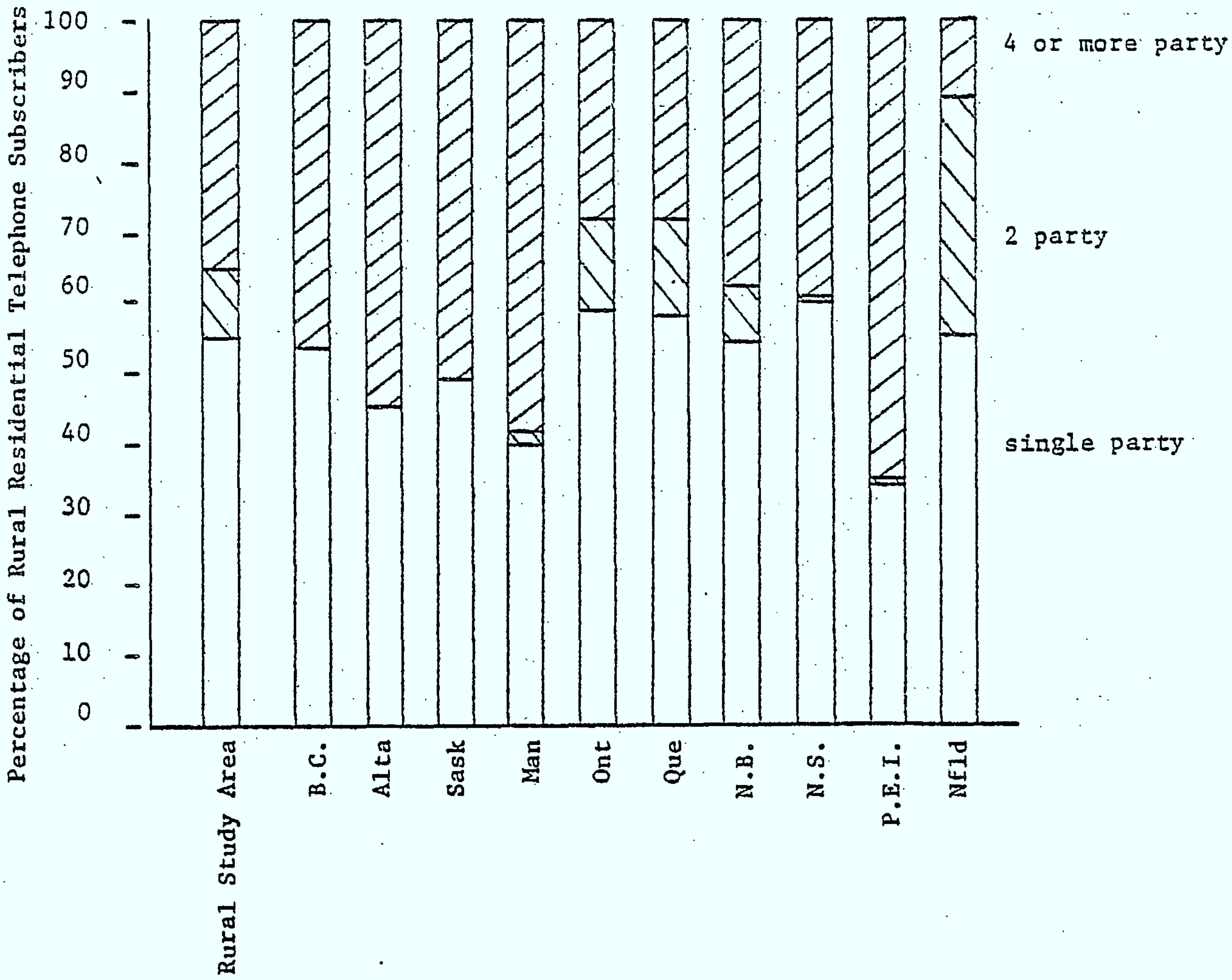

FIGURE 6. RURAL TELEPHONE SERVICE (1976 ESTIMATES)

We have also estimated that further improvement of the remaining party-lines, after 1983, to single line service by means of conventional copper pairs would cost approximately $1 Billion (1979 dollars).

In addition to the need for an improved telephone service, our studies have also identified a need for better mobile radio communications. The degree to which these needs might be reflected in price-dependent demand is being measured at the present time by means of a rural demand survey.

(c) <u>Television and Radio Services</u>

(Ref. 1, 9, 10, 11, 16, 18, 23, 24)

A large proportion of the rural population of Canada is not able to receive Canadian AM radio broadcast during evening and early morning hours. Even during daytime hours, about 6% of the population are not able to receive any radio broadcast signals at all. On the other hand, urban residents have become accustomed to four or more TV channels to choose from (up to 30 or 35 wherever CATV service is available), and a variety of both AM and FM broadcast channels.

These figures indicate that rural residents, by comparison, are very poorly catered for in terms of such services. Furthermore, those rural residents that happen to receive some of these services generally have to be content with an inferior reception quality and a limited choice of programs. However, 43% of rural dwellers are served with two or less TV channels and only 10% have access to CATV service.

A breakdown by province of the percentage of the total population receiving no radio and TV service is given in Table II.

Whereas Canadian city dwellers have access to an average of 13 different TV channels, less than 4 channels, are available on average to rural Canadians. This number decreases drastically as one moves further away from metropolitan areas.

While there is some indication that rural people want a greater choice, the extent of their needs, their willingness and ability to pay can only be assessed after a proper country-wide survey is conducted. This survey has been initiated and is scheduled for completion by Summer 1981.

(d) Other Communication Services

- Telidon:

The need by rural residents for a general information retrieval service to the home, such as Telidon, should be evaluated on the basis of current and prospective experiments such as the Elie-St. Eustache fibre optic field trial and the IDA trial of Manitoba Telephone System.

- Alarms and Meter Reading

Low-cost automated alternatives to the present emergency meter-reading systems are desirable in rural areas. However, this same need may exist throughout Canadian society and not just in rural areas. Also, pilot installations are being implemented now in Canada, so no further stimulus is recommended for the moment. But monitoring

Table II

Non-Coverage of Radio and Television Services, by Provinces
(Per cent of total population receiving no service)

(1976 Estimates)

Provinces	Monaural Radio Sunrise to Sunset	Stereophonic Radio	Television
Newfoundland	5.9	97	6.6
PEI	0	67	7.0
Nova Scotia	1.2	21	0.0
New Brunswick	1.6	36	0.2
Quebec	0.8	6	.1
Ontario	0.6	3	0.4
Manitoba	1.5	11	3.2
Saskathewan	0.7	58	8.4
Alberta	0.5	18	
British Columbia	3.6	16	4.1
Yukon Territory	13.4	100	18.8
Northwest Territory	32.8	98	43.4
Canada	1.23(1)	13	2.0

Note: Not covered by any station. The Accelerated Coverage
(1) Program (ACP) will bring this to 1% for Canada and by language group and CBC coverage. Projected figures by province after implementation of the ACP are not available.

of activity in this service area is important in order to ensure that rural interests are eventually heeded.

3.1.2 Levels of Communications Services Desired by Rural People and Their Willingness and Ability to Pay

This aspect of the quantification of the rural communications problem unfortunately encountered some delays because of difficulties in finding a suitable research group to carry out the work and the raising of necessary funds for the project. The necessity for conducting a survey to assess the needs of the rural population was recognized at the beginning of the Rural Program. A small contract study was carried out in 1978-79 by the University of Ottawa on a possible demand model. This was to be followed by a country-wide survey. This survey is the key to the full and proper definition of the rural communications problem. Its completion is scheduled for the Summer of 1981.

3.2 Feasible Technological/Economic Options

(Ref. 2, 3, 4, 12, 13, 14, 15, 16, 17, 25, 28, 30, 31, 33, 34, 35, 43)

A great deal of attention has been devoted to this issue under the Rural Program, and the bulk of the R&D effort was expanded in analyzing the technological/economic options. As a result, this aspect of the Rural Program objectives has been satisfactorily met.

The rural communications problem is a very complex one and our studies have shown that no individual technological solution is unique for all situations. The problem is further complicated by the fact that there exists an intricate regulatory and institutional situation in Canada, which will certainly make the application of any one set of solutions on a national scale difficult, if not impossible to implement. In general, each local environment will have particular technological solutions that are best suited for its own situation. Such may be the case, for example, when trying to choose between integrated coaxial cables and integrated optical fibre systems for telephone and TV distribution. Provincial authorities may choose to implement a variety of these systems as they consider appropriate and wherever permitted by regulatory authorities.

The main purpose of the Rural Communications Program, however, is to identify those technological areas which promise to offer economical solutions to the rural communication problems discussed in section 3.1. This program has identified the following potential technological solutions:

(a) For Telephone Service

- Use of the Rural Interface Device (RID)
- Potential use of Rural Mobile/Fixed Radio

(b) - Use of Anik-C type satellite for direct broadcast to rural homes

The sub-sections that follow discuss the study findings in some detail.

3.2.1 Improved Telephone Service

For the purpose of improving telephone service to the rural areas at acceptable costs, the following technologies were examined:

(a) Rural Interface Device (RID)

(b) Digital Subscriber Carrier

(c) TDMA (Time Division Multiple Access) Subscriber Radio

(d) 18-GHz Rural Digital Microwave Radio

(e) Rural Mobile/Fixed Radio

(f) Satellite Distribution

The following sections describe various studies conducted under this program in exploring the above listed technologies.

3.2.1.1 Rural Interface Device (RID)

(Ref. 45, 46)

The RID is a "black box" that can be retrofitted to all existing party-line telephone stations in order to improve party-line service. It essentially converts the basic party-line system to provide most desirable features that are available to an individual line service such as a complete privacy, selective ringing and Party Automatic Number Identification for toll charging purposes. The only remaining inconvenience in a party-line system using RID is that when one of the subscribers uses the line, the line will give a busy signal to all the other subscribers, sharing the same line, i.e. no more than one subscriber can use the line simultaneously. To alleviate this inconvenience, "Automatic Ring-Back" and "Emergency Break-in" features are incorporated in the system.

(a) Automatic Ring-Back

This is a feature whereby if a party-line subscriber attempts to access the line and receives a busy signal, the RID will be activated to ring the calling subscriber's phone as soon as the line becomes available. Therefore the calling subscriber, waiting to access the line, need not continually check whether the line is still busy.

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(b) Emergency Break-in

In an emergency, a party-line subscriber may access a busy line by flashing the switch-hook and may speak to the parties already on the line for a limited 10 second period. The access interval is preceded and ended by a short warning tone burst heard by the parties speaking on the line.

The installed cost of the RID unit together with the shared cost of the Party Automatic Number Identification (PANI) equipment at The Central Office is estimated at a total of $110 (1979 dollars) per subscriber.

It is estimated that there will be approximately 650,000 four-party lines remaining in Canada after 1983, at the completion of the carriers' up-grade program, and it would cost approximately $71.5M to retrofit the 650,000 four-party lines with RID and PANI equipment. This cost is very small in comparison with overall invested or annual capital expenditures for telecommunications equipment in Canada.

The acceptance and success of the RID/PANI concept was evaluated in a field trial conducted by the Alberta Government Telephones (AGT). The LSI (large scale integrated) chip for the RID device was developed by Mitel Corporation. The Department of Communications partly funded both the field trial and the LSI chip development.

The field trial was successfully completed on schedule in October 1980 and AGT has issued its report on the trial.

Summary of some of the major findings of the trial are:

a) The subscribers who participated in the trial provided a positive response in favour of the RID unit.

b) Subscribers have indicated their willingness to pay the necessary additional cost for the use of RID if they are made available.

c) The prototype RID units used in the trial exhibited several technical difficulties related to reliability and maintenance of the equipment.

d) The RID unit needs further development to overcome the technical problems and minor design deficiencies identified in the trial, before it can be marketed for general implementation.

Mitel Corporation is now actively re-engineering the RID device and plan to manufacture and market the device in 1982.

The field trial has proven the potential of RID to improve party line service in Rural Canada. Thus if a solution to the technical problems and minor design deficiencies of the device can be attained, then Rural Canada could be given pseudo single-line telephone service at resonable cost within a very short time.

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3.2.1.2 Digital Subscriber Carrier

(Ref. 44)

Although many types of subscriber carrier systems are available on the market, none was found to meet the objective of economically providing telephone service to low density rural areas. The Rural Program studied twenty-seven kinds of subscriber carriers encompassing analog, digital, radio and subscriber line concentration systems.

Existing digital carrier systems with subscriber line concentration are high capacity carrier systems designed to concentrate up to 256 subscriber lines through multiple remote terminals homing on the central terminal. These carrier systems are intended for use in high density areas located close to urban centres and are not economical for use in low density rural areas.

Low capacity digital carriers on the other hand, are generally used as point-to-point systems, because of high cost of multiple remote terminals. They provide no line concentration and will thus serve only 48-96 subscriber lines. Low capacity digital carrier can be supplied with multi-terminal options at much higher cost. Therefore, these carrier systems might be suitable for use only in small areas where the subscribers are closely clustered together, but would be uneconomical to use in spread-out low density areas.

Also existing in the market are some very low capacity (7 subscriber lines) analog carrier systems with multiple remote terminals capability. However, the high cost and potential obsolescence of analog technology tend to make it non-viable in the long run for rural telephone applications. In view of the growing trend towards all-digital networks, including the implementation of an increasing number of digital switching exchanges, trunks and feeder cables, a conceptual need for a small capacity (under 48 subsriber lines) digital subscriber carrier was identified.

A study was carried out, under contract by SED Systems Ltd. to establish the cost and performance of a digital subscriber carrier system for rural telephone applications based on the objectives of the Rural Program.

The study contract resulted in an exploratory development of a laboratory model for a 24-channel digital subscriber carrier system with optional capability to concentrate up to 48 subscriber lines.

Based on the laboratory model some feeling for the cost per subscriber was obtained. The cost per subscriber was found to be sensitive to various factors such as the distribution of subscriber premises, sharing of common equipment, subscriber concentration and use of remote power.

The following four hypothetical cases using 24 and 48 subscriber line systems were configured to demonstrate some typical cost situations.

1. 46 subscribers scattered at random so that no remote terminals can be shared: - $ 1600 per subscriber.
2. 46 subscribers with 4 subscribers per remote terminal: - $ 800 per subscriber.
3. 46 clustered subscribers all sharing the same remote terminal: - $ 450 per subscriber.
4. 24 clustered subscribers all sharing the same remote terminal: - $ 600 per subscriber.

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These cost figures do not include any additional cost of switching equipment due to increase of traffic associated with individual line service. It is estimated that the cost of subscriber carrier could be about 60% of the cost of the conventional copper pair systems. Technical performance demonstrated by the laboratory model was satisfactory. However, system reliability and service availability will have to be tested beyond the laboratory model stage to take into account such factors as the number of subscribers sharing a cable pair and the additional complexity of electronic equipment introduced to the system. Also redundant back-up of equipment which is a contributory factor in determining service reliability and availability, was not taken into account in the above cost estimates.

In summary, we conclude that unless further studies are conducted, there is no sufficient justification at this juncture to recommend a full-scale implementation of digital subscriber carriers in low density rural telephone areas. Nevertheless, digital subscriber carriers may have potential applications in areas where subscriber clustering permits economical sharing of costly common equipment.

3.2.1.3 TDMA Subscriber Radio

(Ref. 48)

TDMA subscriber radio is a time-division, multiple-access, local loop distribution system. This system, manufactured by Farinon Ltd., in Canada, is already in use in some rural areas.

Each TDMA Subscriber Radio is located at a central office and provides local loop facilities by radio to surrounding subscribers.

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The system links subscriber terminals with the public telephone networks and operates under existing switching, signalling and numbering plan arrangements.

The advantage of radio systems is that they are less dependent on terrain than conventional cable systems.

TDMA systems are confined to 800 MHz and higher frequency bands due to constraints on the available spectrum. These systems can operate over radio path distances ranging from 10 km to 65 km.

A TDMA radio system has the following features:

1. It is a point-to-multipoint system consisting of a Central System and several Outstations with one or more subscribers per Outstation.
2. It provides multiple access on a demand-assignment basis for up to 94 subscriber lines served by 15 channels.
3. It permits full access to all trunks by any line.
4. All equipment is environmentally self-sufficient.
5. So far as the subscriber is concerned, the system operates identically to conventional copper pair systems.

A large portion of the total system cost is attributed to common equipment and support structures. Hence, the cost per subscriber is dependent on the total number of subscribers to be served. Individual line service using a TDMA system, can be provided roughly at 65% of the cost of a conventional cable system in many rural situations, depending on terrain and distance.

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3.2.1.4 18-GHz Rural Digital Microwave Radio

(Ref. 15 and 47)

A study on new 18-GHz microwave radio system was conducted jointly between industry and government and then was followed by a preliminary development of such a system. This study showed that an 18-GHz microwave radio system could provide a cost-effective method of carrying traffic between a switching office and a subscriber distribution system in rural environments. Based on available demographic statistics the system was designed for routes with traffic capacities equivalent to 4 T1 (1.544 Mb/s) lines with an overall system length of under 50 km.

Such system is also equipped with drop-and-insert capabilities so that traffic from communities along its route can be dropped and inserted inexpensively.

Dictated by the nature of subscriber dispersion in rural communities, the experimental system was designed with intermediate repeater hops spaced about 10 km apart to allow optimum drop-and-insert of subscriber circuits.

Traffic from the drop-and-insert points would be distributed on voice frequency cables to the communities along the 18-GHz microwave link.

The major advantage of an 18-GHz rural radio over cable or lower-frequency radio systems is that traffic from communities along its route can be extracted and added inexpensively, and with a good quality of service. This advantage is largely due to the lower repeater cost and the short distance between repeaters, which allows traffic from a community on the route to

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travel less than 10 km on voice frequency cables to reach the nearest repeater for transmission on the higher quality trunk lines. In contrast to this, the repeaters of a conventional radio system are about 50 km apart, and traffic from a community situated halfway between them has to be sent up to 25 km on voice frequency lines to reach the closer one. This long haul on voice frequency lines makes for lower quality of transmission and higher costs.

An 18-GHz digital microwave system would be more cost-effective in a rural environment than putting in new T1 cable carrier systems, particularly in areas with rugged terrain.

A comparison among relative costs of new digital cable systems, conventional 2-GHz radio, and 18-GHz rural radio for trunk applications shows that the new 18-GHz radio is very competitive for short-haul applications. A factor of two-to-one cost saving could be achieved using a combination of 18-GHz radio and cable distribution versus a system based entirely on cable.

3.2.1.5 Rural Mobile/Fixed Radio

(Ref. 12, 13, 31)

Mobile/fixed radio telephone systems in the VHF/UHF bands have been in several studies, for local distribution in rural areas. The studies carried out so far lead to the following conclusions:

(a) Radio systems available in the market, at the time of the study, for rural telephone subscriber services were not cost-effective, and will not significantly contribute to the overall improvement of rural communications services in Canada.

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(b) Based on current technology it is technically feasible to develop a universal radio system to cater for the need of rural and mobile telecommunications, but the economic viability of such feasibility has yet to be proven.

The universal radio system will have to be designed and manufactured to serve both mobile and fixed station applications.

In theory, some economy of scale could be achieved on equipment cost as a result of universal system approach because of larger mass production of common equipment.

(c) From the technology standpoint, some development efforts may be needed in the following technical areas in order to improve rural radio services in Canada.

- Cost reduction of systems and equipment
- Transmission and distribution
- Signalling and network control
- Radio propagation and efficient spectrum utilization

(d) There is apparently, a large potential market for radio services in rural Canada and other countries. This potential market could be successfully realized if the latest technology could be exploited to reduce the cost of radio equipment and hence create a massive market volume. The development of radio equipment in Canada is somewhat fragmented among several manufacturers. As a result R&D investment by individual manufacturers is restricted to small segments of the market.

(e) With regard to the potential market for a Rural Radio Service, it is concluded that a large market exists for the right type of Rural Radio Service in Canada and abroad.

(f) With regard to the use of spectrum in rural areas, it is concluded that:

- The growth of large area systems, such as public mobile and province-wide mobile systems, has been impeded by the spectrum congestion and high demands for frequency allocations in urban areas.
- Better allocation of radio frequency bands coordinated thoughout the country, would be needed in order to implement an effective Rural Radio Service.
- The cellular approach to spectrum allocation might be desirable in rural areas, and more effective utilization of spectrum such as by improved modulation methods might also be desirable to achieve the most cost effective service.

No firm cost figures were derived in the studies, as these would require a major study beyond the scope and resources of the Rural Program. However, the factors in favour of a mobile/fixed radio solution are such that it is recommended that the Federal Government should give serious consideration to mounting a major research program in mobile/fixed radio networks.

3.2.1.6 Satellite Distribution

(Ref. 16, 17, 18)

It is technically feasible when Anik-C becomes operational, that telephone and other new services to rural Canada could be provided by Satellite provided that subscribers are willing to pay the higher cost for such

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services via satellite distribution.

From the telephone service standpoint Anik-C could be to provide the following links:

(i) between switching centers (Toll service),

(ii) between concentrator points and switching centers,

(iii) long-loop connections

It would, of course, be necessary to ensure that no single telephone call ever passed through more than one satellite link because of the unacceptable delay that occurs in that situation. Such precautions can be designed into the network.

(i) <u>Toll Service</u>

At least half of the country's end offices are located in rural areas. These offices are small, have slow growth, and have expensive toll connecting links. Therefore economical benefits could be derived by using a satellite toll network for these offices. Such a network would link all rural end offices with all other end offices via a demand-assignment toll overlay network. Growth in toll traffic between rural end offices and between rural and urban end offices would be routed via this new toll network. Calls between urban end offices at relatively short distances would still be routed over terrestrial links/networks.

(ii) <u>Concentrator Point</u>

In a satellite network, concentrator points could be established at base stations for mobile radio systems and for radio telephone systems in rural areas. Concentrator points would also be used to reduce cost of outside plant for establishment of single party line service. These new centers would be integrated into the toll overlay network described above.

(iii) Long Loops

Satellites could be used to establish direct telephone connection to rural homes. This service could be integrated with the satellite broadcast system or with the toll network described above. A preliminary study of the use of Anik-C for rural areas summarized those conclusions related to telephone service by satellite (Ref. 16).

Long loop systems integrated with the Direct Broadcast Satellite (DBS) system would be needed to provide private line telephone service to any hard to reach subscribers. The number of users would depend on the cost of the remote unit. At high cost only a few subscribers will benefit and at low cost the service could expand to such an extent that an upper limit of space segment capacity will be reached. At that point long loops via satellites could be established. Many of the "new services" to homes could then be readily integrated with the telephone transponder in the DBS. Two-way interactive services could be implemented relatively cheaply to homes already equipped for long loops via satellites.

In summary, satellite derived systems can play a role in providing improved communication to rural areas. The development of a cost effective channel unit is of paramount importance, if cost effective systems are to be derived.

3.2.2 Television and Radio Broadcast

Under the Rural Program, the following technologies were examined for television broadcast:

(a) Direct Broadcast Satellite (DBS)

(b) Multi-Channel TV and Radio Rebroadcast

(c) Integrated Coaxial Cable

(d) Integrated Optical Fibre Cable

Radio (sound) broadcasting was examined under item (b) and is inherently available under items (c) and (d) without significant additional costs.

3.2.2.1 Direct Broadcast Satellite (DBS)

It has been generally assumed in the past that for direct-to-home satellite broadcasts, a very high power satellite similar to the Hermes (CTS) Experimental Satellite would be needed. With the technique of spot-beam satellite antenna and the advances in low-cost low-noise receivers on the ground, the development of which was supported by DOC, it has now been demonstrated in the Anik-B program that small low-cost earth stations are feasible for the direct-to-home reception of TV signals. If mass produced, the cost of these earth terminals is expected to be in the region of $ 400 to $700 (1979) (manufacturer's price).

In the context of the Canadian environment, there are significant advantages in proposing that the Anik-C satellite be seriously considered for delivery of TV programs directly to rural homes (and to remote and urban homes as well for that matter). These advantages are:

(i) The satellite for DBS programs could share the standby satellites (two required) that are also back-ups to the communications satellite dedicated to the common carriers use. This sharing not only has cost benefits but also has operational advantages (e.g. common ground control station, staff, etc).

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(ii) A satellite project could be implemented within a very short time. There is, in fact, a current application before the CRTC to provide Direct Broadcasting Service to rural areas. Already three satellites are being manufactured and one of these could be deployed for the DBS TV service. On the basis of $ 50 million per satellite (including launch costs), the half share of a 4-satellite space segment (one for TV, one for TCTS and two common standby satellites) would cost $ 100M. In addition, it would be assumed that there would be 4 TV up-link earth stations (located across Canada from east-to-west) costing a total of $ 10M, making a total of space segment cost of $ 110M. This is translated as $ 33M annual operational cost, assuming a satellite life of 7 years. Inclusive of the satellite ground control operational cost, we arrive at a ball-park total figure of $ 35M annually.

3.2.2.2 <u>Multi-Channel TV and Radio Rebroadcast</u>
(Ref. 55)

A study was conducted to examine possible wide-scale application of low-power rebroadcast transmitters in all rural Canada. Four model packages were examined, each suitable to a specific set of environments:

<u>Model 1:</u> <u>Pole-Mounted Model</u>

For settlements requiring a 2-mile (3.2 km) coverage and for large communities requiring up to 4-mile (6.4 km) coverage.

<u>Model 2:</u> <u>Standard Shelter Model</u>

To provide coverage of more than 4 miles (6.4 km).

<u>Model 3:</u> <u>Specialized Shelter Model</u>

For settlements in mountainous areas.

<u>Model 4:</u> <u>Existing-Housing Model</u>

For general application in communities.

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In general we found rebroadcasting to be an economical and attractive solution to deliver TV and FM signals to rural homes in the majority of cases. But, in some minority cases, representing about 30% of households in rural Canada where the communities are of a highly dispersed nature, rebroadcasting will be less economical because of the lesser number of households sharing the system costs.

Another case in which it is also less economical to provide TV and FM signals using rebroadcast methods, is in communities that are beyond the radio propagational range of the primary broadcasting transmitter necessitating the use of terrestrial or satellite microwave links to carry the signal to the community local broadcast transmitter.

From our studies, rebroadcasting appears to be an economical solution to distribute a limited number of TV and FM channels to high density rural communities. However, for most of these communities coaxial cables could also be viable alternatives because of the inherently greater channel capabilities of coaxial cables.

3.2.2.3 Integrated Coaxial Cable (Ref. 28, 34)

It is generally accepted that the use of coaxial cable to distribute TV programs to rural areas is not economically viable. However, a study was conducted to see if combined telephone and TV distribution in one cable system could bring the cost of both services down to an acceptable level. The study concludes as follows:

(a) In relatively high density rural areas (5 to 50 households per km):

i) An integrated coaxial cable system could prove viable as a new or replacement system.

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ii) It would not generally be economical to put a new integrated system into areas where an adequate telephone or CATV system already exists or in areas where upgrading or reinforcement of existing plant cannot yet be justified.

(b) In the very low density areas (less than 5 subscribers per km), no line system, (whether integrated or separate), can be economically viable.

Considering that some 80% of rural households are located in areas with densities of 5 or more households per kilometer, an integrated coaxial cable system might be economically viable in some parts of rural Canada. The extent of these areas is not known.

3.2.2.4 <u>Integrated Optical Fibre Cable</u>

(Ref. 35)

The question of integrated optical fibre cable system is very much the same as that of integrated coaxial cable system. Our studies indicate that at present projections of cost, an integrated optical fibre system is about the same in cost as (or marginally lower than) a comparable integrated coaxial cable system. Therefore, in general, the same conclusions drawn for the integrated coaxial cable study, will apply. However, the following additional factors will have an impact on any long term considerations:

(a) The cost of coaxial cable will most likely go up, at least with inflation. On the other hand, the cost of optical fibres will probably go down, especially if its large scale use in urban areas comes about.

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(b) The capacity of optical fibre systems is much higher than that of coaxial cable systems, leading possibly to evolution of new networks and services.

The DOC is currently participating jointly in an optical fibre system field trial with CTCA, in Elie-St. Eustache (Manitoba). This field trial will give some insight into the technical and operational problems and costs and opportunities.

In summary, in areas where an integrated telephone and television rural distribution system is justifiable, it is likely then an optical fibre system will be preferable because of its higher future potential. Such a system is likely to be viable in areas having subscriber densities of 5 to 50 subscribers per kilometre where a new or replacement telephone system is required.

3.3 Fostering Federal-Provincial Cooperation in Rural Services

This aspect of the Rural Program objective has been satisfactorily met. Good contacts have been established between the DOC research workers and provincial telephone companies' personnel. Study reports were made available to telephone companies and verbal presentations were also given. In addition, a number of studies were carried out either as joint projects or with strong support and co-operation of telephone companies. In the development of Low-Capacity Digital Subscriber Carrier System all Provincial telephone companies were consulted. The Rural Interface Device (RID) development and field trail represent a close cooperation with Alberta Government Telephones (Ref. 44, 45). The Elie (Manitoba) fibre optics field trial is a cooperative effort between the DOC, and the Manitoba Telephone System. Occasional briefings were given to the Atlantic Consultative Committee on Communications. Cooperative studies were carried out with the Governments of Newfoundland and of Ontario.

3.4 Stimulation of Canadian Product Design

(Ref. 15, 17, 44, 45, 46)

This aspect of the Rural Program objective has been satisfactorily met. A number of contracts awarded were in this category. The potentially viable products include the Rural Interface Device (RID) in the form of a large scale integrated (LSI) chip and the complete RID system. Other telephony contracts included exploratory development of a low capacity Digital Subscriber Carrier System for rural applications and sponsorship of associated market studies. The low-cost earth station development for the ANIK-C type satellite has been successfully undertaken in the Space Sector of the Department of Communications. The Elie fibre optics field trial is based on Canadian designed products and the 18 GHz radio is also a potentially viable product.

3.5 Basis for a Coherent Domestic Market

The essential vehicle here is voluntary national standards. Achieving these is difficult considering the present highly fragmented Canadian environment. Each telephone company feels that it is its inherent right to determine its own technical specifications for its equipment and systems and to purchase independently of the others. Yet without accepted national standards, it is impossible to develop products that can be integrated easily into all systems. Therefore, the problem is not solely technical but is also a policy matter. Both the National and Research Branches should work together on this problem. It is, however, primarily a matter of industrial policy in which communications policy would play a part. Significant effort would be required at both federal and provincial levels of government to bring about any measurable improvement in the situation. A major component of such an indus-

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trial/communications policy would be the availability to selected manufacturers of interface specifications for the major new digital switching and transmission systems being installed by all telephone companies.

4. CONCLUSIONS

Four broad objectives were established for the Rural Communications Program:

(a) To provide an engineering/economic framework for the development of federal policies on rural communications,

(b) To foster federal-provincial cooperation in the improvement of rural services,

(c) To stimulate Canadian product design for rural communications,

(d) To provide the basis for a coherent domestic market for equipment used in improving rural services

All these objectives have been met, except for objective (d) which can be said to be partially met. This is an objective of some complexity and is a matter of joint industrial and communications policy which would have to be tackled at both federal and provincial levels of government.

Objective (a) is by far the most important and has been met; this includes the rural services demand survey field activity completed in March 1981. The completion of the survey was largely due to the support of several federal and provincial government departments. The completion of the rural demand survey report by mid 1981 would be the last step in the assembly of a very comprehensive set of information about the rural demographic/communications environments. The rural communications problem can then be said to be adequately quantified.

The Rural Communications Program has investigated a full range of technology and network solutions.

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The important conclusions are the following:

(i) For the telephone service, the RID/PANI equipment could transform all the remaining 650,000 multi-party telephone stations to provide a level of service almost as good as individual line service in all of rural Canada, at a total cost estimated to be only about $ 70M (1979 dollars). This transformation could be implemented as a retrofit to existing equipment over a very short period of time, say 3 to 5 years at the most. This compares with a total cost of about $ 1.0B using conventional copper pairs or about $ 0.6B using pair-gain techniques such as subscriber carrier, 18-GHz digital microwave or TDMA radio.

(ii) For a longer range solution for telephone service and new data services such as Telidon, alarms and meter reading there appears to be a strong case for the DOC to mount a coordinated research program on the application of a new mobile/fixed radio network architecture for rural communications.

(iii) For television services, the use of the Anik-C type satellite appears to be the most attractive solution. The annual cost for the space segment of a possible service is estimated to be about $35 M (1979 dollars). This would bring direct-to-home TV broadcasts to all of rural Canada (and to remote and urban areas as well), with a capability of 4 to 8 choices of TV channels in most areas. The home reception terminals (excluding the TV set itself) would probably cost about $400 to $700 (1979) (manufacturer's price), when large volume sales are reached.

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(iv) In some specific rural environments, particularly those of higher household densities (say 5-50 households per kilometer) where a new or replacement telephone system is required, the use of an integrated optical fibre cable system for telephone and TV, might be economically viable in the future.

It must be stressed that these conclusions are general in nature. However, local environments vary greatly and each individual situation may have a particular technological solution that fits it best. In practice therefore, even if all the recommended technological solutions are adopted, there will always be a mixture of other solutions, such as microwave distribution, coaxial cables, or copper pairs. The conclusions however, do indicate the major technological thrusts that should be considered in any program aimed at improving rural communications.

The conclusions are derived purely from technological and cost considerations. The technological and cost issues form only a part, albeit an important part, of the overall considerations that must be taken into account in developing any policies or actions on rural communications.

The Rural Communications Program was entirely a research activity. It was aimed at developing the background technological and cost information needed for any policy consideration. The Program has met all its major objectives.

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