

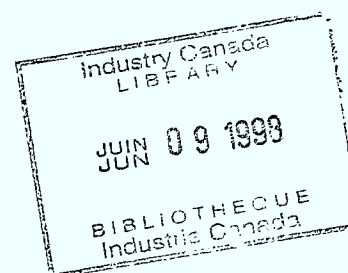
# *COMMUNICATIONS IN THE CANADIAN NORTH*



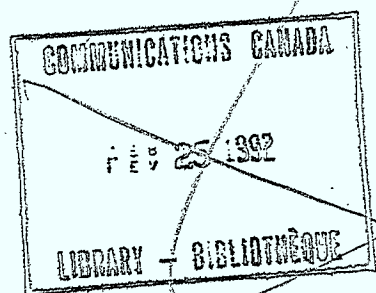
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# *COMMUNICATION IN THE CANADIAN NORTH*



AN APPRECIATION ]



DEPARTMENT OF COMMUNICATIONS

NATIONAL TELECOMMUNICATIONS BRANCH



*Hidden in wonder and snow, or sudden with summer,  
This land stares at the sun in a huge silence  
Endlessly repeating something we cannot hear.  
Inarticulate, arctic,  
Not written on by history, empty as paper,  
It leans away from the world with songs in its lakes  
Older than love, and lost in the miles....*

*....But a deeper note is sounding, heard in the mines,  
The scattered camps and the mills, a language of life,  
And what will be written in the full culture of occupation  
Will come, presently, tomorrow,  
From millions whose hands can turn this rock into children.*

*f r scott*

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## DEPARTMENT OF COMMUNICATIONS

Gilles Bergeron,  
Assistant Deputy Minister.

This Report represents the initial phase of a study by the National Telecommunications Branch of the existing facilities and future trends of telecommunications as they relate to the people and physiography of the Canadian North.

The study was prepared under the direction of Mr. D. S. Loftus, Northern Systems Consultant, of the National Telecommunications Branch.

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Messrs. G. C. Brooks and D. Fraser provided supporting information for the study on behalf of the Telecommunications Regulations Branch.

Information received from the Departments of National Defence, Indian Affairs and Northern Development, Health and Welfare, and the Canadian Broadcasting Corporation is acknowledged and appreciated.

Roy Bushfield,  
Director,  
National Telecommunications Branch.

June 30, 1969.



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## USE OF MAPS AND PLATES

- Notes:
- 1 This Report contains fold-out, fold-in maps which can be overlaid by one or more of the Plate transparencies.
  - 2 Plates and figures follow as closely as possible after the subjects in the text to which they are related. They are also listed in the section headings for easy reference.

## I SCOPE OF REPORT

This Report is the initial phase of a telecommunications study for the Canadian North. It is supported by a separate supplement called a "Telecommunication Systems Catalogue" which contains the technical details for engineering reference.

Both civilian and military systems are defined. Interconnection arrangements to show how telecommunications traffic is routed from major trunk systems in southern Canada to communities in the North are also described and illustrated.

The deployment and growth of telecommunication services in Canada's North are set in relief by an outline of the demographic, physiographic, and climatic features of the

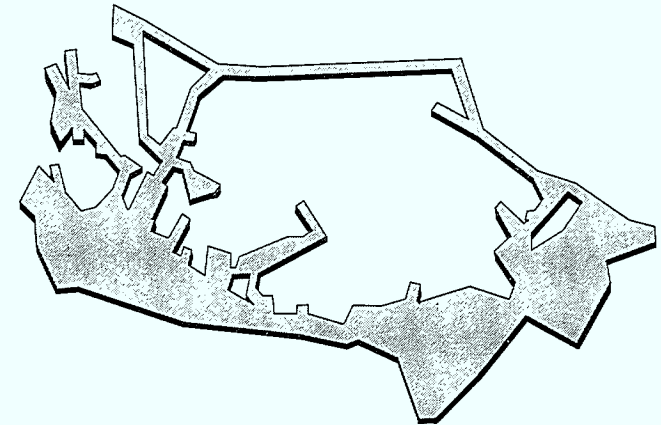
environment. In this way the pattern of development of communications can best be appreciated and the future growth of services more easily discerned.

The theme of this Report is that there are certain incentives and constraints which dictate the evolution of communication systems in the North. Geography, climate, dispersed population and lack of transportation facilities impose constraints on the spread of communications. Human and resource development, the maintenance of sovereignty, technical innovation, and national security provide the incentives to drive communication frontiers northwards.



## 2 HIGHLIGHTS

- Communications are vital to the development of the North but are presently inadequate when compared with the variety, sophistication and quality of services in southern Canada.
- Dispersed population in a harsh environment cannot provide a base for viable commercial communications unless a consolidation of user requirements is encouraged.
- Technological progress in transportation promises easier access to vast mineral and fuel resources.
- Main communication corridors to the North primarily carry defence circuits over tropospheric scatter systems.
- Live network television is unavailable but off-the-air pickups and frontier packages serve some communities. Radio programs are beamed by short wave facilities to the far North.
- Prime need is for satellite and terrestrial systems carrying broadband telephony and television to main centres - supplemented by area distribution systems for extension of service to peripheral settlements.
- The Canadian Domestic Satellite will revolutionize northern communications by bringing high quality telephone services and live television to the North.
- A total systems approach is necessary to tie in the growth of communications with resource development, transportation and power, and social services.
- Future key developments in Northern communications are:
  - Demand Assignment satellite utilization.
  - Solid state radio and cable systems using Pulse Code Modulation.
  - Improved high frequency radio design and computer selection of operating frequencies.
  - Direct home reception of TV broadcasts via satellite.



### 3 INTRODUCTION

The Canadian North stands on the threshold of unprecedented growth. The area is vast and has the capacity to support millions of people. Modern technical advances can now be harnessed to create a human environment for permanent settlement. Development of resources and maintenance of sovereignty are the key priorities which must be recognized for the systematic and planned coming-of-age of the Canadian North.

A planned approach to northern development must also recognize the need for communications, transportation and power, and the importance of the inter-relationship of these services.

Communications are vital to progress in the North. Isolated communities must have adequate communications to support essential health services and to establish human contact with southern Canada. Substantial population growth, which is so necessary, not only for the extraction but also for the processing of resources, cannot be expected unless communications enjoyed by most Canadians are extended to the silent North. Defence of our nation requires reliable communication corridors reaching to the top of the Continent.

The "Canadian North" in communication terms means those parts of Canada not enjoying telephone and television services presently available in the populated southern belt. Generally this is Canadian territory lying above the 55th parallel. It includes the Arctic, Mid-Canada, and the northern extremities of the Provinces where interconnections are made to southern trunk networks.

Communication satellites will add a new dimension to the development of the North. Reliable telephone service and network television can at last reach remote northern settlements. Flexibility will be essential in satellite planning to ensure that a variety of different communication needs can be properly met. Priorities must be established in determining the areas that would most benefit from satellite service, with special consideration given to those communities not accessible to service by terrestrial means.

As a pre-requisite to communications planning, it is necessary to have comprehensive information on the communication systems that presently operate or are proposed for operation in the North. This Report provides this essential information.

## 4 NORTHERN ENVIRONMENT

See Figure 1  
Plates 1 to 4

Environmental factors have particular influence on the growth and pattern of development of the Canadian North. Settlement is closely related to the physiography and climate of the region.

### 4.1 PHYSIOGRAPHY

Figure 1

The Canadian North can be divided into six distinct physiographic regions. These are shown in Fig. 1.

#### Arctic Ocean

The Arctic Ocean is a large virtually land-locked sea centred on the North Pole. Drifting pack ice averaging five to ten feet in thickness covers much of its area. Massive oil finds in Prudhoe Bay (Alaska) and anticipated similar finds on the continental shelf below the Archipelago Islands give economic importance to the region.

#### Arctic Lowlands and Plateaus

This region is underlain by sedimentary rock. The terrain is gently rolling with occasional rock outcrops. Economic activity centres around mineral and oil exploration. Permafrost forms the major obstacle to physical construction and development.

#### Canadian Shield

This is a vast rugged area of very old and weathered Precambrian rock covering nearly one half of the country. The region is poorly drained and is characterized by numerous lakes, rocky ridges, precipitous rivers and muskeg areas. The shield is rich in minerals and is the source of Canada's present mineral production.

#### Hudson Bay Lowlands

This region is underlain by sedimentary rock and has a very gentle slope from south to north. The drainage is extremely poor and muskeg is widespread - a major deterrent to physical development. Other than hunting or trapping, there are few economic activities in this region.

#### Cordilleran Region

This is a region of rugged mountains, steep slopes, deep valleys and interior plateaus. Mining, forestry, hydro-electric power, fisheries and agriculture are all important resource industries in this region. The rugged nature of the terrain makes transportation and communication difficult and costly.



## Interior Plains

The Interior Plains Region is a large continental depression of sedimentary rocks. Because of its relatively flat relief and fertile soils the area is ideal for agriculture. Oil, gas and minerals are important resources. There are no major obstacles to transportation and physical development in this region.

## 4 . 2 CLIMATE

Plates 2 to 4

The climatic regions of the Canadian North can be divided into three groups as illustrated in Plate 4.

### Tundra

The tundra climate is characterized by long and cold winters followed by short summers. Temperatures range from sub-zero to as high as 50°F. This climate is experienced mostly in the northernmost latitudes and high altitude regions. Precipitation is generally low in the arctic tundra and heavy in the alpine areas.

### Sub-Arctic

This is the most extensive climatic region in the Canadian North. The region enjoys about three months of cool summers when the average maximum temperature is around 60°F. Precipitation ranges from fifteen to twenty inches per year and is concentrated in the summer months. A combination of precipitation and low evaporation rates supports plant growth.

### Humid continental

Most Canadians are familiar with this southern climate. Summers are warm with a mean temperature over 60°F; for three to five months temperatures drop below freezing. Mean annual precipitation varies from fifteen inches in the Prairie Provinces to fifty inches in Newfoundland. The areas around Fort. St. John, Peace River and Fort Nelson experience this climate in the North.

#### 4 . 3 POPULATION

Plate I

People are the basic element in the resource development of an area. The areas of population concentration in the Canadian North are shown in Plate I.

The major concentration of settlements are found in the:

- o Valley of the upper Mackenzie River and the Great Slave Lake area.
- o Peace River, Dawson Creek area.
- o Triangle of mineral resource towns centred around Noranda in the east, Kapuskasing in the west and Sudbury in the south.

Other agglomerations exist in:

- o Mackenzie River Delta settlement including Inuvik and Tuktoyaktuk.
- o British Columbia; Prince Rupert, Terrace, Kitimat areas.

- o Yukon; Whitehorse, Dawson City, Skagway areas.
- o Victoria Island; Cambridge Bay.
- o Northern Manitoba; The Pas, Flin Flon, Thompson, Churchill area.
- o District of Keewatin; Baker Lake, Chesterfield Inlet, Rankin Inlet, Whale Cove, Eskimo Point.
- o Northwestern Ontario; Pickle Lake, Sioux Lookout, Redlake areas.
- o Baffin Island; Frobisher and Pangnirtung.
- o Northeastern Quebec and Labrador; Wabash, Labrador City and Gagnon.

Most of these agglomerations are related to areas containing several resources and access to transportation and other services. The estimated 1968 population by ethnic origin in the principal settlements of the far North is shown in the table overleaf.

ESTIMATED 1968 POPULATION BY ETHNIC ORIGIN IN PRINCIPAL SETTLEMENTS  
IN THE NORTH

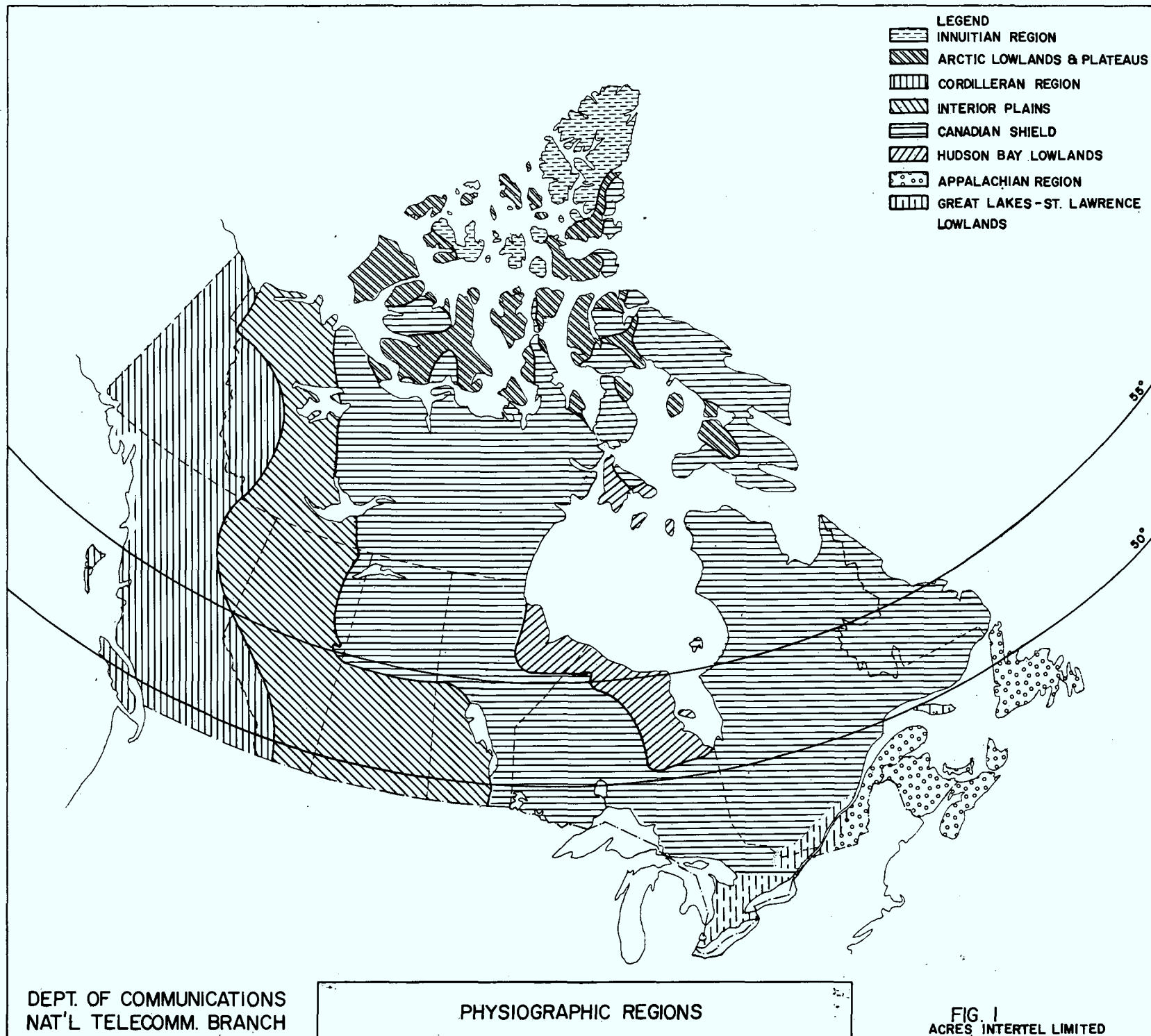
MAJOR POPULATION CENTRES

Location	Indians	Eskimos	Others	Total
Aklavik	130	230	280	640
Baker Lake	-	560	80	640
Cambridge Bay	-	300	280	580
Cape Dorset	-	340	40	380
Copper Mine	-	480	60	540
Coral Harbour	-	270	40	310
Eskimo Point	-	450	30	480
Fort Good Hope	310	-	40	350
Fort Franklin	320	-	10	330
Fort McPherson	460	10	200	670
Fort Providence	360	-	40	400
Fort Resolution	510	-	200	710
Fort Simpson	460	-	260	720
Fort Smith	650	-	1,650	2,300
Frobisher Bay	-	1,200	800	2,000
Igloolik	-	330	10	340
Inuvik	200	500	1,700	2,400
Pangnirtung	-	380	20	400
Pine Point	20	-	590	610
Rae	740	-	60	800
Rankin Inlet	-	400	30	430
Tuktoyaktuk	-	480	50	530
Yellowknife	400	-	3,900	4,300

MINOR POPULATION CENTRES

Location	Indians	Eskimos	Others	Total
Arctic Bay	-	120	10	130
Belcher Island	-	200	-	200
Broughton Island	-	210	-	210
Chesterfield Inlet	-	160	60	220
Discovery	-	-	150	150
Fort Liard	170	-	20	190
Fort Norman	160	-	70	230
Holman Island	-	190	-	190
Lac La Martre	140	-	10	150
Lake Harbour	-	160	20	180
Norman Wells	30	-	180	210
Pelley Bay	-	180	-	180
Pond Inlet	-	180	10	190
Port Burwell	-	110	-	110
Resolute Bay	-	200	70	270
Sachs Harbour	-	110	20	130
Snowdrift	180	-	-	180
Spence Bay	-	240	30	270
Whale Cove	-	180	20	200
Wrigley	140	-	10	150



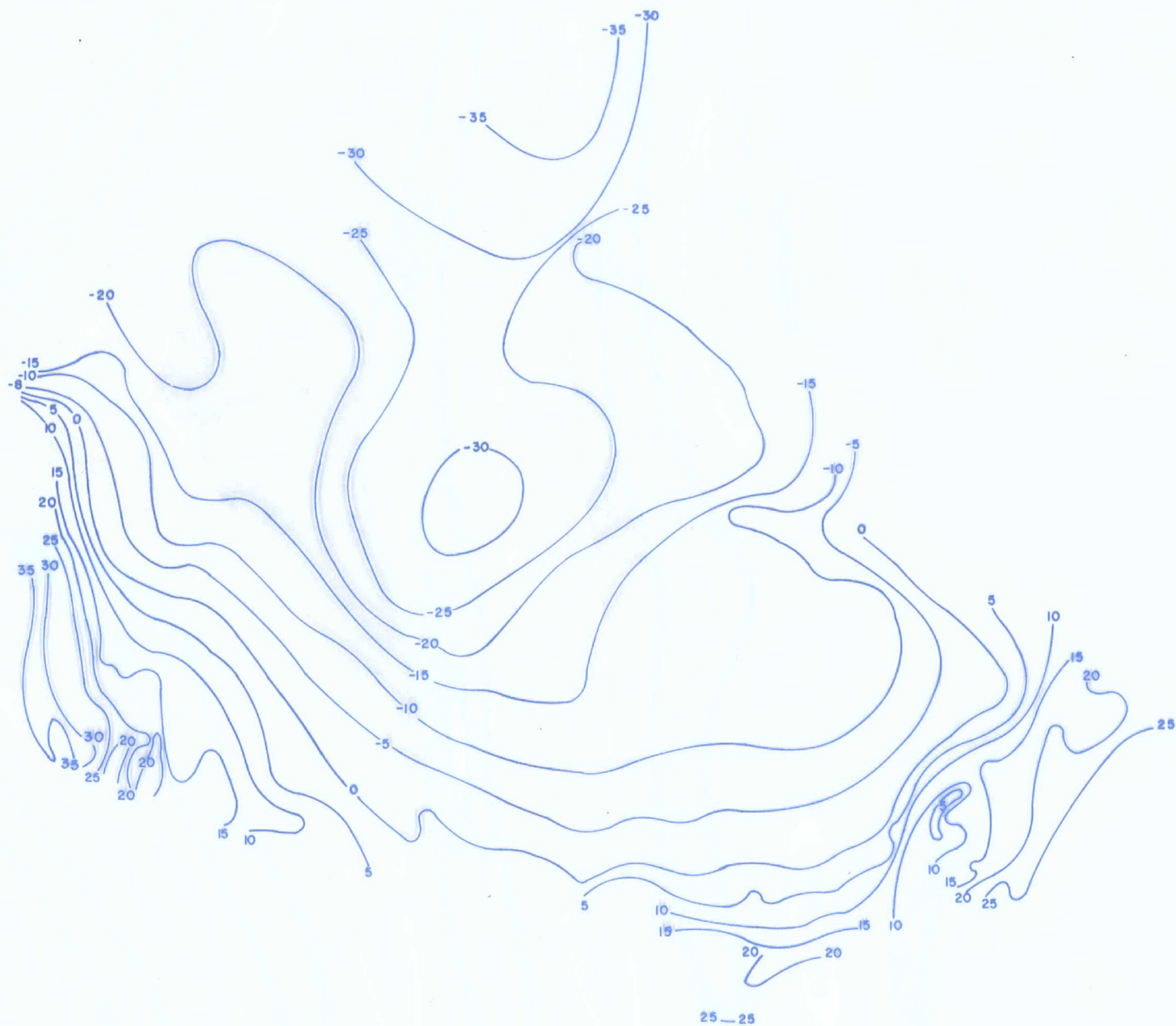


NOTE: 1.5% OF CANADIAN POPULATION LIES NORTH OF POPULATION FRONTIER



MAJOR POPULATION CONCENTRATIONS

PLATE I



JANUARY MEAN DAILY TEMPERATURE

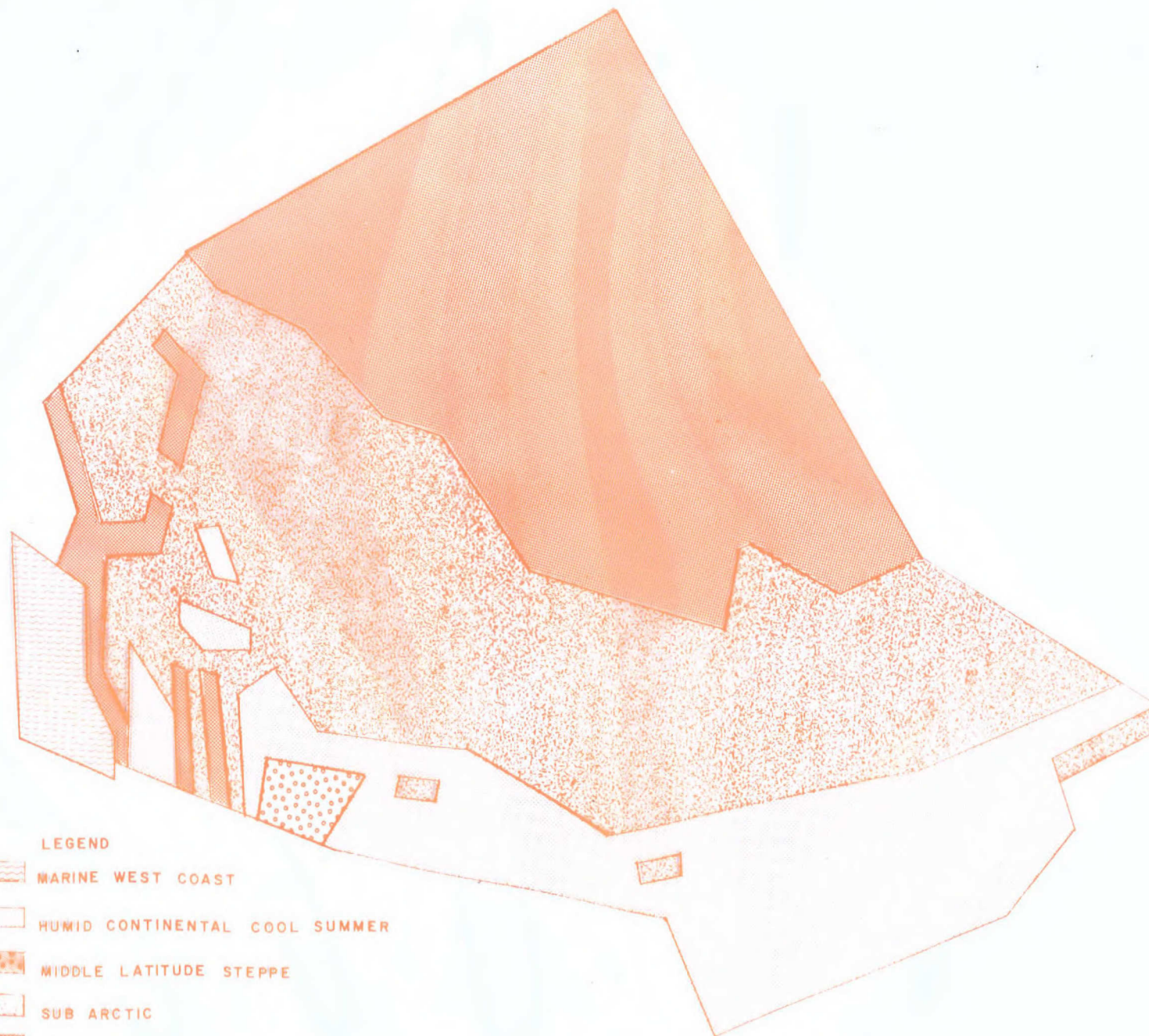
PLATE 2



JULY MEAN DAILY TEMPERATURE

PLATE 3





LEGEND

- MARINE WEST COAST
- HUMID CONTINENTAL COOL SUMMER
- MIDDLE LATITUDE STEPPE
- SUB ARCTIC
- TUNDRA

CLIMATIC REGIONS

PLATE 4

## 5 TRANSPORTATION SERVICES

See Figure 2  
Plates 1, 5, 6 and 7

Access to the North is essential to development. In the past the climate and the nature of the terrain have rendered physical movement difficult and costly and have kept most of the areas remote from major world markets. Improved transportation services will be necessary to support permanently settled communities.

Communications in the North have been and will continue to be closely tied to the growth of transportation services. This applies particularly to the installation of conventional microwave radio relay systems where the cost of installation and maintenance of stations would prove prohibitive in the absence of access roads.

### 5.1 AIRWAYS

Plate 5

Air travel is often the only means of transportation to northern communities. Not only is air service essential for high speed passenger and freight movements, but it is also vital to many small outposts and settlements located in regions which are otherwise inaccessible for part of the year.

The non-scheduled services provided by the charter

and contract services, flying clubs and special air services, contribute most to transportation. Float equipped planes are in wide use. Many airports are merely terminal points and refuelling stations scattered widely in the North. The Department of Transport is the only operator of civil airports in the Yukon and Northwest Territories.

Due to vast distances and a scarcity of year-round surface transport, air cargo operations play an important role. This is true particularly in cases where speed is essential, and for the transport of low-weight high-value goods such as precious metals. Air fares and freight rates in the North are approximately 50% to 100% higher than those in southern Canada.

Plate 5 shows the network of air services available in the Canadian North.

### 5.2 ROADS

Plate 6

Though the roads built in recent years have made the Canadian North less remote, the total mileage and routing are still inadequate when compared to actual needs.



One of the major roads built in the last 25 years is the Alaska Highway, completed in 1942. It is 1,527 miles long, and cost more than \$100 million. This highway is of great economic importance to the Northwest Territories and Alaska.

Just after World War II, a highway was established between Whitehorse, Carmacks, Mayo, Dawson City and Fairbanks (Alaska) where it connects with the Alaska Highway. This highway has branch roads to the Eagle plains oil exploration area. Two all-weather roads link Ross River to the Alaska Highway at Johnson Crossing and Watson Lake.

Another major road is the Mackenzie Highway from Grimshaw (Alberta) to Hay River and Yellowknife on Great Slave Lake, with an extension to Fort Smith. The recent establishment of a snow road from Fort Simpson to Inuvik, and the planned roads from Hay River to Tuktoyaktuk and from Yellowknife to Coppermine, will aid development in these isolated areas.

In 1965, the Department of Northern Affairs and Natural Resources embarked on a 10-year road building program, with annual expenditures of \$10 million. Its

objective is to bring all potential areas of resource development in the Yukon and Northwest Territories to within 200 miles of the nearest permanent road. This will reduce the north's isolation, and its dependence on seasonal transportation.

Road building in north-central Canada is confined mainly to a paved road to Flin Flon, and gravel roads to Churchill Lake and to Southend. The most northern points served by roads in northwestern Ontario are Red Lake, Pickle Crow and Nakina. In Quebec, there are few roads into the north with the exception of the Chibougamau Road. The Labrador City and Schefferville areas are at present served by rail only. However, recent planning in this region centres on the proposed Labrador Highway, designed to connect Labrador City with Churchill Falls, Goose Bay and Forteau on the Strait of Belle Isle.

No land based route penetrates the mineral-rich Ungava District. Airlines, and coastal shipping for part of the year, are the only connections to this area.

Plate 6 shows the major road networks in the Canadian North.

### 5 . 3 RAILWAYS

Plate 7

The pattern of existing railway transportation in the Canadian North differs from that in the southern areas of Canada. In most cases the northern routes have been developed on the basis of single purpose requirements which promotes piece-meal development and leaves many areas unserved.

The majority of the north-south lines have been built since 1950. Their combined mileage (approximately 2,400 miles) is almost equal to the distance between Ottawa and Vancouver.

Among the more important railway extensions is the Hudson Bay Railway, built in 1929, which runs 510 miles from The Pas to Churchill. Another line is the privately owned Quebec North Shore and Labrador Railway built in 1954, running from Sept Iles and terminating at Schefferville. The most recent addition is the 400 mile Great Slave Lake Railway, which was constructed to service the Pine Point Mines in the Northwest Territories.

Plate 7 shows the major railway networks in the Canadian North.

### 5 . 4 SHIPPING

Plate 7

Heavy reliance is placed on water transportation, particularly in the Northwest Territories and the Arctic coasts. The Mackenzie Valley system in the Northwest Territories provides a navigable inland waterway of more than 1000 miles. With the inclusion of one 16 mile section in Alberta which must be portaged, the system extends another 700 miles south to waterways on the Athabasca River.

In the Arctic regions water transport constitutes the most economical means of transportation particularly where large tonnage is involved. These regions are subject to seasonal shipping restrictions due to massive ice formations which limit the use of these routes. However, with the development of the Alexbow ice breakers and advanced transportation techniques using hovercraft, cargo submarines, etc., it is anticipated that the present barrier imposed by the severe climatic conditions will be overcome, and that water transportation will play a major role in the development of the north.

Plate 7 shows major shipping routes in the Canadian North.

## 5 . 5 TRENDS

Future technical advances in the transportation industry will involve the refinement of existing modes of transportation, including railways, roads, water and air transport. Pipelines, hovercraft, cargo submarines, and track vehicles will be made more effective, and these relatively new vehicles will be able to provide more efficient service than traditional transport modes.

### Pipelines

For the transportation of fluids and some types of solids, pipelines are a cheap controlled transportation system. In the future, they will carry a greater variety of raw materials which will be moved by fluids in the pipeline. Pipelines are unique in the sense that they are not affected by adverse weather conditions.

### Hovercraft

The hovercraft has unlimited potential for assisting in the development of the North. This craft can travel at

relatively high speeds on land and water and holds promise of providing economical northern transport without the necessity of large capital investments in roads. Large models, with the capacity to carry several hundred passengers and 30 automobiles, are now being constructed.

### Cargo Submarines

These submarines can travel under the icecap at speeds as great, or greater, than those of surface ships. Due to the high cost of operating surface ships in the waters of northern Canada, submarines may prove to be an important economical long-haul transportation vehicle for bulk cargo.

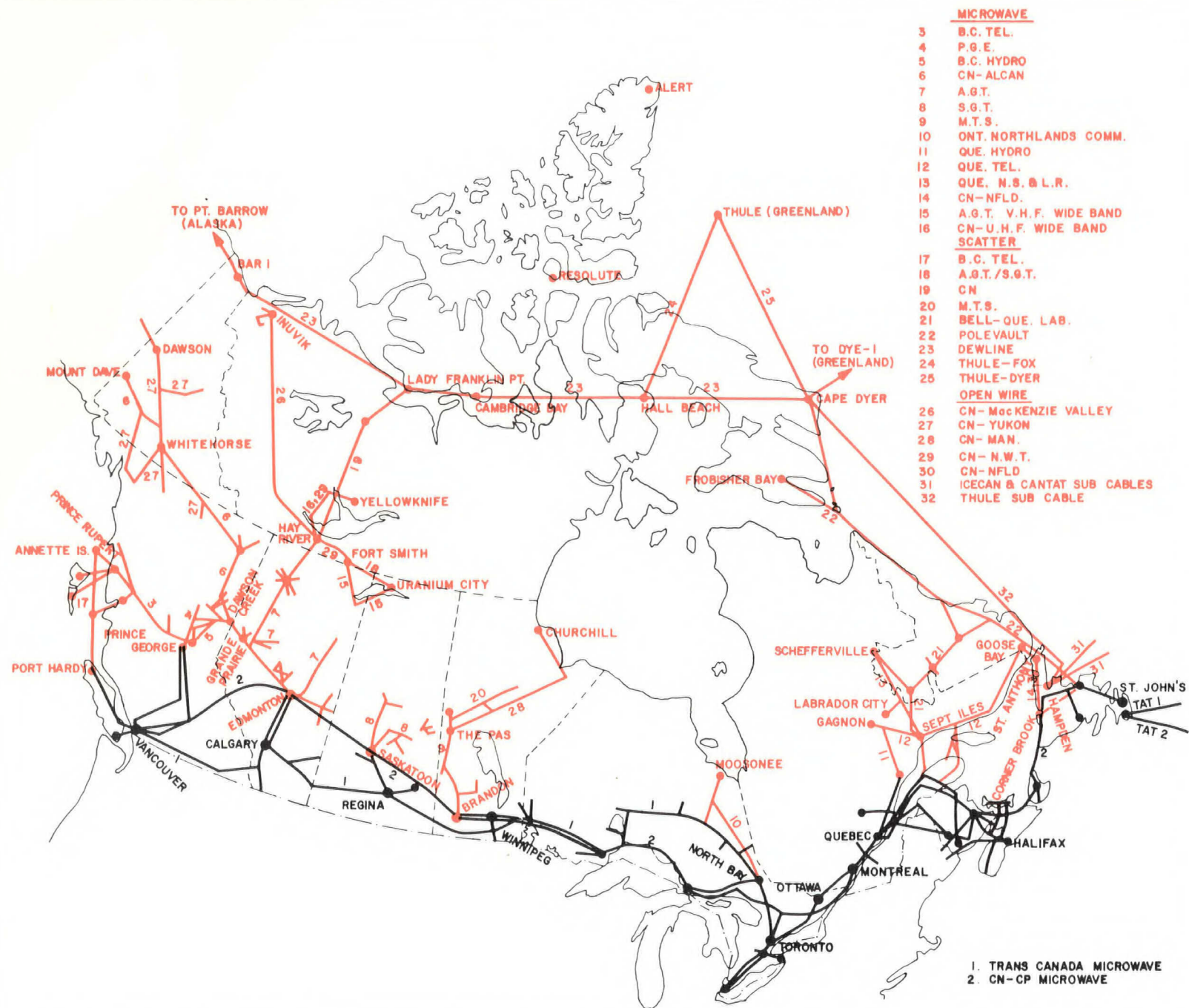
### Track vehicles

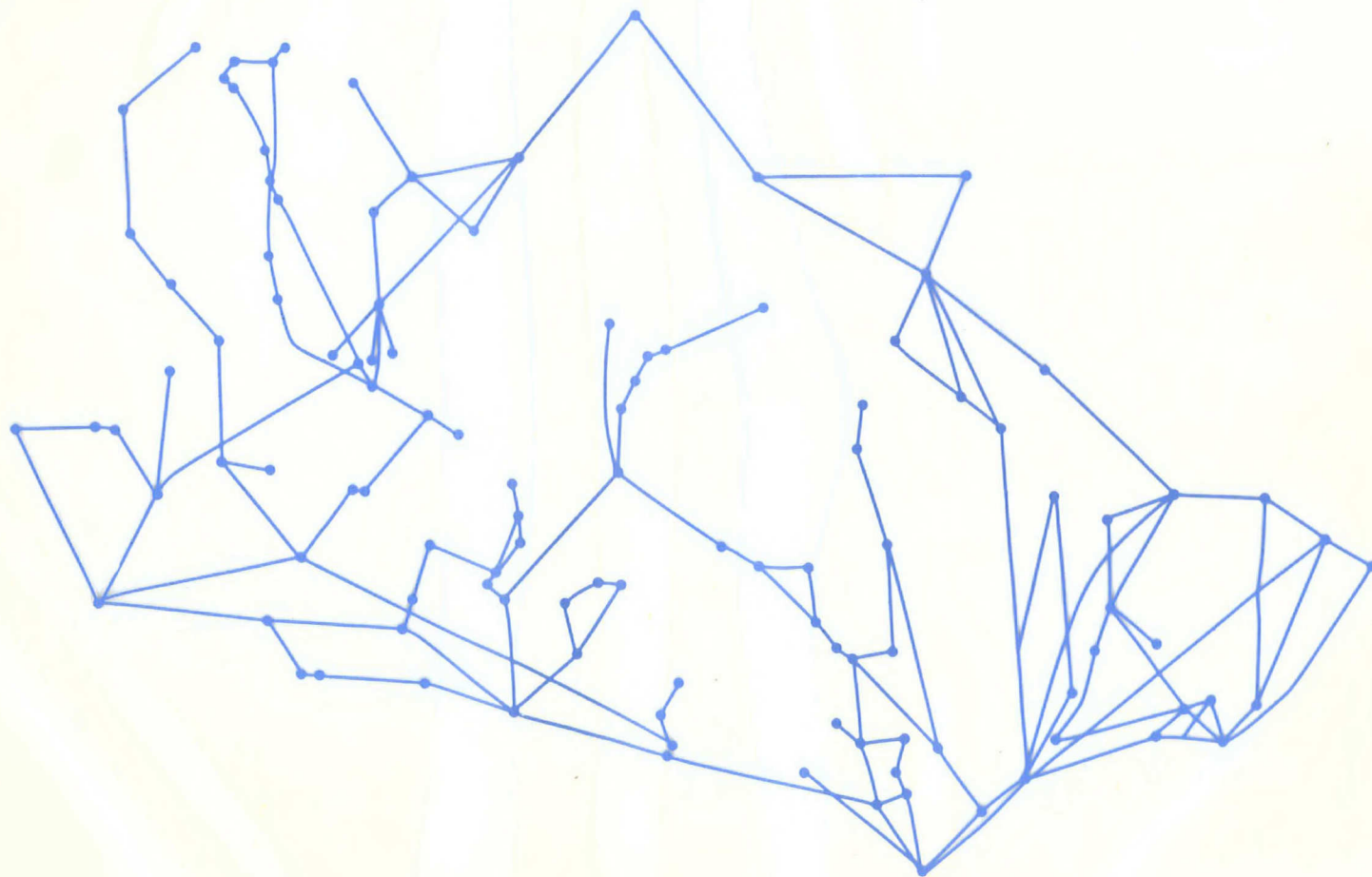
Track vehicles are designed to travel mainly on soft marshy ground or snow. Improvements will have to be made in the design of these vehicles, however, if they are to compete with the hovercraft.

DEPT. OF COMMUNICATIONS  
NAT'L TELECOMM. BRANCH

# MAJOR OPERATIONAL SYSTEMS

FIG. 2  
ACRES INTERTEL LIMITED





TRANSPORTATION-AIRWAYS

PLATE 5





A map showing a network of roads. The roads are represented by lines with dots at the vertices. The map is divided into two main regions by a vertical line. The left region contains a dense network of roads, while the right region contains a sparser network. The roads are color-coded according to the legend: red for major existing paved roads and blue for major existing gravel roads. The map is titled 'TRANSPORTATION-ROADS' and is labeled 'PLATE 6'.

LEGEND  
..... MAJOR EXISTING PAVED ROADS  
---- MAJOR EXISTING GRAVEL ROADS

TRANSPORTATION-ROADS

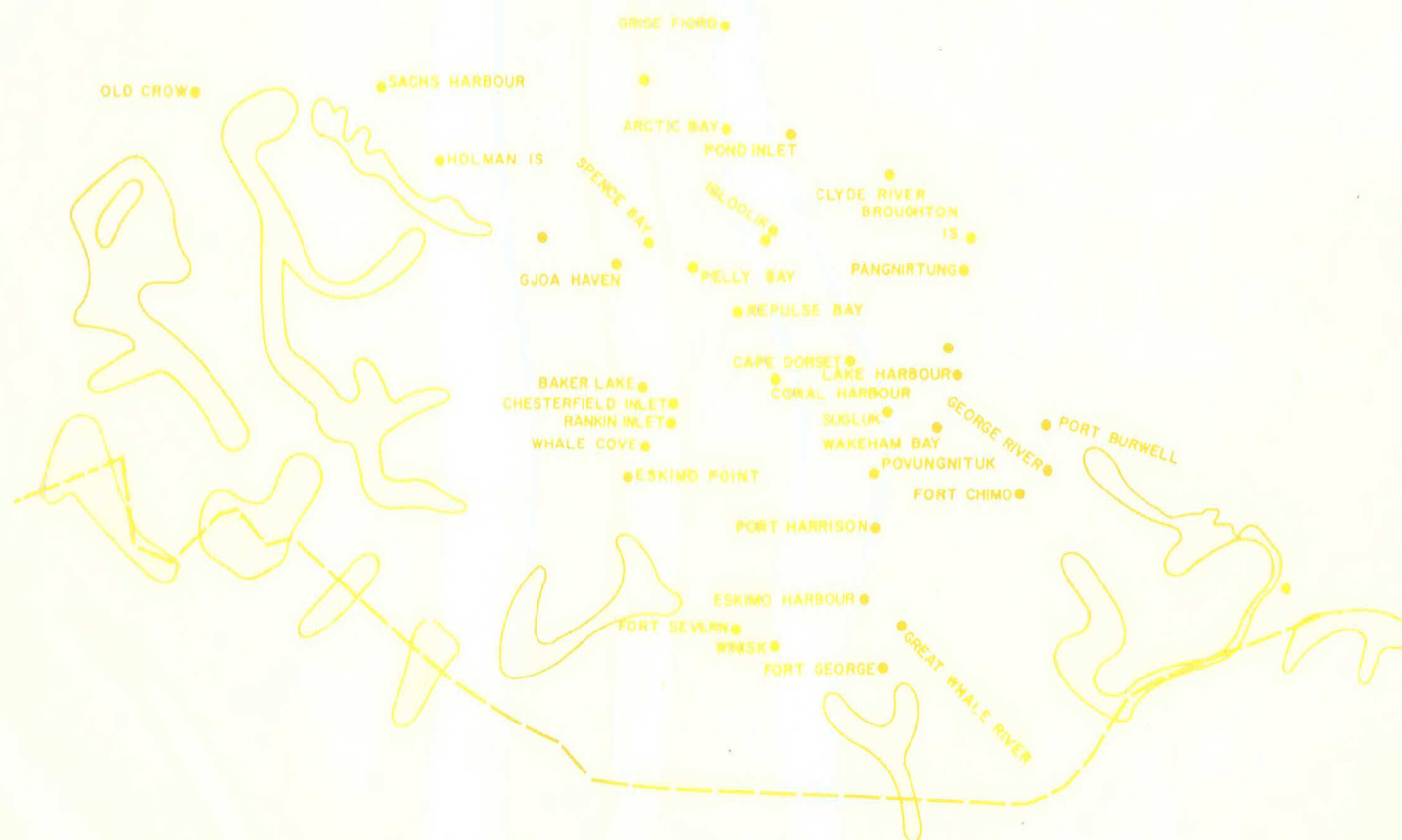
PLATE 6



LEGEND  
+++ RAILROAD  
||||| SHIPPING



NOTE 1.5% OF CANADIAN POPULATION LIES NORTH OF POPULATION FRONTIER



LEGEND  
 --- POPULATION FRONTIER  
 • ISOLATED POPULATION CENTRE  
 [ ] POPULATION CONCENTRATIONS

MAJOR POPULATION CONCENTRATIONS

PLATE I

## 6 RESOURCES

See Figure 2  
Plates 8 - 12

Canada's North has tremendous natural resources awaiting the human and capital commitment for development. While permanent self-sustaining communities in the North are the eventual goal it is apparent that the development of natural resources will be the incentive for early settlement and growth.

Raw materials, energy sources, and water supplies for industrial and domestic use in the North are widely distributed. Resource activity presently extends from the northern reaches of the Provinces to the Arctic Ocean.

Natural resources consist of mineral wealth, petroleum products, timber, water, and recreational areas.

Plates 8 - 12 show the locations of these resources.

### 6.1 MINERALS

Plate 8

The export of metal ores and fabricated metals is of fundamental importance to the Canadian economy. The expansion and diversification of mineral production has seen a rise in total output from \$726 million in 1954 to \$2,561 million in 1966. These figures represent 18.4% and 25% of all exports for these years. Although the

growth of mineral production is great, many reserves exist that are presently inaccessible but will be marketable eventually.

Plate 8 shows the distribution of mineral bearing rocks in Canada. Nearly every known metal underlies the hard granite surface of the Precambrian Shield and the rugged mountains of British Columbia and the Yukon.

#### Iron Ore

Iron ore is mined in Labrador and the Ungava District of Quebec. It has been found on the Belcher Islands and huge deposits are known to straddle the Mackenzie-Yukon border. The most valuable iron find has been located near Mary's River in northwestern Baffin Island.

#### Lead and Zinc

These important base metals are being mined at Elsa in the Yukon but much larger and richer deposits are waiting at Pine Point on the southern shore of Great Slave Lake. They are the largest and richest of their kind in the North American continent with ores very close to the surface. A major mine is being opened in Carmacks (Yukon) this year.

### Copper

Copper is mined in the vicinity of Noranda near the northern border of Quebec and Ontario. Deposits are also located in Lynn Lake (Manitoba) and near Whitehorse (Yukon).

### Asbestos

A large deposit of asbestos exists near Asbestos Hill (Quebec) adjacent to Hudson Strait. It is mined in the Eastern Townships of Quebec, northern British Columbia and the Yukon.

### Nickel

Canada is the world's leading producer of nickel. It is mined near Lynn Lake and many locations within the Precambrian Shield. A nickel mine is currently productive at Rankin Inlet on the northwest coast of Hudson Bay.

### Gold

There are small gold producing mines near Yellowknife (NWT) and in the Yukon. Gold is also mined intermittently in areas of northern Ontario, Manitoba and Saskatchewan.

### Uranium

Uranium has been mined in Uranium City (Saskatchewan) and Port Radium on the eastern shore of Great Bear Lake (NWT).

### Rare Metals

Rare metals are also found in the North e.g. tungsten, tantalum, beryllium and lithium are available around Great Slave Lake.

Successful mining in the vicinity of the Great Slave and Great Bear Lakes has proven that mining can be a sound operation at high latitudes in the northern regions.

## 6 . 2 FUELS

### Plate 9

The North contains an abundant supply of oil, gas and coal. Oil production is the most important economic factor that can unlock the North and provide the necessary impetus for planned development.

#### Oil and Gas

A new dimension was given to resource activity in the North by the discovery last June of a very rich oil field at Prudhoe Bay (Alaska) on the Arctic Ocean. It may prove to be one of the largest stores of petroleum known. The search for oil is now proceeding vigorously on the mainland and off-shore areas of the Northwest Territories, the Yukon and in the Archipelago Islands. It has been estimated that Canada's Arctic Islands contain ultimately recoverable reserves of oil amounting to 50-100 trillion barrels, plus 200-300 trillion cubic feet of natural gas. In comparison, the total oil reserves in the United States are estimated at 40 trillion barrels.

Other important fuel areas are the oil reserves of the Athabasca Tar Sands and the Rainbow Lake areas of northern Alberta. The Athabasca Tar Sands are estimated to hold oil reserves of 15 to 45 billion barrels. Rainbow and Zama Lake reserves are in the order of 285 million barrels.

The Federal Government has responded to the challenge of massive oil finds in the North by joining with twenty petroleum and mining corporations in the formation of Panarctic Oils Limited. This consortium holds 44 million permit acres in the far North covering 63% of the Arctic Islands regarded as potential oil bearing territory. Exploratory surveys have already been made on the Queen Elizabeth Islands and it is hoped that the potential oil and gas reserves on Melville Island near latitude 76°N will be exploited in the near future. This year Panarctic plans to extend seismic operations to the Bathurst, Ellef Ringnes and Amund Ringnes Islands.

#### Coal

Possible coal bearing formations in the North appear to be limited to the Mackenzie Lowlands and northern Alberta with scattered patches in northern British Columbia, the Yukon and in the Hudson Bay Lowlands. These deposits are likely to produce only soft coal with the possible exception of those in British Columbia and the Yukon. Although the demands for coking coal is high, the known reserves are very small.

Plate 9 shows the distribution of major fuel (oil, gas and coal) reserve areas in Canada.

### 6 . 3 WATER AND HYDRO POTENTIAL Plate 10

Water is essential for industrial development and settlement. As the demand for water increases and pollution reduces the fresh water supply, the task of locating and exploiting water resources becomes critical. Canada is in a most favorable position in regard to the quantity and distribution of fresh water resources.

The economic significance of Canada's water resources is substantial. Approximately 7.6% of the country's total area consists of fresh water bodies and these resources in turn are estimated to be more than 25% of the world's fresh surface water supply. On a local or regional scale there may be severe water problems, but from a national perspective, the total foreseeable demand for water for Canada is a small fraction of the existing supply. Problems do occur in geographic distribution and the quantity of the supply in relation to demand. This applies particularly to high volume water-using industries such as pulp and paper mills, refineries, food processing plants and tanneries.

The principal drainage basins involved in the development of the North are the Arctic, Hudson Bay, Pacific and

Atlantic Basins. The available water supply is sufficiently abundant to meet the needs of several million people who might live in this region even at an advanced stage of development.

Important water power sites await development in the North. On the Yukon River and on the South Nahanni River in the Northwest Territories, preliminary investigations indicate a hydro-electric power potential of one million kilowatts. There are further indications that rivers draining the Keewatin District will contribute substantially to the total power potential of the Northwest Territories. In Labrador, at Churchill Falls, one of the country's largest power developments is being constructed.

Developed water power in the North is only a fraction of the potential. In January, 1965, the installed generating capacity in Canada was 20.3 million kilowatts. The undeveloped water power has been conservatively estimated at 63.5 million kilowatts.

Plate 10 shows the locations of major water supplies and undeveloped water power resources in the country.



#### 6 . 4 FORESTRY

#### Plate II

Canada, with 22% of the world's supply, is one of the two countries where the available softwood resources are extensively under utilized - the other is the Soviet Union. Forest products are responsible for a major portion of Canada's export earnings. Exports of the products amounted to \$2,231 million in 1966, a gain of 7% over the 1965 export value.

Many of the new mills now proposed or under construction will obtain all or a large portion of their raw material from the southern part of the boreal forest. The boreal forest stretches from Newfoundland across the continent and up into the Yukon Territory. From the northern limit of the boreal forest to the tree line, a transitional area exists, which ends in tundra and barren land. The southern half of the boreal forest is heavily forested.

Of Canada's 968,000 square miles of productive forest land, less than one-third (312,000 square miles) is commercially operated. The development of transportation and communication in Northern Canada would provide access to the other two-thirds of the area, and would open the forest to productive use.

In the forestry sector, the development of the pulp and paper industry will predominate. The major requirements of the industry are adequate sources of low-cost power, facilities for the bulk handling of raw wood material and paper products, large supplies of fresh water and efficient communication and transportation systems.

The distribution of major forest reserves in Canada is shown in Plate II.

## 6 . 5 TOURISM AND RECREATION      Plate 12

Tourism is expected to play an important role in the development of the Canadian North. It is at this moment one of the country's most dynamic industries and makes a major contribution to U.S. dollar earnings. The opening of the North will provide access to new recreational areas and create new tourism opportunities.

Among the inherent problems existing for tourist development of the North are seasonability, distance from major urban areas, lack of suitable transportation and communication facilities. Development of planned transportation and communication facilities will open up

vast recreational areas in the North where tourist potential exists.

Fishing is a major recreational activity and is at present the prime tourist attraction in the North. As there are thousands of lakes, rivers and streams in the area, the potential for the further development of fishing as a tourist attraction is great.

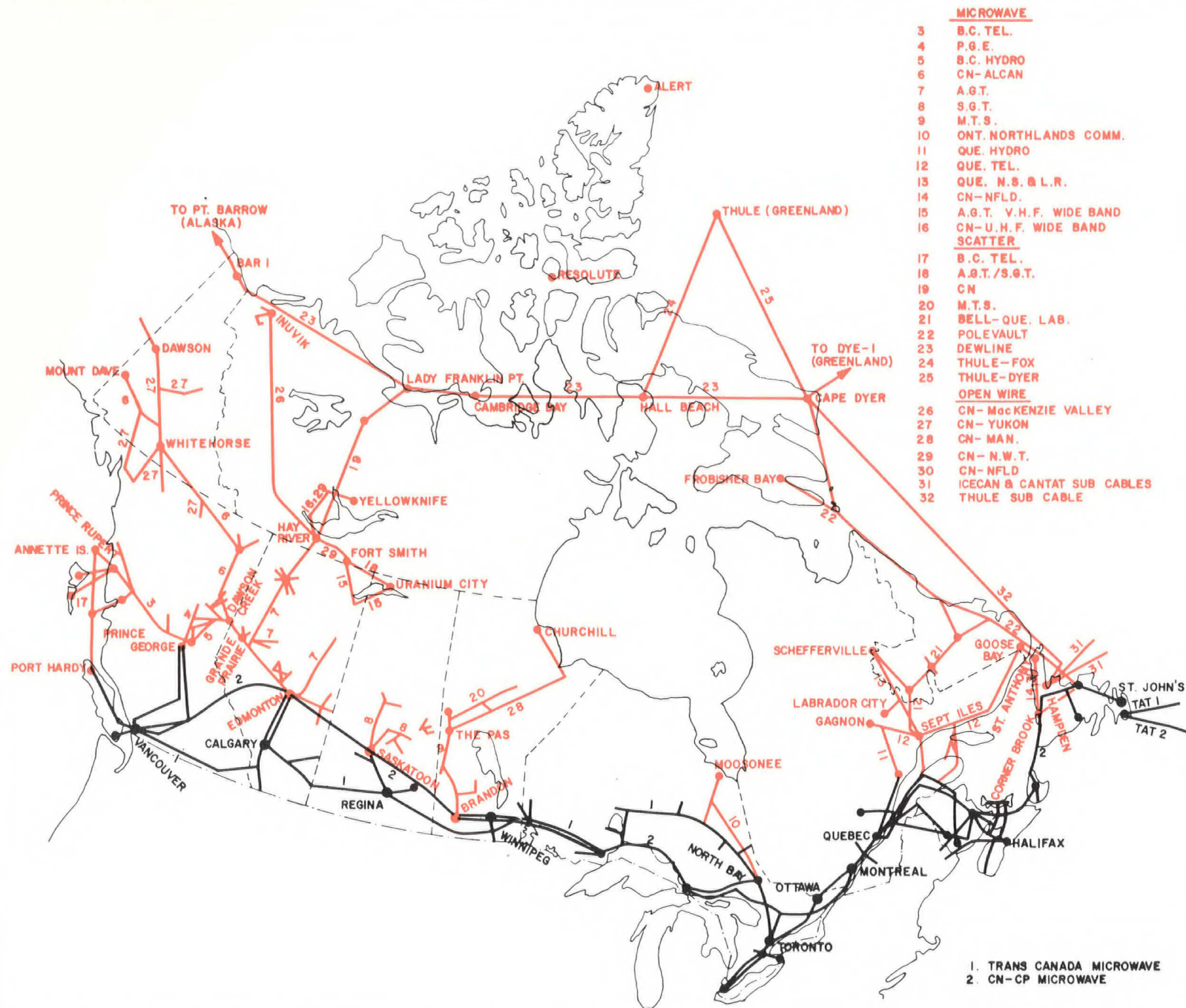
Hunting is also important. Animal species which will attract the hunter to the North include moose, grizzly bear, black bear, mountain sheep, mountain goat and deer.

Tourist areas with potential drawing power in the North are mapped on Plate 12.

DEPT. OF COMMUNICATIONS  
NAT'L TELECOMM. BRANCH

# MAJOR OPERATIONAL SYSTEMS

FIG. 2  
ACRES INTERTEL LIMITED





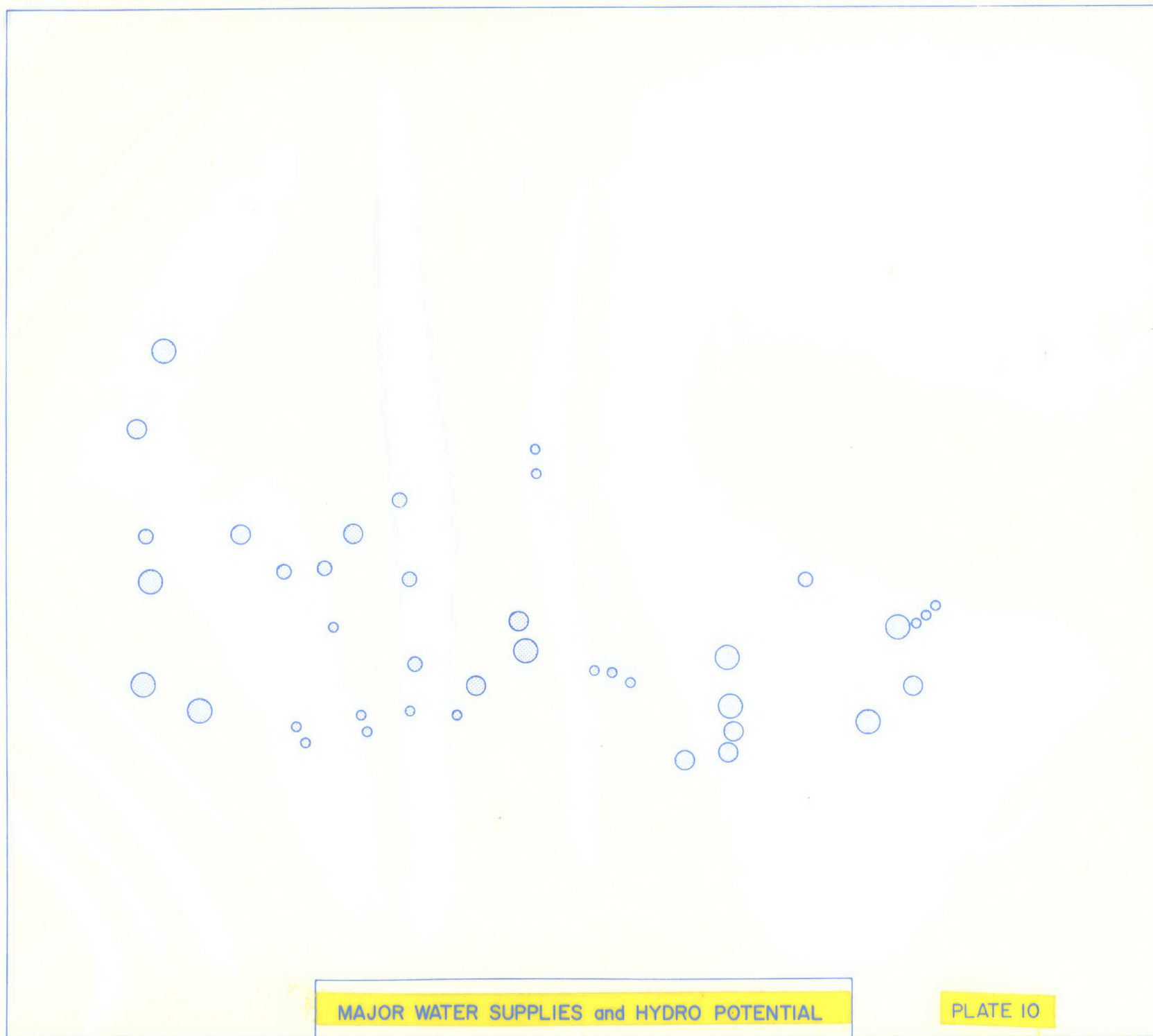
MAJOR MINERAL RESERVES

PLATE 8



MAJOR FUEL RESERVES

PLATE 9







LEGEND

 BOREAL FOREST

 TRANSITION FOREST



## 7 COMMUNICATION SYSTEMS

Dispersed population in a harsh environment has seriously handicapped the growth of communications in the North. Communication carriers face high risks in providing services because of large installation, operation, and maintenance costs associated with a small and widely scattered market. Despite these obstacles communications have been satisfactorily carried to many populated points but coverage falls below desirable levels in other areas. Live television is unavailable and radio programs do not reach points in the far North except by CBC short wave broadcasts. Small communities in Northern Canada are deprived of adequate communications.

### 7.1 SYSTEM TYPES

#### High Frequency Radio

High Frequency (HF) radio and tropospheric scatter radio systems have been most widely used to meet the communication needs of the far North. Both techniques overcome the problem of providing communications for long distances over inaccessible terrain. High frequency radio is relatively cheap but it is limited to the transmission

of a single telephone circuit. Outages occur frequently due to changing ionospheric conditions and frequency interference from other users. A typical HF radio station for multi-frequency operation with 1 kW transmitter with antenna and supports costs about \$30,000.

#### Tropospheric Scatter Radio

Tropospheric scatter (troposcatter) radio systems use essentially a "brute-force" technique to transmit up to 240 channels over hop distances of 70 - 300 miles. They are characterized by high power transmitters feeding large antennas with diameters ranging from 30 to 120 feet. The propagation mode is by scattering or reflection of the radio signals from the troposphere. A high degree of reliability in transmission performance can be achieved. Tropospheric scatter systems are expensive and do not have the capability to transmit television. The cost of a typical terminal would be at least several hundred thousand dollars and may go up to 2 or 2.5 million dollars for major installations.

### Microwave Radio

Microwave radio relay (microwave) systems are installed when traffic-demands reach sufficient proportions. Usually in northern territory relay repeater stations are installed adjacent to roads or railways since construction costs without access facilities rise steeply. There are two types of microwave radio relay equipment that can be used depending on the distance and nature of the information to be carried.

The type of equipment used for long distance transmission (over 500 miles) consists of chains of repeater stations each separated by about 30 miles. These systems can transmit 600 to 1800 telephone circuits or television initially. The circuit loading can be progressively increased to 6, 8, 10 or 12 times this amount by adding radio and antenna equipment. The capital cost of a repeater station including equipment, engineering and installation, ranges between \$150,000 and \$300,000 while augmentation

costs range from \$20,000 to \$40,000 for each additional broadband channel.

An economical type of microwave radio relay equipment is designed for short distance transmission systems. Such systems carry about 300 telephone circuits for distances from 30 to 300 miles. Alternatively they may be designed to carry television for 2 or 3 hops from an off-the-air reception point to a re-broadcasting station. Costs run between \$75,000 and \$175,000 for each repeater station.

### Open Wire and Cables

Open wire systems have been used in the North for transmitting up to 32 telephone circuits. However, there has been difficulty in maintaining these open wire systems in the northern climate. It is anticipated that low cost solid state radio relay systems in the 150-470 MHz (million cycles per second) band may prove more effective in the future.

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## 7 . 2 OPERATING AGENCIES

Many agencies operate communication systems in the North. There are common carriers who provide service and facilities connecting into the national telephone and telegraph network. Defence commitments have necessitated the establishment of extensive military communication networks in the North. Federal Government departments operate private systems to meet functional and administrative requirements. In addition to the major agencies, there are many private organizations such as oil companies, retail businesses and religious missions who all have extensive systems in the North to support their particular activities.

### Common Carriers

The most important common carriers in the North are Canadian National Telecommunications and Bell Canada. These companies provide public telephone and telegraph service in the western and eastern Arctic respectively.

CN Telecommunications serve the Northwest Territories above the 60th parallel and west of 102° longitude. Bell Canada operate east of this longitude in the eastern Arctic and also serve northern Ontario and Quebec. The division of territory served by Bell Canada and CN Telecommunications was mutually agreed by these carriers since this was considered to be the economic way of providing service to these areas.

Other large common carrier organizations serving the northern parts of the Provinces are:

- o B.C. Telephone Company
- o Alberta Government Telephones
- o Saskatchewan Government Telephones
- o Manitoba Telephone System
- o Ontario Northland Communication
- o Quebec Telephone Company

### Canadian National Telecommunications

CN Telecommunications have pioneered the extension of high quality communication corridors to the North. The Alcan system, built at a cost of \$26 million is the only high quality microwave system operating in the Northwest Territories or the Yukon. Open wire systems have been extensively used and the most notable example is the Mackenzie River Valley system running from Hay River to Inuvik. This 1020 mile system was constructed at a cost of \$4 million, a sum which includes many very high frequency (VHF) radio, cable, and mobile radio extensions to extend telephone and telegraph services to communities in the vicinity of the Mackenzie River Valley.

Both the Alcan and Mackenzie River Valley systems were constructed in record time by CN Telecommunications and are high points in Canadian communications history.

CN Telecommunications operate a major troposcatter radio system between Hay River and Lady Franklin Point (NWT).

### Bell Canada

Bell Canada provides service in the Eastern Arctic by troposcatter radio and HF radio systems. The first troposcatter radio system was established between Sept Iles and Goose Bay. One of the world's most northerly exchange is operated by Bell Canada at Resolute which is 600 miles inside the Arctic circle.

The main commercial base stations operated by Bell Canada in the east are located in Alma (Quebec), Frobisher Bay (Baffin Island), Goose Bay (Labrador), Moosonee on James Bay and Churchill (Manitoba). Most stations use HF single sideband radio equipment to conserve the frequency spectrum. Radio stations generally operate on a simplex basis meaning that press-to-talk control is mandatory.

### Manitoba Telephone System

Manitoba Telephone System (MTS) have installed a troposcatter radio system between Thompson and Snow Lake providing long distance connections with The Pas.

Saskatchewan Government Telephone  
Alberta Government Telephone

Saskatchewan Government Telephone (SGT) and Alberta Government Telephone (AGT) companies collaborated to install a troposcatter radio link between Uranium City (Saskatchewan) and Fort Smith (NWT).

#### Military

Military requirements have dominated the provision of communication corridors to the North. Both the Distant Early Warning (DEW) Line and Polevault troposcatter radio systems are owned and controlled by the U.S. Air Force. The DEW Line is a chain of troposcatter radio stations spanning Northern Canada at a latitude of 70° North and is the only system providing lateral communications across the top of the continent. Construction of the system was a mammoth undertaking with costs exceeding \$600 million. It is presently manned by U.S. military staff and associated civilian personnel under contract. Each station is completely self-sufficient in that it can operate for long periods without supplies.

Polevault provides the rearward communications from the DEW Line to strategic control centres in the south, a function served by the Hay River-Lady Franklin Point system in the western Arctic.

One of the major defence communication networks, the Mid Canada Line, extending laterally across Canada at about the 55th parallel from Hopedale in Labrador to Dawson Creek in British Columbia, was dismantled during mid 1960.

The 1400 mile Air Defence communication (Adcom) system which runs through territory in Ontario and Quebec was sold to Bell Canada for commercial use during 1966. The system operates in the 2 GHz frequency band and is capable of providing up to 480 two-way voice circuits.

The Canadian Armed Forces operate two major HF stations at Inuvik and Alert Bay. Both low frequency (LF) and high frequency (HF) radio circuits are used for ship-shore and air-ground communications in the Arctic. The Canadian Land Forces are presently testing small portable earth stations working into a United States military satellite.

## Government Departments

Federal Government departments owning their own private systems include the Department of Transport, Department of Indian Affairs and Northern Development and the Royal Canadian Mounted Police (RCMP). Provincial Forest Services are equipped with extensive HF and VHF radio systems covering their territories. Some of these systems have access to regional trunk networks for communications with associated administrative centres, but commercial use by the public is discouraged.

The Department of Transport is the most extensive government user of private HF and LF radio systems in the North. This Department has been faced with the problem of providing essential communication services for handling air traffic control and meteorological data. It also provides radio-telephone and telegraph service to the public and to other government departments when the common carriers have been unable to provide communica-

tion facilities.

This Department employs powerful 5 kW transmitters for its HF radio services. This investment in high powered transmitters has paid dividends in achieving high standards of reliability and quality of service.

The Department operates LF radio air navigation radio beacons in the North to serve a dual purpose. Teletype circuits are available by using frequency shift keying (FSK) of the beacon radio frequency carriers. Major circuits using FSK operate between the following stations:

- o Resolute-Cambridge Bay
- o Inuvik-Norman Wells
- o Churchill-Coral Harbour
- o Coral Harbour-Frobisher Bay

These LF stations use 3 kW transmitters and provide reliabilities exceeding 90%. Several LF transmitters using lower powers (400 watts) are also in operation.

The status of communication services in the North vividly contrasts with the variety, concentration and sophistication of services available in southern Canada.

The quality of transmission facilities in the south is excellent and sufficient capacity is on hand to cater for growth within the next decade. The density of trunk microwave networks in the 200 mile populated strip adjacent to the border is unparalleled anywhere in the world. This telecommunications network is operated by the common carriers and the owners of private systems and brings high quality telephone service to 98% of the people. Live television is brought to 95.9% of the English speaking population and 92.7% of the French speaking population by a combination of network facilities, Frontier Packages, and off-the-air pick ups.

A visual presentation of communication frontiers and corridors to the North can give orientation and

perspective to the availability of service throughout Canada. This approach is developed overleaf and serves to classify systems according to their type and importance. Main communication corridors are identified to show what routes exist to the North for the reliable transmission of information. Separately considered are systems which extend coverage beyond the main corridors and to isolated settlements.

The key to the information contained in the summaries in sections 8 and 9 is as follows:

- Name of system (section 8 only)
- Owner/operator, figure and item number
- Province(s) in which operational
- System terminals
- Route length, frequency
- System capacity
- Major stations



## 8 MAIN COMMUNICATION CORRIDORS

See Figure 2

### SUMMARY

#### Alcan Microwave Radio System

CN Telecommunications, see fig.2, item 6  
Alberta, British Columbia and Yukon  
Grande Prairie to Mount Dave  
1100 miles, 2 GHz  
600 telephone circuits, no TV  
Grande Prairie, Dawson Creek and Whitehorse

#### Edmonton-Hay River Microwave Radio System

AGT/CN Telecommunications, see fig.2, item 7  
Alberta and NWT  
Edmonton to Hay River  
650 miles, 2 and 6 GHz  
240 telephone circuits, no TV  
Edmonton, Peace River and Hay River

#### Mackenzie Valley Open Wire System

CN Telecommunications, see fig.2, item 26  
NWT  
Hay River to Inuvik  
1020 miles  
16 telephone circuits, no TV  
Hay River, Fort Simpson and Inuvik

#### Hay River-Lady Franklin Pt. Tropospheric Scatter Radio Sys.

CN Telecommunications, see fig.2, item 19  
NWT  
Hay River to Lady Franklin Pt.  
600 miles, 2 GHz  
120 telephone circuits, no TV  
Hay River, Port Radium and Lady Franklin Pt.

#### The Pas-Churchill Open Wire System

CN Telecommunications, see fig.2, item 28  
Manitoba  
The Pas to Churchill  
500 miles  
18 telephone circuits, no TV  
The Pas, Thompson, Gillam and Churchill

#### DEW Line Tropospheric Scatter Radio System

U.S. Air Force, see fig.2, item 23  
Arctic regions of NWT and Yukon  
Cape Dyer to BAR-I (Komakuke Beach)  
2000 miles, 900 MHz  
72 telephone circuits, no TV  
Cape Dyer, Hall Beach, Cambridge Bay and Cape Parry

#### Polevault Tropospheric Scatter Radio System

U.S. Air Force, see fig.2, item 22  
Newfoundland, Labrador and NWT  
St. John's to Frobisher Bay  
spurs to Harmon Field and C. Dyer  
1273 miles, 565-735 MHz  
36 telephone circuits, no TV  
St. John's, Goose Bay and Frobisher Bay

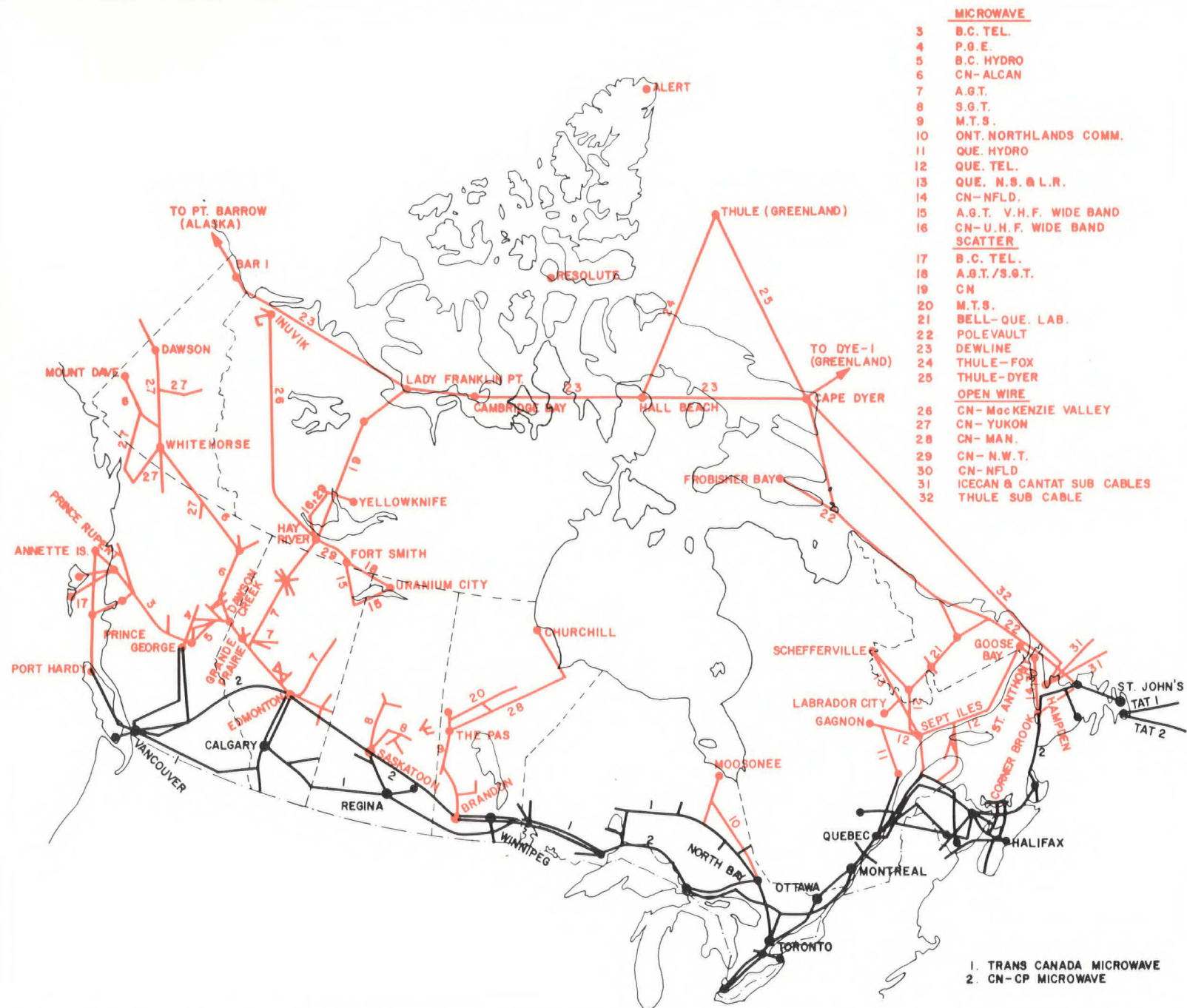
#### Sept Iles-Goose Bay Tropospheric Scatter Radio System

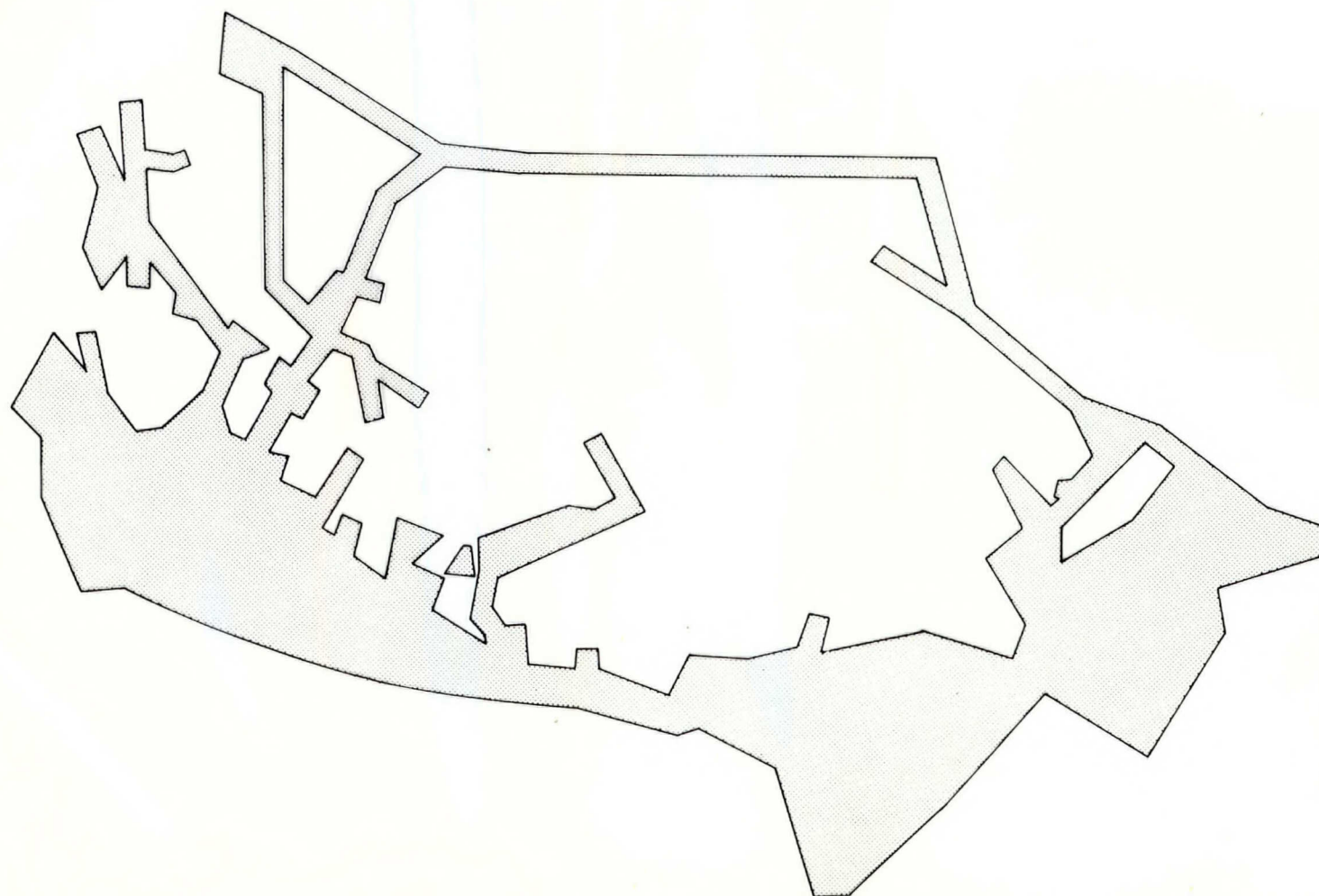
Bell Canada  
Quebec and Labrador, see fig.2, item 21  
Sept Iles to Goose Bay  
450 miles, 960 MHz  
132 telephone circuits, no TV  
Sept Iles, Emeril, Sona Lake and Goose Bay

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# MAJOR OPERATIONAL SYSTEMS

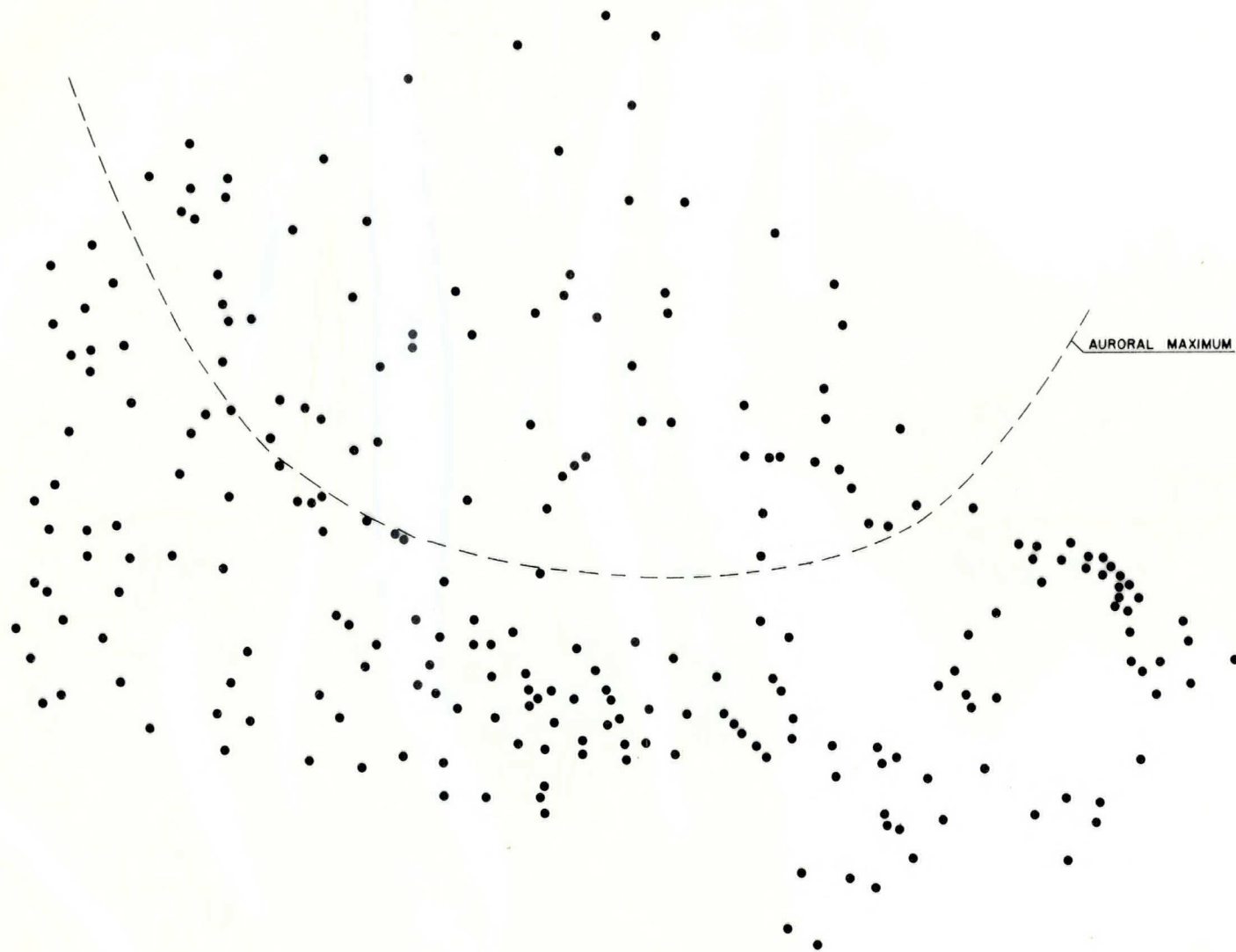
FIG. 2  
ACRES INTERTEL LIMITED





COMMUNICATION FRONTIERS

PLATE 13



DISTRIBUTION OF H.F. RADIO STATIONS

PLATE 14



## 8 . 1    ALCAN SYSTEM

The Alcan microwave radio relay system is the backbone of communication networks in the Yukon. It is owned and operated by Canadian National Telecommunications and carries telephone and data traffic from Alberta to the Yukon and Alaska.

Commercial and military traffic is carried from Grande Prairie (Alberta) to Mount Dave (Yukon) for subsequent routing to Fairbanks (Alaska). The system comprises 40 intermediate radio relay stations and spans a total distance of 1,100 miles. Major stations en route are Dawson Creek, Watson Lake, Teslin and Whitehorse.

The radio system operates in the 2 GHz (billion cycles per second) frequency band and is capable of carrying either a television signal or 600 two-way telephone circuits on one radio frequency (RF) channel. The system is now operational under partially loaded conditions and is equipped to carry 348 two-way telephone circuits.

At present the system transmits one working and one protection RF channel to carry telephone traffic between terminals. With the existing repeater sites and tower configuration, the system capacity can be augmented to

a maximum of six RF channels.

Interconnections to the southern communication networks are available at Grande Prairie and Dawson Creek.

## 8 . 2    EDMONTON - HAY RIVER SYSTEM

The Edmonton - Hay River microwave radio relay system provides communication between Alberta and the Northwest Territories. It is jointly owned and operated by Canadian National Telecommunications and Alberta Government Telephones.

Commercial and military traffic is carried from Edmonton (Alberta) to Hay River (NWT). The system comprises 20 intermediate relay stations, including several passive repeaters and spans a total distance of about 650 miles. Major stations en route are Valley View, Triangle and Peace River.

The system operates in the 2 GHz and 6 GHz frequency bands and is capable of carrying 240 two-way telephone circuits between the terminals. The present loading is 72 telephone circuits.



At present the system transmits one working and one protection RF channel carrying telephone traffic between the terminals. With the existing repeater sites and tower configuration, two more RF channels can be added thereby extending the overall system capacity to 720 two-way telephone circuits. Television cannot be sent over this system.

The terminal at Edmonton provides network connections with southern communication networks. Northward communications from Hay River proceed on the Mackenzie River Valley open wire and Hay River tropospheric scatter radio systems. Microwave and Ultra High Frequency (UHF) - Very High Frequency (VHF) radio spurs extend communications from the main system to the oil rich areas in northern Alberta.

### 8 . 3 MACKENZIE RIVER VALLEY SYSTEM

The Mackenzie River Valley open wire line communication system provides communication facilities along the Mackenzie River from Hay River to Inuvik in the Northwest Territories. The system is owned and operated by Canadian

National Telecommunications.

This open wire system carries long distance telephone, teletype, air traffic control and CBC radio program circuits for a total distance of 1,020 miles. There are 19 intermediate repeaters and the major locations served en route are Fort Simpson, Wrigley, Fort Norman, Norman Wells, and Fort Good Hope. From Inuvik the system is extended by UHF-VHF radio links to Aklavik, Fort McPherson, Arctic Red River and Tuktoyaktuk.

The maximum capacity of the system is 16 two-way telephone circuits. On the lower section of the route between Hay River and Fort Simpson this capacity has been reached. No economical means are available at the moment for increasing this capacity beyond the present limit.

At the Hay River terminal, the system has facilities for interconnection with the Edmonton-Hay River microwave radio relay system for communications to southern Canada. At Tuktoyaktuk, connections to the DEW Line system are available for east-west communications.

#### 8 . 4 HAY RIVER - LADY FRANKLIN POINT SYSTEM

The Hay River - Lady Franklin Point tropospheric scatter radio system provides military communication circuits between Hay River and Lady Franklin Point on Victoria Island (NWT). The system is owned and operated by Canadian National Telecommunications.

The overall route length of the system is about 600 miles with intermediate repeaters at Snare and Port Radium (NWT).

The system operates in the 2 GHz frequency band and is capable of carrying 72 two-way telephone circuits between the terminals. This capacity can be further augmented to 120 two-way telephone circuits with additional channelling equipment and perhaps some system modifications. The system is presently operational with 24 two-way telephone circuits and provides the western connection to the DEW Line system from the south.

Interconnection to the southern communication networks is made at the Hay River terminal while connection to the DEW Line system is available at Lady Franklin Point.

#### 8 . 5 THE PAS - CHURCHILL SYSTEM

The open wire line communication system from The Pas to Churchill (Manitoba) constitutes a major communication system to the North in central Canada. It is owned and operated by Canadian National Telecommunications.

The system spans a total distance of about 500 miles and carries long distance telephone, teletype, railway, air traffic control and CBC radio program circuits along the route.

The system serves major locations like Wabowden, Thicket Portage, Thompson, Gillam and Kelsey along the route. It has a capacity for carrying 18 two-way telephone circuits and is at present working under fully loaded conditions.

Interconnections with the southern communication networks are available at The Pas while linking facilities with the HF radio network emanating from Churchill extend communication service to the Keewatin District in the north.

## 8 . 6 DEW LINE SYSTEM

The Distant Early Warning (DEW) Line tropospheric scatter radio system is a chain of relay stations traversing Canada from Cape Dyer in the east to Komakuke Beach (Yukon) in the west along the 70th parallel. The system was installed in 1956 and is owned, operated and maintained by the U.S. Air Force.

The DEW Line was established principally to act as an early warning system against the approach of manned bombers. However, with the development of the guided missiles and the Ballistic Missiles Early Warning System (BMEWS) in the further north, the emphasis on the DEW Line function has now changed. The system is increasingly being used to provide military communication, data and navigational aid circuits and its initial surveillance role has gradually transformed into that of a data link for BMEWS traffic.

The overall system is about 6000 miles long and in all comprises six main stations (Cape Dyer, Hall Beach, Cambridge Bay, Cape Parry, Barter Island, Point Barrow) and 27 auxiliary stations. The Canadian section of the system is about 2000 miles long and includes four major stations (Cape Dyer, Hall Beach, Cambridge Bay, Cape Parry) and 18 auxiliary stations.

The system operates in the 900 MHz frequency band and is capable of carrying 72 two-way telephone circuits. The section of the route between Komakuke Island and Lady Franklin Point now carries 36-48 two-way telephone circuits. The remaining section from Lady Franklin Point to Cape Dyer is fully loaded.

Major rearward connections to southern Canada are available at Cape Dyer and Lady Franklin Point. At Cape Dyer a 132 channel troposcatter radio communication circuit (108 channels are in use) is available to the Polevault system and at Lady Franklin Point a 36 channel communication circuit (24 channels are in use) is available to the Lady Franklin Point-Hay River System. The eastern section of the DEW Line extends 72 two-way telephone circuits to Greenland and then to the North Atlantic Radio System (NARS) providing communication to Europe. The western section will ultimately provide 24 two-way telephone circuits to the White Alice troposcatter radio system in Alaska. Troposcatter radio extension links from Hall Beach and Cape Dyer, having capacities of 12 and 24 telephone circuits respectively, provide connections to the U.S. Air Force base at Thule (Greenland).

## 8 . 7 POLEVULT SYSTEM

The Polevault tropospheric scatter system which runs along the eastern coast of Canada from St. John's (Newfoundland) to Frobisher Bay (NWT) was installed in 1955 by the Bell Telephone Company of Canada (now Bell Canada) under a joint U.S./Canadian Project Office. Excluding a section between Newfoundland and Labrador which is now administered by Canadian National Telecommunications, the system is owned and operated by the U.S. Air Force for defence communication purposes.

The main system (Polevault I) spans a distance of 1273 miles between St. John's and Frobisher Bay with intermediate repeater terminals located at Gander, St. Anthony, Cartwright, Goose Bay, Hopedale, Saglek and Resolution Island. A second system (Polevault II) about 450 miles long, was installed between Hopedale and Resolution Island in 1957 with an intermediate repeater

at Saglek. A 36 channel troposcatter radio link provides connection to Harmon Field (Newfoundland).

Both Polevault I and Polevault II operate in the 565-735 MHz frequency band. The overall system capacity for two-way telephone circuits varies over sections of the route (72 circuits between St. John's and Hopedale, 96 circuits between Hopedale and Resolution Island and 24 circuits between Resolution Island and Frobisher Bay). The system is operating under almost fully loaded conditions.

Interconnections to the southern communication networks are made at St. John's and Goose Bay while access to the DEW Line system is available through a 132 channel troposcatter radio link (108 channels are in use) between Resolution Island and Cape Dyer (NWT).

#### 8 . 8 SEPT ILES - GOOSE BAY

The Sept Iles - Goose Bay tropospheric scatter radio relay system provides commercial and military communications service between Sept Iles (Quebec) and Goose Bay (Labrador). It is owned and operated by Bell Canada.

The system is about 450 miles long with intermediate repeaters at Cantiche, Emeril and Sona Lake. A 120-mile troposcatter radio spur from Emeril provides connection to Schefferville (Quebec). VHF spurs from Emeril and Sona Lake extend communication facilities to Labrador City and Churchill Falls respectively.

The system operates in the 900 MHz frequency band

and has varying capacities for two-way telephone circuits on various sections of the route (192 circuits between Sept Iles and Emeril, 132 circuits between Emeril and Sona Lake and 120 circuits between Sona Lake and Goose Bay). The system is operating under almost fully loaded conditions.

Interconnection with the southern communication networks is available at the Sept Iles terminal while the major east-west connection for military traffic is available at Goose Bay via the Polevault troposcatter radio system. VHF and HF links emanating from Goose Bay and serving areas of eastern Labrador have access facilities to this troposcatter radio system.



## 9 SUPPORTING COMMUNICATION SYSTEMS

See Figure 2

Major supporting communication systems in the North can be classified under the following headings:

- o Microwave Radio Systems
- o Tropospheric Scatter Radio Systems
- o UHF-VHF Radio Systems
- o Open Wire Systems.

These systems, shown in fig.2, assist in extending the communication frontiers northwards and in providing the necessary interconnections between the main trunk routes in the North and the national networks in southern Canada.

### SUMMARY

#### 9.1 MICROWAVE RADIO SYSTEMS

BC Tel, see fig.2, item 3

British Columbia

Prince George to Prince Rupert

480 miles, 4 and 6 GHz

600 telephone circuits, one TV

Prince George, Houston and Prince Rupert

BC Tel, see fig.2, item 3

British Columbia

Prince George to Dawson Creek

220 miles, 4,6,7 and 11 GHz

300 telephone circuits, no TV

Prince George and Dawson Creek

PGE, see fig.2, item 4

British Columbia

Prince George to Dawson Creek

300 miles, 6 GHz

120 telephone circuits, no TV

Prince George, Chetwynd and Dawson Creek

BC Hydro, see fig.2, item 5

British Columbia

Prince George to Portage Mountain

200 miles, 8 GHz

900 telephone circuits, no TV

Prince George and Portage Mountain

AGT, see fig.2, item 7

Alberta

Edmonton to Grand Centre and Fort McMurray

400 miles, 2,6 and 7 GHz

120 telephone circuits, no TV

Edmonton, Boyle, Fort McMurray and Grand Centre

AGT, see fig.2, item 7

Alberta

Edmonton to Athabasca

100 miles, 2 GHz

240 telephone circuits, no TV

Edmonton, Sangudo and Athabasca

SGT, see fig.2, item 8

Saskatchewan

Saskatoon to Waskesiu

140 miles, 2 and 4 GHz

120 telephone circuits, one TV to Prince Albert

Saskatoon, Prince Albert and Waskesiu

MTS, see fig.2, item 9

Manitoba

Brandon to Flin Flon^

500 miles, 2,4 and 6 GHz

136 telephone circuits, one TV Atik - The Pas

Brandon, The Pas, Atik and Flin Flon

Ontario Northlands Communications, see fig.2, item 10

North Bay to Moosonee

400 miles, 2,6 and 7 GHz

600 telephone circuits, no TV

North Bay, Cochrane and Moosonee

Que Tel/Bell Canada, see fig.2, item 12

Quebec

Sept Iles to Gagnon

160 miles, 4,6 and 11 GHz

600 telephone circuits, one TV

Sept Iles, Manicouagan and Gagnon

Que Tel, see fig.2, item 12

Quebec

Sept Iles to Blanc Sablon

450 miles, 2 and 6 GHz

120 telephone circuits, no TV

Sept Iles, Havre St. Pierre and Blanc Sablon

QUE NS&LR, see fig.2, item 13

Quebec and Labrador

Sept Iles to Schefferville with spur to Labrador City

380 miles, 6 GHz

600 telephone circuits, 1 TV Labrador City - Schefferville

Sept Iles, Emeril, Labrador City and Schefferville

Que Hydro, see fig.2, item 11

Quebec

Hauterive to Manicouagan

180 miles, 6 GHz

264 telephone circuits, no TV

Hauterive and Manicouagan

CN Telecommunications, see fig.2, item 14

Newfoundland

Cornerbrook to St. Anthony

230 miles, 2 GHz

120 telephone circuits, no TV

Cornerbrook and St. Anthony

## 9 . 2 TROPOSPHERIC SCATTER RADIO SYSTEMS

BC Tel, see fig.2, item 17

British Columbia

Port Hardy to Annette Island

350 miles, 900 MHz

72 telephone circuits, no TV

Port Hardy, Trutch Island and Annette Island

AGT/SGT, see fig.2, item 18

Alberta and Saskatchewan

Fort Smith to Uranium City

120 miles, 4.4 GHz

36 telephone circuits, no TV

Fort Smith and Uranium City

MTS, see fig.2, item 20

Manitoba

Cranberry Portage to Thompson

160 miles, 450 MHz

48 telephone circuits, no TV

Cranberry Portage and Thompson

### 9 . 3 UHF-VHF RADIO SYSTEMS

CN Telecommunications, see fig.2, item 16

NWT

Enterprise to Yellowknife

250 miles, 450 and 900 MHz

36 telephone circuits, no TV

Enterprise, Trout and Yellowknife

AGT, see fig.2, item 15

Alberta and Saskatchewan

Fort Smith to Uranium City

210 miles, 150 MHz

24 telephone circuits, no TV

Fort Smith, Fort Chipewyan and Uranium City

### 9 . 4 OPEN WIRE SYSTEMS

CN Telecommunications, see fig.2, item 27

Alberta, British Columbia and Yukon

Grande Prairie to Mount Dave with spur systems  
to Cassiar and Dawson City

1800 miles

36 telephone circuits on main route and

16 telephone circuits on spur routes, no TV

Grande Prairie, Whitehorse, Cassiar, Dawson City,  
Mayo and Mount Dave

CN Telecommunications, see fig.2, item 29

NWT

Hay River to Yellowknife

250 miles

24 telephone circuits, no TV

Hay River, Enterprise and Yellowknife

CN Telecommunications, see fig.2, item 29

NWT

Hay River to Fort Resolution and Fort Smith

230 miles

24 telephone circuits, no TV

Hay River, Pine Point, Fort Resolution and Fort Smith

CN Telecommunications, see fig.2, item 30

Newfoundland

Cornerbrook to St. Anthony

230 miles

12 telephone circuits, no TV

Cornerbrook and St. Anthony

CN Telecommunications, not shown

Quebec

St. Félicien-Chibougamau-Senneterre

400 miles

20 telephone circuits, no TV

St. Félicien, Chibougamau and Senneterre

## 9 . 5 HF RADIO COMMUNICATIONS SYSTEMS: SUMMARIES

### CN-CP AND BELL CANADA

Figure 3

#### CN-CP

British Columbia : 4 stations  
Network centre : Fort Nelson

Alberta : 2 stations

Yukon Territory : 5 stations  
Network centre : Whitehorse

N.W.T. : 22 stations  
Network centres : Hay River, Inuvik, Cambridge Bay

#### BELL CANADA

Manitoba : 1 station  
Network centre : Churchill

Ontario : 12 stations  
Network centres : Kenora, Moosonee

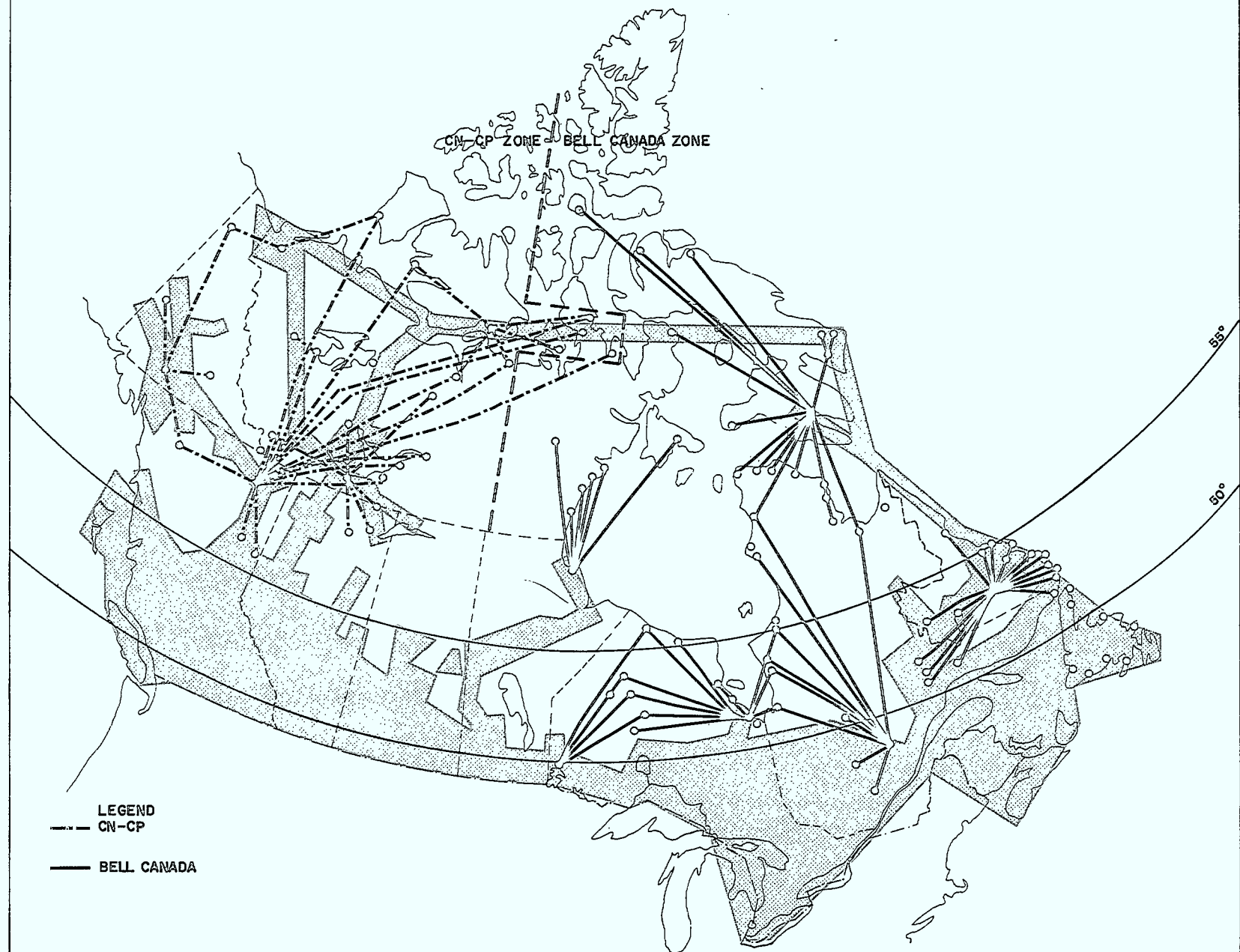
Quebec : 26 stations  
Network centre : Alma

Newfoundland : 8 stations

Labrador : 14 stations  
Network centre : Goose Bay

N.W.T. : 15 stations  
Network centre : Frobisher Bay

NOTE: SYSTEM ALSO INCLUDES L.F. & M.F. STATIONS



DEPT. OF COMMUNICATIONS  
NAT'L TELECOMM. BRANCH

H.F. COMMUNICATION CN-CP and BELL CANADA

FIG. 3  
ACRES INTERTEL LIMITED

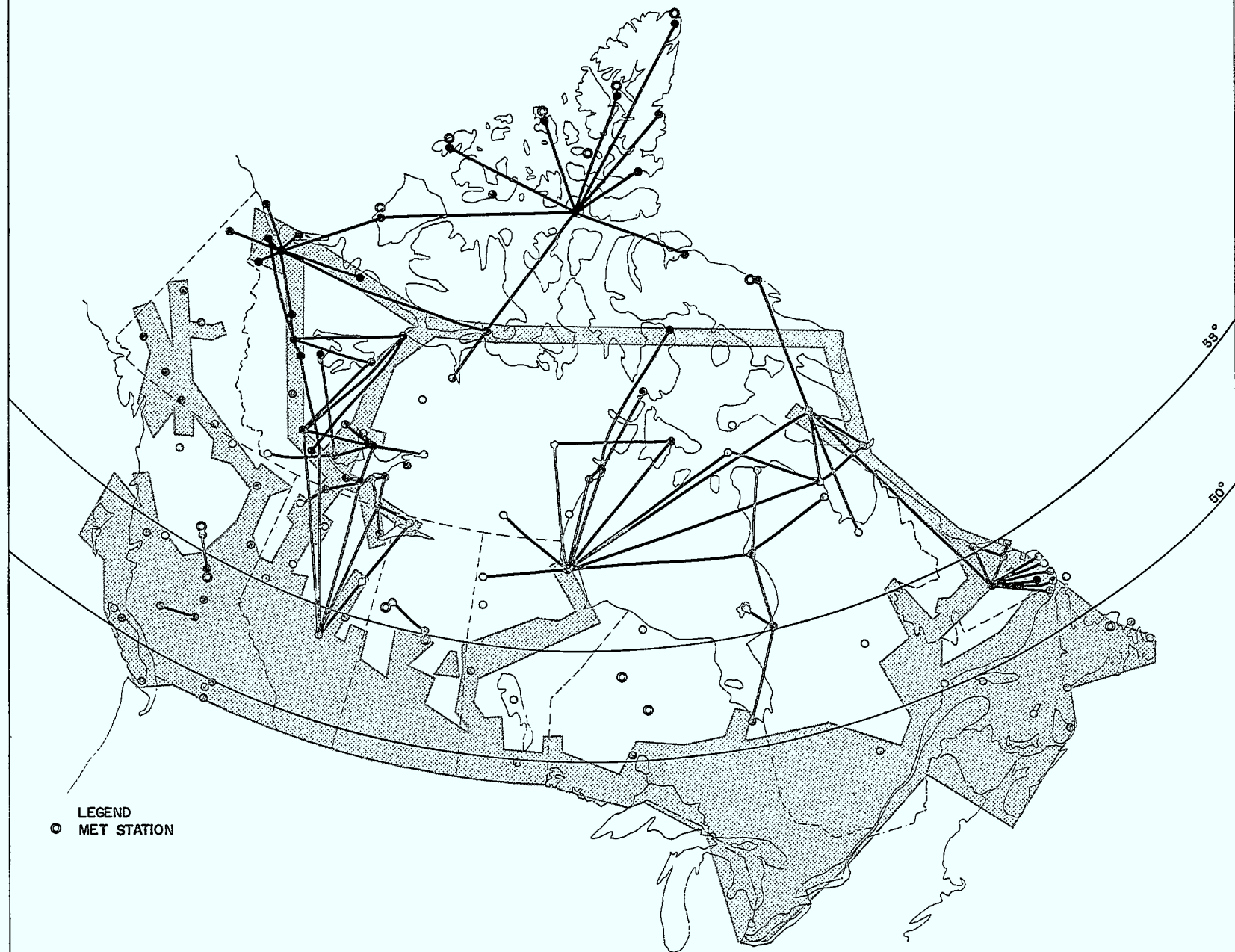


THE DEPARTMENT OF TRANSPORT

Figure 4

British Columbia :	19 stations (incl. 2 met. stations)
Alberta :	9 stations
Network centre :	Edmonton
Saskatchewan :	5 stations (incl. 2 met. stations)
Manitoba :	6 stations
Network centre :	Churchill
Ontario :	5 stations (incl. 2 met. stations)
Quebec :	13 stations
Network centre :	Port Harrison
Nova Scotia :	1 station
Newfoundland :	5 stations (incl. 1 met. station)
Labrador :	7 stations
Network centre :	Goose Bay
Yukon Territory :	8 stations
N.W.T. :	56 stations (incl. 7 met. stations)
Network centres :	Resolute, Frobisher Bay, Cambridge Bay, Inuvik, Coral Harbour, Coppermine, Fort Good Hope, Fort Simpson, Hay River, Yellowknife, Fort Smith

NOTE: SYSTEM ALSO INCLUDES L.F. & M.F. STATIONS



DEPT. OF COMMUNICATIONS  
NAT'L TELECOMM. BRANCH

H.F. COMMUNICATION DEPARTMENT OF TRANSPORT

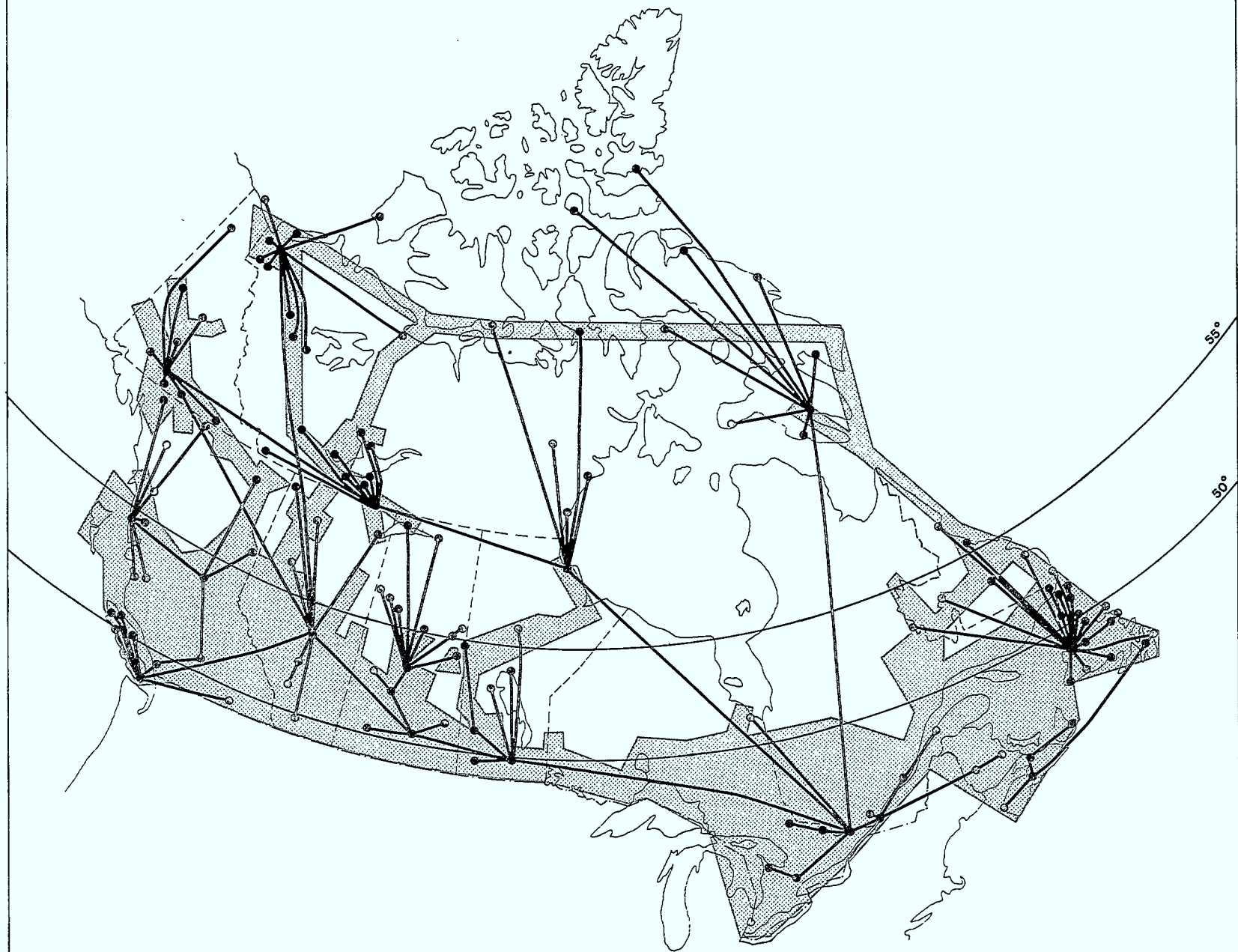
FIG. 4  
ACRES INTERTEL LIMITED

## ROYAL CANADIAN MOUNTED POLICE

Figure 5

British Columbia :	19 stations
Network centres :	Vancouver, Prince George, Prince Rupert
Alberta :	8 stations
Network centre :	Edmonton
Saskatchewan :	14 stations
Network centres :	Regina, Saskatoon
Manitoba :	8 stations
Network centres :	Edmonton, Churchill
Ontario :	6 stations
Network centre :	Ottawa
Quebec :	3 stations
Network centre :	Montreal
New Brunswick :	1 station
Nova Scotia :	5 stations
Network centre :	Halifax
Newfoundland :	15 stations
Network centre :	Cornerbrook
Labrador :	8 stations
Yukon Territory :	9 stations
Network centre :	Whitehorse
N.W.T. :	31 stations
Network centres :	Fort Smith, Inuvik, Frobisher Bay

NOTE: SYSTEM ALSO INCLUDES L.F. & M.F. STATIONS



DEPT. OF COMMUNICATIONS  
NAT'L TELECOMM. BRANCH

H.F. COMMUNICATION R.C.M.P.

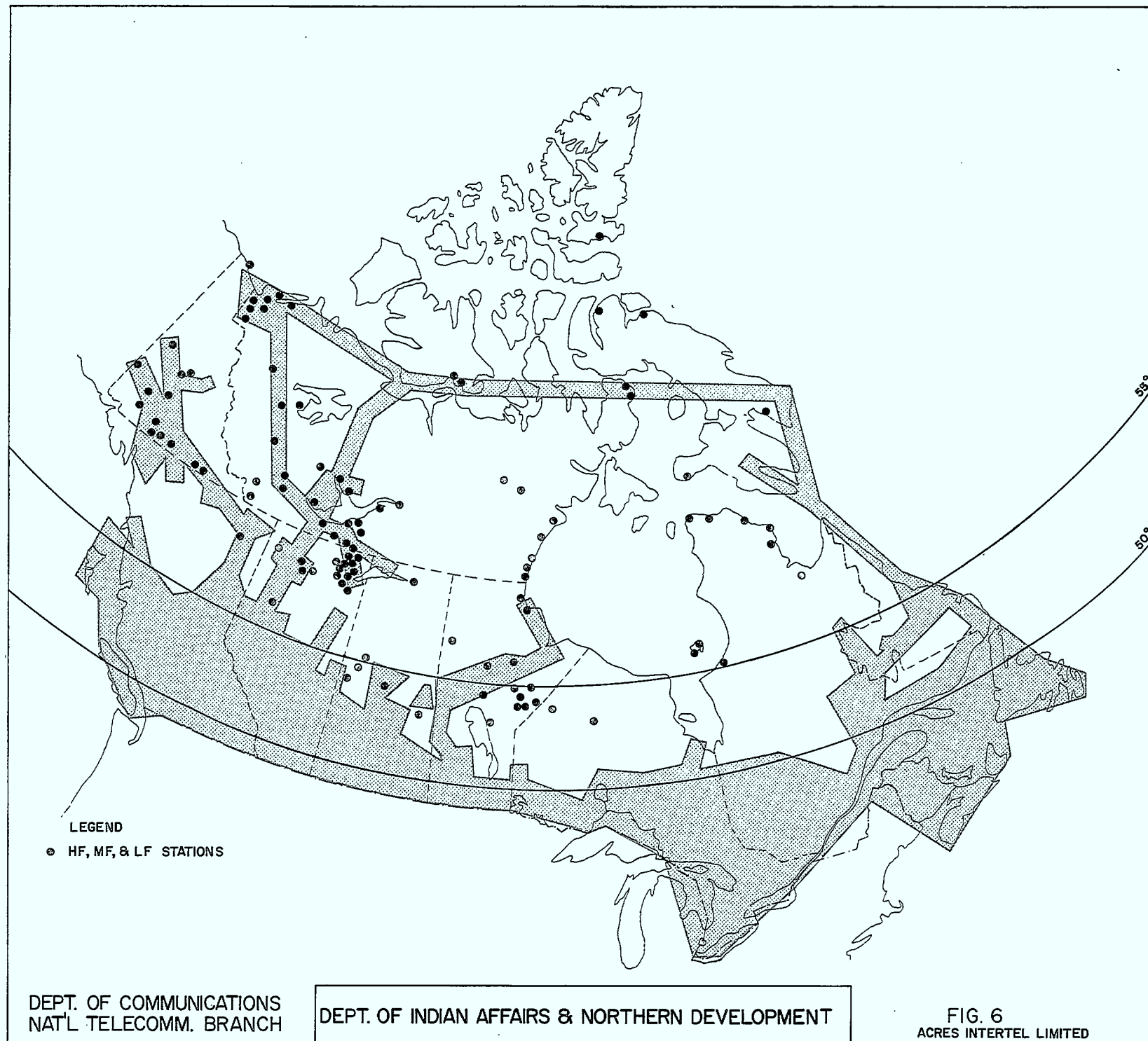
FIG. 5  
ACRES INTERTEL LIMITED

DEPARTMENT OF INDIAN AFFAIRS AND  
NORTHERN DEVELOPMENT

Figure 6

British Columbia :	1 station
Alberta :	16 stations
Saskatchewan :	6 stations
Manitoba :	13 stations
Ontario :	2 stations
Quebec :	7 stations
Yukon Territory :	14 stations
N.W.T. :	46 stations



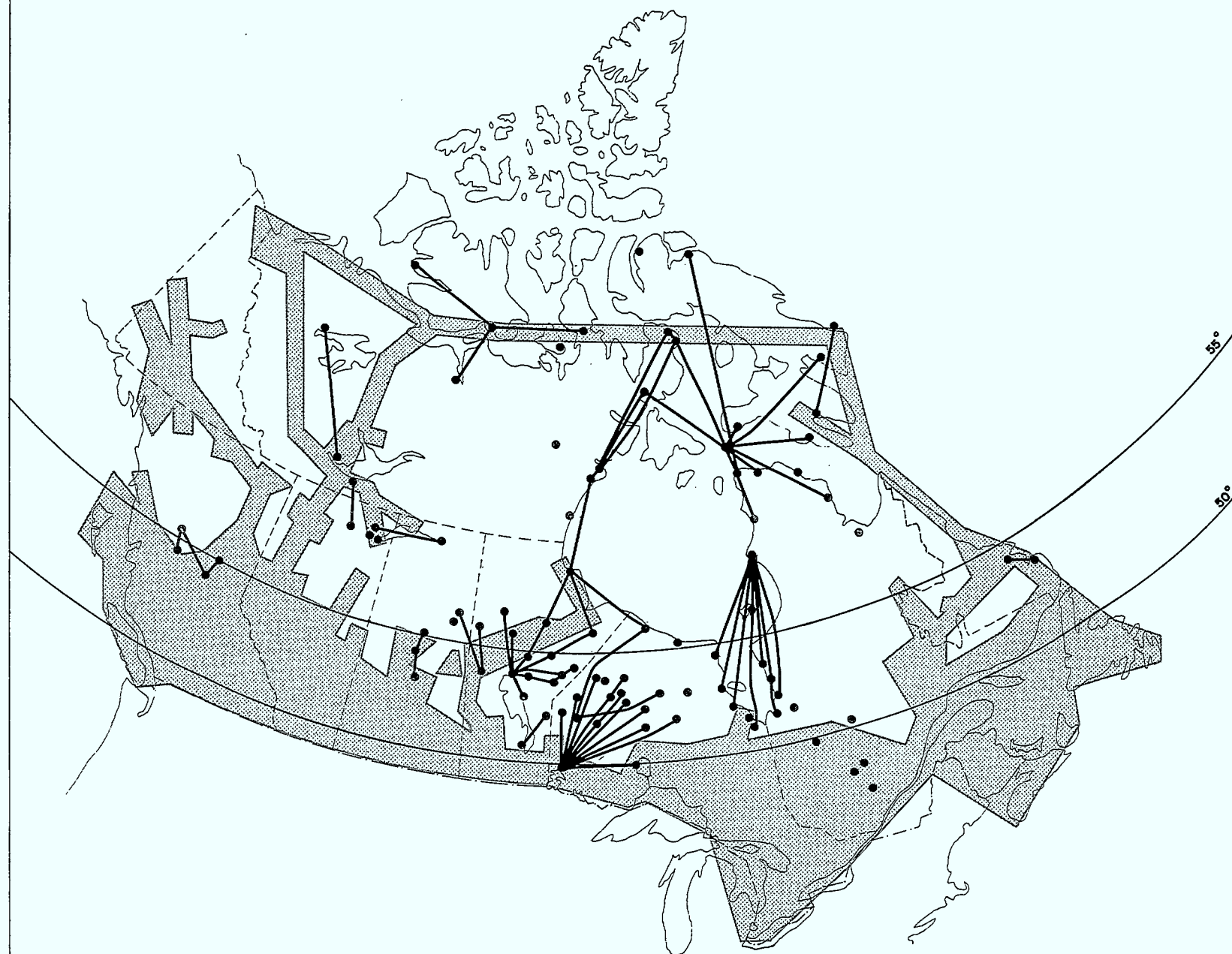


HUDSON'S BAY COMPANY LTD.

Figure 7

British Columbia :	4 stations
Alberta :	4 stations
Saskatchewan :	5 stations
Manitoba :	14 stations
Network centres :	Norway House, The Pas, Churchill
Ontario :	24 stations
Network centre :	Kenora
Quebec :	17 stations
Network centre :	Port Harrison
Labrador :	2 stations
N.W.T. :	18 stations
Network centres :	Nottingham Island, Chesterfield Inlet, Cambridge Bay

NOTE: SYSTEM ALSO INCLUDES L.F. & M.F. STATIONS



DEPT. OF COMMUNICATIONS  
NAT'L TELECOMM. BRANCH

H.F. COMMUNICATION HUDSON'S BAY CO. LTD.

FIG. 7  
ACRES INTERTEL LIMITED

RELIGIOUS MISSIONS      Figure 8

Roman Catholic Episcopal of Keewatin

Saskatchewan: 9 stations

Manitoba : 11 stations

Ontario : 1 station

Roman Catholic Episcopal of Mackenzie

Alberta : 2 stations

Saskatchewan: 2 stations

N.W.T. : 20 stations

Northern Canada Evangelical Mission

Alberta : 1 station

Saskatchewan: 3 stations

Manitoba : 2 stations

N.W.T. : 7 stations

Les Missionnaires Oblates de Marie Immaculée

Manitoba : 1 station

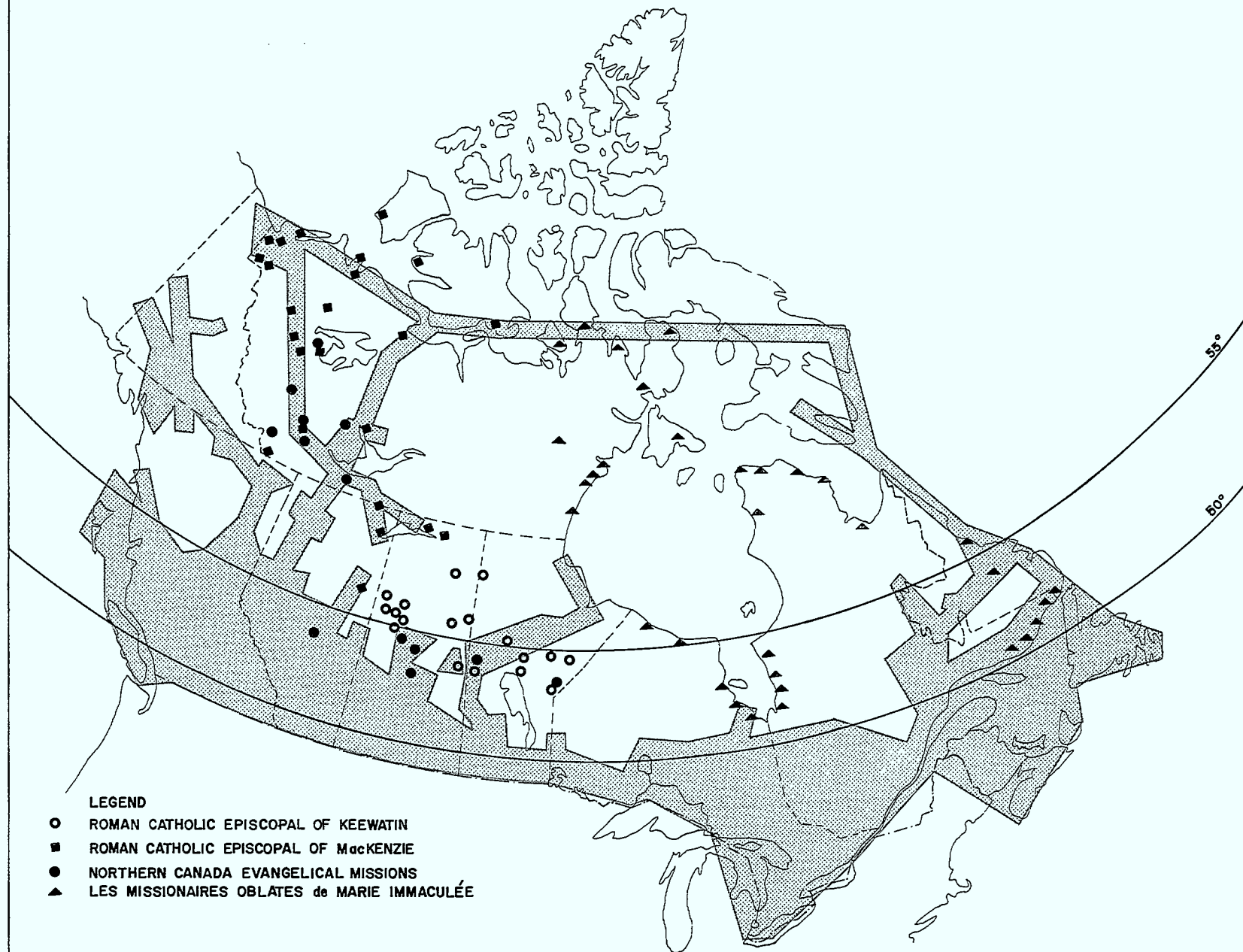
Ontario : 5 stations

Quebec : 16 stations

Labrador : 2 stations

N.W.T. : 13 stations

NOTE: SYSTEM ALSO INCLUDES L.F. & M.F. STATIONS



DEPT. OF COMMUNICATIONS  
NAT'L TELECOMM. BRANCH

H.F. COMMUNICATION RELIGIOUS MISSIONS

FIG. 8  
ACRES INTERTEL LIMITED



## PROVINCIAL SYSTEMS

Figure 9

The British Columbia Department of Highways

Number of stations: 22

Network centres : Vancouver, Prince George, Prince  
Rupert, Fort Nelson

The Alberta Department of Lands and Forests

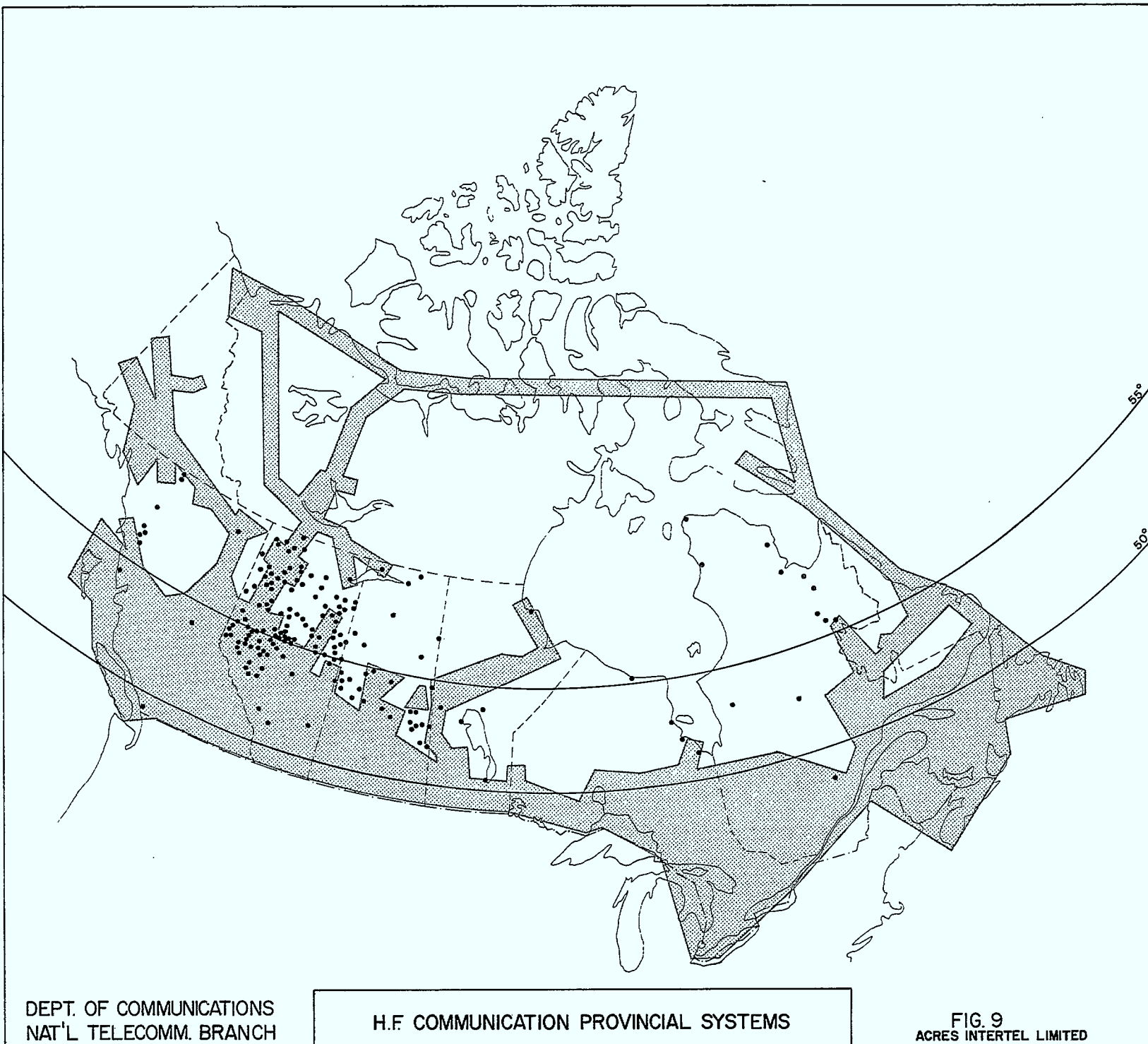
Number of stations: 131

The Saskatchewan Department of National Resources

Number of stations: 20

The Quebec Department of Natural Resources

Number of stations: 8



## 10 BROADCASTING

### 10.1 RADIO

Radio is the only major medium of mass communication in the North. As such it has specific responsibilities to provide a program service to meet the special needs of the people in this area. Its schedule combines local programs such as news, public affairs, reports on weather, flying, roads, rivers and trapping with national network programs including drama, variety, national public affairs, national news, etc.

Community programs for Indians, Eskimos and Métis which include personal messages e.g. between patients in hospitals and their families at home, and between members of families separated on trap lines or on journeys, have already achieved a great deal of success.

The Northern Service of the Canadian Broadcasting Corporation provides a radio service for the majority of the people living in the Canadian North by means of medium and short wave broadcasts.

This Northern Service serves 29 communities on medium wave in the Yukon, the Northwest Territories and the northern areas of the provinces. Program material for the short wave High Arctic service originates at Montreal and is sent by landline to Sackville (New Brunswick) for transmission.

The Northern Service has six program centres: Happy Valley (Labrador), Yellowknife, Inuvik, Frobisher Bay (NWT), Whitehorse (Yukon) and Churchill (Manitoba). With the exception of the station at Frobisher Bay, all are connected to the national network. The remaining stations which are designated as Low Power Relay Transmitters (LPRT), are normally unattended. These are also connected to the national network and are grouped into three regional networks having program centers at Whitehorse for the Yukon, Yellowknife for the Mackenzie River Valley, and Happy Valley for Labrador.

The community station at Frobisher Bay is served by tape recordings and short wave transmission pickups from the southern stations.

A large area in the southern section of the Canadian North is not served by the CBC's Northern Service. This area includes about twelve network stations and 17 LPRTs forming a part of the main CBC radio network.

Short wave radio transmission to the Canadian North suffers from serious problems in terms of reliability. Two of the major problems include transmission across the auroral zone and interference from foreign broadcasting stations.

Long term development plans of the Northern Service have taken recognition of these factors and have proposed replacement of the existing transmitting arrangements with 250kW transmitters and efficient wide beam antenna arrays for improved performance and coverage.

## 10. 2 TELEVISION

The CBC and its affiliates operate television stations in the North at Labrador City and Goose Bay (Labrador), Churchill (Manitoba), Prince Albert (Saskatchewan), Dawson Creek, Prince Rupert and Terrace (British Columbia) and Schefferville (Quebec). In addition there are about 28 re-broadcasting stations carrying the CBC network service. A privately owned closed circuit television system operates at Whitehorse (Yukon). To provide a television service to residents of remote and isolated areas of the North where off-the-air, micro-

wave or network service is unavailable or would prove too costly to install and operate, CBC has developed the frontier package service. In its simplest form, the frontier package consists of a helical-track master video tape recording installation, which is installed in a television network-connected or originating studio building. The recorded video tapes are regularly flown to the frontier transmitter stations where video playback units provide the audio and video inputs to the television transmitter. Taped programs run for about 4 hours. A typical frontier package installation may cost between \$80,000 and \$100,000 with annual operating and maintenance costs around \$50,000. Three CBC frontier package stations are in daily operation at Yellowknife (NWT), Lynn Lake (Manitoba) and Havre St. Pierre (Quebec).

## II PROPOSED SYSTEMS FOR THE NORTH

See Figure 10  
Plates 15 to 18

### II . I TERRESTRIAL SYSTEMS

Plate 18

The following information is tentative and does not imply that the proposed systems are acceptable for licensing.

#### Inter-Provincial System

The Inter-Provincial microwave radio relay system between Vancouver (British Columbia) and Toronto (Ontario) when completed, will provide the third major communication network in Canada. This new trunk route is being constructed and will be operated by the Trans-Canada Telephone System.

The planned route passes through the northern reaches of British Columbia, Alberta and Saskatchewan thereby extending and supplementing trunk communication facilities to these regions.

The radio system will operate in the 4 GHz frequency band and be capable of carrying either a television signal

or 1200 two-way telephone circuits on one RF channel.

Several sections have now been installed and commissioning tests are in progress.

Winnipeg - Grand Rapids  
Grand Rapids - Kettle Rapids  
Grand Rapids - Flin Flon

The Manitoba Telephone System has undertaken major expansion programmes for its microwave radio relay systems in Manitoba. When completed these systems will provide the much needed communication facilities along the length and to the north of Lake Winnipeg.

The radio systems will operate in the 2 GHz frequency band and be capable of carrying either a television signal or 600 two-way telephone circuits on one RF channel.

Several sections have now been installed and commissioning tests are in progress.



Hauterive - St. Marguerite

The Quebec Hydro-Electric Commission has put forward plans for a microwave radio relay system between Hauterive and St. Marguerite (Quebec). This system is mainly intended as the rearward link for Hydro-Quebec's proposed tropospheric scatter radio system between St. Marguerite and Logan.

The radio system will operate in the 7 GHz frequency band and be capable of carrying 300 telephone circuits per RF channel.

Whitehorse - Carmacks  
Ferry Hill - Arctic Red River - Tuktoyaktuk

Canadian National Telecommunications have tentative plans for the development of their trunk communication facilities in the Yukon and the Northwest Territories.

Their plans include the construction of microwave or UHF radio systems between Whitehorse and Carmacks (Yukon) and between Ferry Hill (Yukon) and Arctic Red River (NWT)

with eventual extension to Inuvik and Tuktoyaktuk.

The microwave system would operate in the 2 GHz and 4 GHz frequency bands with initial equipped capacity for about 60 telephone circuits per RF channel. The UHF systems would carry about 24 telephone channels in the 450 MHz band.

\*Carmacks - Dawson City  
Dawson City - Arctic Red River  
Carmacks - Ross River

These VHF-UHF radio relay systems form part of the overall communication development plans in the Yukon and Northwest Territories proposed by Canadian National Telecommunications.

These systems are intended to operate in the 150 MHz and 900 MHz frequency bands carrying between 24 and 60 telephone circuits per RF channel, depending on the sections of the routes under consideration.

#### St. Marguerite - Logan

The Quebec Hydro-Electric Commission has put forward plans for a tropospheric scatter radio relay system between St. Marguerite (Quebec) and Logan (Labrador), with a repeater at Eric, to provide communication and supervisory facilities for their power line transmission systems originating at Churchill Falls.

The system is intended to operate in the 2 GHz frequency band and will have the capability for carrying up to 120 telephone circuits on one RF channel.

#### Goose Bay - L'Anse Au Loup

Bell Canada has proposed the installation of a two-hop tropospheric scatter system between Goose Bay and L'Anse Au Loup (Labrador).

The proposed system is intended to operate in the

900 MHz frequency band with an ultimate capacity for carrying up to 120 telephone circuits.

#### Fort Nelson - Fort Simpson

This microwave radio relay system between Fort Nelson (British Columbia) and Fort Simpson (NWT) forms part of the plans considered by Canadian National Telecommunications to improve communication facilities in the Northwest Territories.

This radio link will provide the communication network in the Mackenzie Valley with direct interconnection facilities to the Alcan system at Fort Nelson.

The system is intended to operate in the 2 GHz frequency band with a capacity for carrying 120 telephone circuits on one RF channel.

## 11.2 SATELLITE SYSTEMS      Plates 15 to 17

The communication satellite is a unique electronic bridge capable of carrying high quality telephone and television between points widely separated by inaccessible terrain. Direct access to the national telephone and television networks can be extended to most communities in the North because of the satellite's special characteristics.

The Canadian Domestic Satellite System will use a six-transponder satellite in synchronous orbit. Some of the transponders will be available for telephone and data traffic to the North. The remaining satellite transponders will be used for television distribution in both languages and for back-up communications between major centers in southern Canada.

Two types of earth stations have been planned for northern areas. One type will receive television channels but will have no transmit capability; the other will receive television and simultaneously transmit and receive

telephone signals in a multiple access mode. Earth stations for telephone and data communications will be more sophisticated than the TV receive-only stations and will cost much more.

Arctic communication stations will operate in a Frequency Division Multiple Access mode (see Glossary) providing telephone and data communications between northern stations and a master terminal in southern Canada. Intercommunication between the northern stations will also be possible. A typical station will be able to transmit one RF carrier and receive up to five RF carriers, with each carrier handling up to 24 telephone circuits. Since the maximum number of available carriers for the total system may be limited to ten, (this depends on the satellite transponder bandwidth) careful selection of earth station locations will be necessary to achieve the maximum benefit from the Domestic Satellite System.

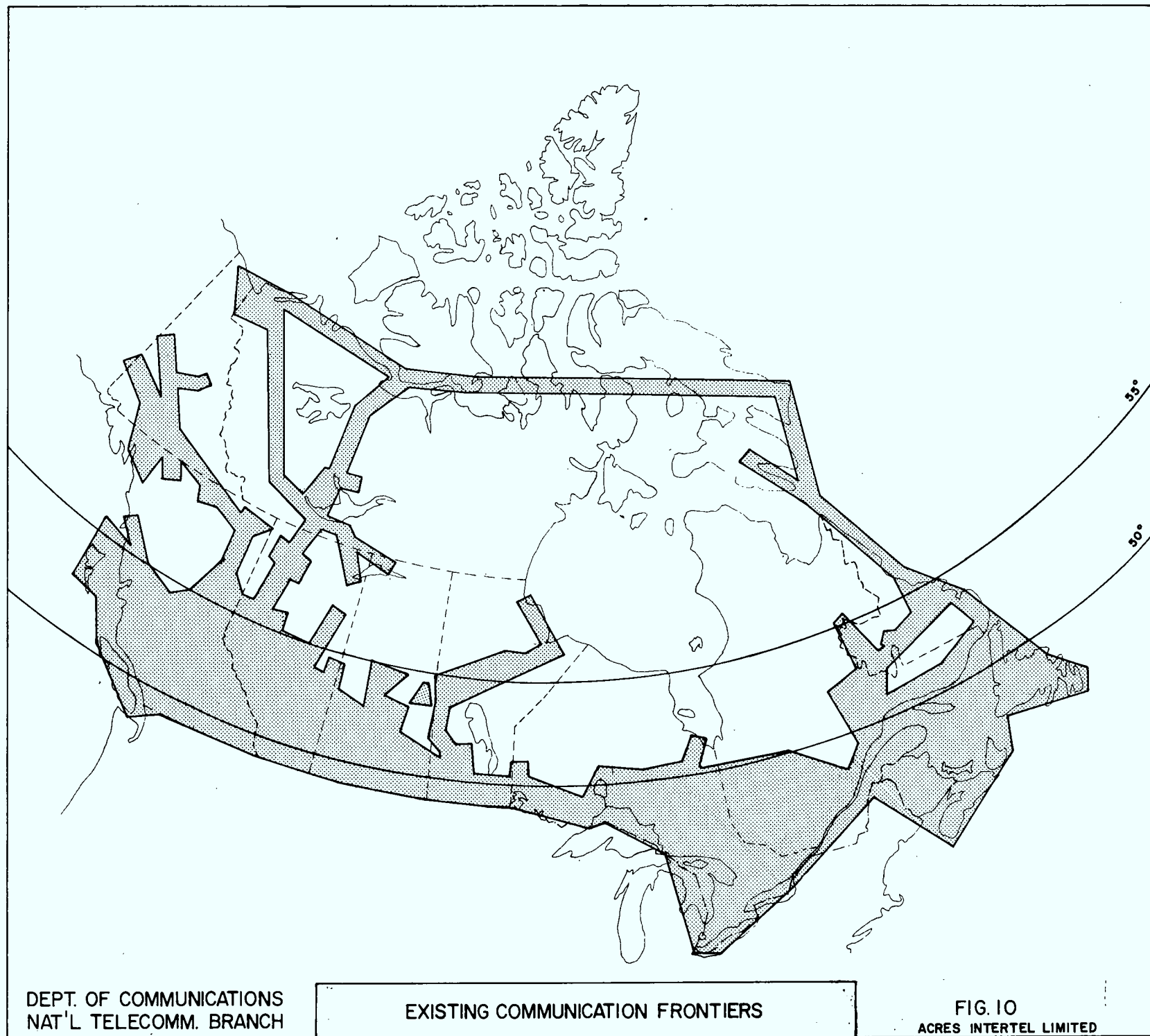
Regions have been outlined in Plate 17 to show the most likely areas that may eventually be candidates for earth station sites in the North. Also shown are the limits of satellite coverage when the satellite is placed at longitudes of  $80^{\circ}$  or  $120^{\circ}$  above the equator. These are approximate outer limits of placement for Canadian satellites in the synchronous orbit which may be shared with the satellites of the United States and South American countries.




The most important considerations affecting northern radio station construction costs are:

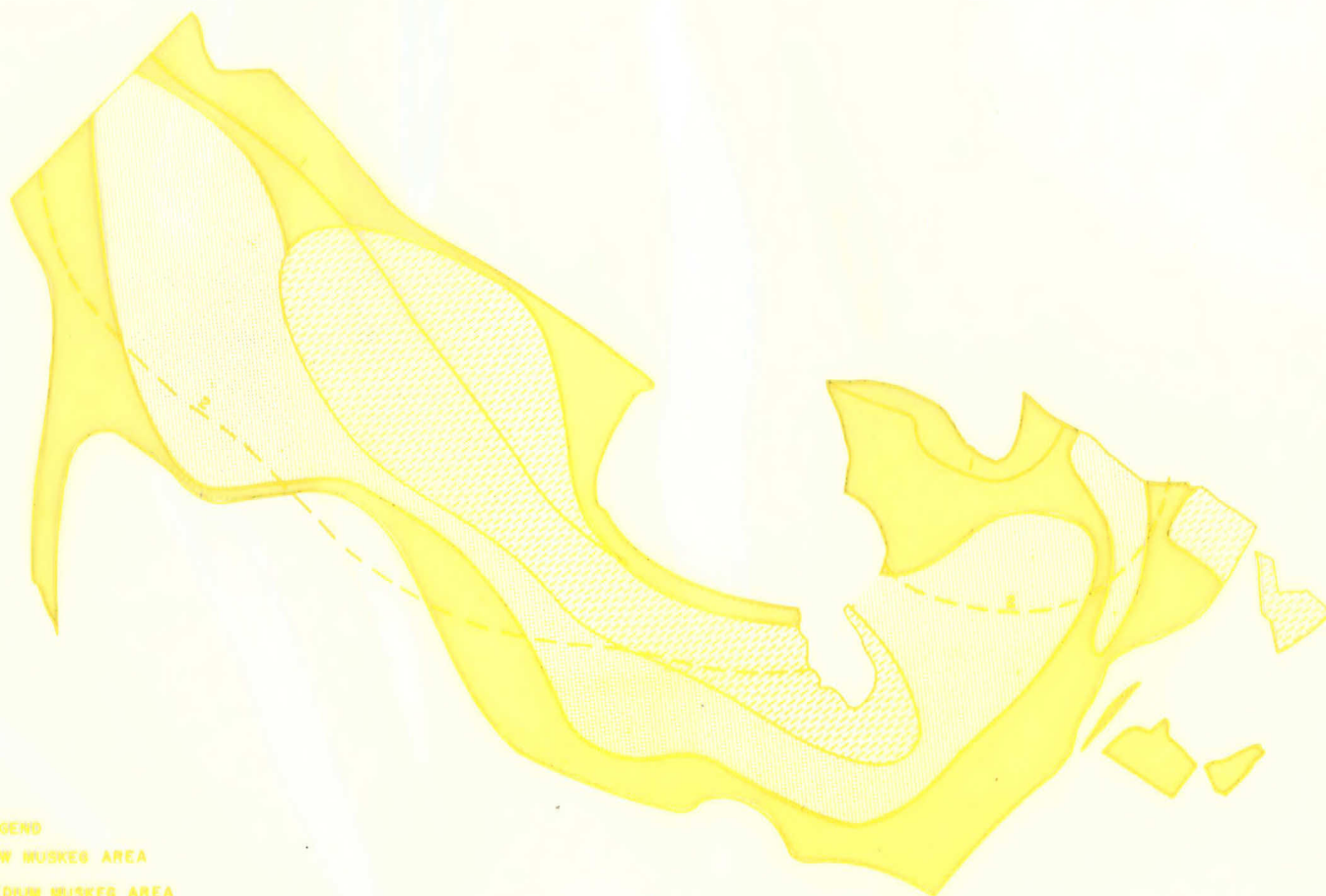
- o Transportation
- o Temperature
- o Soil conditions
- o Wind gust factors

The first two items have been considered earlier in this Report. Soil conditions determine the type of foundation and support necessary for the radio building and antenna structure. Two types of general conditions exist that give difficulty to construction in the North - muskeg and permafrost. Muskeg must normally be cleared before construction can commence while buildings on permafrost are usually supported on platforms resting on piles sunk into the ground. Wind gust velocities and icing depths dictate the rigidity of the antenna and its support.

Plates 15 and 16 show how soil conditions and wind gust velocities vary in different areas of Canada.



- LEGEND
-  LOW MUSKEG AREA
  -  MEDIUM MUSKEG AREA
  -  HIGH MUSKEG AREA
  - 1 SOUTHERN LIMIT OF CONTINUOUS PERMAFROST
  - 2 SOUTHERN LIMIT OF DISCONTINUOUS PERMAFROST



MUSKEG AREAS & PERMAFROST LIMITS

PLATE 15



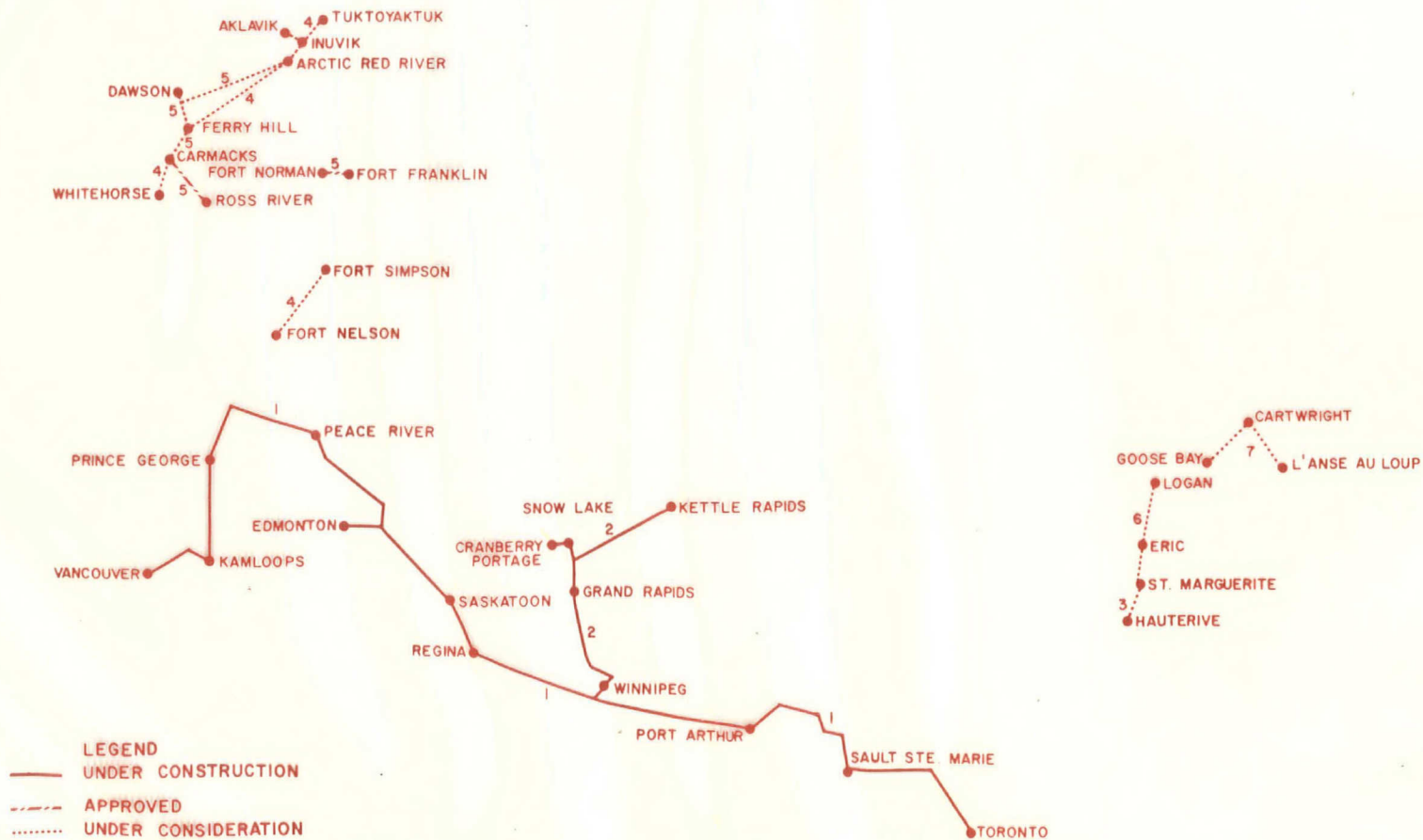


WIND-MAX. GUST SPEED (m.p.h.)

PLATE 16



- MICROWAVE
- 1 INTERPROVINCIAL
  - 2 M.T.S.
  - 3 QUE. HYDRO
  - 4 CN
  - UHF/VHF
  - 5 CN
  - SCATTER
  - 6 QUE. HYDRO
  - 7 BELL



PLANNED SYSTEMS

PLATE 18



## 12 COMMUNICATIONS PLANNING

Communications growth in the North began in the post-war period. Development of major communication systems was intended to support particular government and military activities. The growth of commercial and private systems was sporadic. This was because the sparse population could not provide an economic base for profitable commercial service and users resorted to their own private systems. Communications developed slowly.

The early 1960's saw a change in public policy towards the North. It was appreciated that resource exploitation alone was not sufficient to ensure progressive and meaningful development. The recognized need was for the encouragement of permanent settlement. Government activity was stimulated by the awareness that communications for information and entertainment had become a social necessity.

Further concentrated effort by government and private industry will be needed to accelerate the tempo of development in the 1970's. The commitment for human progress can only be met by increased involvement of the Federal government in northern development. In communications, this will mean that the Federal government should lead

private industry in planning the provision of northern services.

The creation of the Department of Communications presents the opportunity to consolidate communication requirements and to set planning objectives; thus the requirements of individual users can be consolidated and their combined needs assessed.

Optimum communications development for particular regions will depend on:

- 1) Human Importance: existing population centres which are not now served must have communications.
- 2) Resource Importance: the resource potential should be sufficient to ultimately justify commercial investment.
- 3) Strategic Importance: the maintenance of national sovereignty and national defence requires reliable communications.
- 4) Operational Importance: safety-of-life demands adequate communications for navigation and meteorological services.

## 12 . 1 PLANNING OBJECTIVES

Planning objectives must be defined to concentrate attention on the actual communication needs of the North. In broad terms, communications planning must ultimately ensure:

- that broadband trunk connections be established between major centres in southern and northern Canada to obtain a fully integrated national telephone network;
- that sufficient network television channels be available in large and small northern communities for live dual language entertainment and educational purposes;
- that the necessary area distribution networks be established to extend telephone and data services to remote locations from communication centres;
- that a number of network quality radio program channels be available both to large and small northern communities.

It is not possible to realize these objectives within a short time frame. Criteria will have to be established and priorities defined to decide which communities need a given standard of communication service. Planning will be required to ensure that services grow logically within a pattern conducive to overall northern development.

## 12 . 2 COMMUNICATION GROWTH TRENDS

Until recently, troposcatter and HF radio systems offered the only economic means of providing communications to the North. Neither of these techniques can transmit television or broadband communication channels. Therefore, future emphasis will centre on communication satellites and microwave radio relay systems for carrying live television and broadband channels to communities in the North. Broadband cable or waveguide systems could only challenge satellite and microwave systems if the market for telecommunications increased substantially, or technical innovations brought down the costs of using these facilities.

Some growth trends can be discerned from the information on physiography and communication systems presented in this Report. It is expected that many urban communities will eventually form below the tree line. This means that the Yukon, the western section of the Northwest Territories and Mid-Canada may develop in much the same manner as communities have grown in the northern parts of the Provinces.

Microwave systems now provide backbone communications to some of these areas below the treeline and their further extension is anticipated. Spur radio links will carry communications to points on or adjacent to main routes. Communication satellites will be used primarily for television distribution where the cost of routing program channels on existing terrestrial networks exceeds that of satellites.

The Central and Eastern Arctic above the tree line present a different picture. Here most communities are small and are separated by large distances. Communication satellites are the only economical way of providing reliable service. Extensive conventional microwave systems are not likely to develop because of the physical difficulty of their construction, operation and maintenance. Instead, communication centres or hubs fed by satellites may be

established with distribution proceeding radially from these centres. Both radio and cable systems will be needed for radial distribution of high quality communications and television signals.

#### TRENDS - Satellite Systems

The Domestic Satellite System will influence communications planning very significantly in coming years. The satellite to be launched in 1971 will enable television and high quality communications to be extended to the North.

The rate of growth of television service will be dependent on the availability of funds to establish additional earth stations. There is no technical limitation in extending TV coverage to any northern location provided the satellite is visible from the earth station site.

The provision of adequate communication services for telephony employing the satellite will evolve over a longer period. Problems to be overcome are:

- o earth stations for transmitting and receiving telephony are relatively expensive;
- o there is a technical limit to the number of earth stations that can have access to the initial Domestic Satellite System.



It will therefore be necessary to study ways and means of adapting the initial system configuration to arrange for more earth stations to work into the satellite system in the future.

The initial system will use a Frequency Division Multiple Access (FDMA) mode. More efficient techniques such as Time Division Multiple Access (TDMA) are being developed and will subsequently provide a more flexible access facility. It should then be possible to extend communication service to a larger complement of earth stations using the same satellite as proposed for launching in 1971.

Development trends indicate that better techniques for access may be available before the second generation of Domestic Satellites is considered e.g. demand assignment or random access techniques. These techniques should enable the number of earth stations using a given satellite transponder to be increased substantially beyond the limitations of the simple FDMA and TDMA systems. The utilization of the satellite transponders using demand assignment will be much more efficient and should result in lower rental costs on a per telephone channel basis.

Demand Assignment techniques will allow telephone and data services to be extended to a large number of small communities. Transportable and mobile stations for very small or transient settlements may then be feasible. Other technical developments in this period, particularly the use of frequencies above 10 GHz, should tend to lower the costs of earth stations.

Evolution of direct broadcasting from satellites is expected to occur around 1980. This would eventually meet the television distribution needs of individual users. During the period between 1971 and 1980, Frontier Package and low power relay transmitter stations can be used to bring television and radio to the smaller communities.

The Domestic Satellite System cannot serve the northernmost Archipelago Islands. If satellite coverage were contemplated it would be necessary to use non-synchronous satellite(s) in elliptical orbit. Such a satellite system might be considered in the distant future on an international co-operative basis e.g. to satisfy a requirement for international communication links across the Arctic Ocean to aid polar navigation.

## TRENDS - Terrestrial Systems

### Troposcatter Radio

Troposcatter and HF radio systems have partially met the communication needs of the North. But as the communication satellite gradually assumes a more important role it is likely that the rate of implementation of new troposcatter radio systems will decrease. However, existing troposcatter radio systems will need to be maintained for transmitting defence information because of their proven reliability and relative immunity to jamming.

The Distant Early Warning (DEW) Line will continue to be operated for some years to come. The DEW Line is the only trunk system for east-west communications in the North. It would be desirable to use this system for Canadian civilian communications since it is presently not loaded to its full capacity. This system is owned and operated by the U.S. military.

### LF Radio

Low frequency radio can carry reliable low rate data circuits in the Arctic. Tests have demonstrated the feasibility of using compact solid state radio equipment, and

simple horizontal dipole antennas, for communicating between points 150 to 200 miles apart. These systems may find increasing application by virtue of their low cost, transportability, and immunity to ionospheric disturbances.

### HF Radio

A steady increase is anticipated in the installation of high frequency (HF) radio circuits. At least until the second generation of Domestic Satellites, HF radio will be the most economic way of providing communications to small and isolated communities. Communications planning must acknowledge the continuing importance of HF radio for medium and long distance communications.

Major improvements in the reliability of service provided by HF radio can be achieved in many ways. By proper maintenance of radio equipment and the installation of efficient antenna systems, a significant improvement in the performance of existing systems can be obtained. The provision of technical advice to users on how to obtain optimum results from their systems is also necessary for the success of any program to improve service reliability.

Work is already under way to improve the selection of frequencies and the design of HF radio systems by using a computer program developed by the Canadian Research Centre. This program makes use of ionospheric propagation data that has been accumulated over the years; charts will eventually be available to show what frequencies can best be supported by the ionosphere. It is hoped that the usefulness of this method will be enhanced as more complete information on the ionosphere becomes available from the ISIS and related satellite programs.

A major limitation of HF radio circuit reliability is frequency sharing in the HF bands. This problem is being seriously studied by the United States and a computer technique using oblique soundings has been developed. This is the CURTS concept for real time frequency management of HF radio systems. An approach of this type to HF radio frequency assignments for northern Canada would yield substantial returns in reliability of service, but the cost of implementing such a program would be considerable.

The British Post Office has invented a system called the LINCOMPLEX system, to improve the performance of

HF radio telephone circuits. The system employs compressors and expandors linked by a special control circuit. An excellent performance standard has been demonstrated on international HF radio circuits.

Any of the above techniques would enhance HF radio system performance. Application of digital and error correcting methods would further optimize system performance.

#### UHF-VHF Radio

An increasing interest in the establishment of Very High Frequency (VHF) radio systems is foreseen in the next decade. These systems use line-of-sight propagation paths for transmitting 24 telephone circuits or less and may prove ideal for radial distribution from satellite earth stations. They are most attractive for extending communications to small communities via relay stations for distances less than 100 miles. For higher capacities of about 48 telephone circuits, Ultra High Frequency (UHF) radio systems operating in the 450 - 960 MHz frequency band may be used. Both VHF and UHF radio systems using duplex operation can provide an excellent quality of telephone service which cannot be approached using HF radio.

### Wire and Cable

Open wire systems will find most extensive application in local distribution networks. Their maintenance in northern climates is costly and it is difficult to achieve reliable performance when used for long distance transmission.

One development that has interesting potential is the use of underground or buried shielded cables. Special ploughing methods have been used in the Prairie provinces for economical cable installations and these techniques may be adapted to Muskeg areas. Underground cables are now employed for carrying telephony, e.g. the Algoma Railway Cable system in Ontario has a capacity of 120 telephone circuits. Wide band cables for television transmission are being developed but will be very expensive and will require large user markets to support their installation.

### Microwave Radio

Gradual growth is anticipated in the installation of conventional microwave systems in the next few years.

These systems will be used for TV distribution and for transmitting large numbers of telephone channels where traffic demands justify the installation costs.

Pulse Code Modulation (PCM) and solid state techniques will revolutionize the microwave systems of the future. New perspectives will be needed in equipment design and system topology to realize the full potential of PCM.

Emphasis will be on miniaturization. Compact radio equipment will be fitted into a container, the size of a shoebox, and made an integral part of an antenna system which is mounted on top of a self-supporting pole. Primary power requirements will be small. Microwave routes will consist of a chain of these poles separated by distances of 3 to 10 miles. They will follow roads or railways where possible for ease of erection and maintenance. This design concept is economical because the items which make conventional microwave systems expensive are eliminated i.e. access roads, land acquisition, towers, buildings, path testing, etc.

Adaptation of these systems for the Canadian North may be achieved by:

- o employing a tripod support for the poles to permit erection in muskeg and permafrost - a method used for the poles of the Mackenzie River Valley system;
- o design and manufacture of equipment aimed to achieve rugged unattended operation over long periods without maintenance;
- o using fuel cells operated chemically. Alternatively thermo-electric generators of reduced size and weight may be installed and supplied by fuel tanks underneath the poles;

- o engineering routes in the form of a maze where each section provides alternate routing in two directions. This would offer protection against equipment and propagation outages.

The systems described above have already been developed and are undergoing field testing in the 11 GHz and 20 GHz bands. Preliminary studies indicate that the costs of these PCM systems may be one-tenth the cost of conventional microwave systems for the same traffic handling capacity. It is possible that solid state PCM systems could eventually compete economically with satellite systems.

### 13 CONCLUSIONS

Mounting socio-economic pressures have created an awareness that northern development is a major challenge for Canadians in the next decade. The economic development of the North will be closely linked to the exploitation of mineral and fuel resources. But resource exploitation alone cannot suffice to achieve the level of permanent settlement necessary for sustained northern development. Bold social and technological commitments are required if the vision of the North is to be translated into reality.

The major obstacle to progress is not so much the harshness of the climate and environment as it is the lack of basic amenities and services to support permanent settlement. Much scientific and technical knowledge is available and waiting to be applied to overcome these barriers. Our contention is that at this time the priority requirement in the North is for communications.

The role of the Department of Communications is central to the expansion of communications in the North. It has the responsibility to formulate policy and direct activity in communications planning. A systematic and planned approach under the aegis of the Department of Communications is recommended.





## 14 GLOSSARY

### ACCESS

#### -Single Access

The property of satellite communication by which two earth stations can communicate with each other through a satellite transponder at a time, is termed single access.

#### -Multiple Access

The property of satellite communication which enables more than two earth stations to have simultaneous access to each other through the satellite transponder is termed multiple access.

#### -Pre-Assigned Multiple Access

Pre-assigned multiple access satellite circuits are those circuits which are assigned to operate on a point to point basis between pairs of participating earth stations.

#### -Demand Assigned Multiple Access

Demand assigned multiple access circuits are those circuits which are available on demand basis only and are not permanently allocated between pairs of stations.

This access would be available either by means of a network management facility (controlled access) or by ascertaining with appropriate means, vacant radio frequency channels or time slots (self-ordered access) to establish communication.

#### -Random Access

This is a sophistication of the demand assigned access mode in which access to a radio frequency channel would be normally gained without first determining the availability of the channel (un-ordered access).

#### -Frequency Division Multiple Access (FDMA)

In the frequency division multiple access mode, access to the satellite transponder is achieved through a number of discrete r.f channels. Each established communication link (one way circuit) is assigned an access r.f channel and a user has exclusive use of this channel for the duration of the call.

#### -Time Division Multiple Access (TDMA)

In the time division multiple access mode, transmissions in a different communication links (one way circuits) do not overlap in the satellite transponder. Each link is assigned exclusive use of the satellite transponder during specified time slots. An access channel in TDMA system defines a given sequence of time slots and a user has exclusive use of the satellite transponder bandwidth for the duration of the call.

### FREQUENCY BANDS

#### -Very Low Frequency (VLF)

Frequency band between 3 - 30 kHz. These frequencies are immune to ionospheric disturbance and polar cap absorption effects. Suitable for Arctic communication over short distances. A VLF carrier is capable of carrying one telephone circuit.

#### -Low Frequency (LF)

Frequency band between 30 - 300 kHz. These frequencies are not seriously affected by ionospheric disturbance and polar cap absorption effects. Suitable for Arctic comm-

unication between stations spaced several hundred miles apart. A LF carrier is capable of carrying one telephone circuit.

#### -Medium Frequency (MF)

Frequency band between 300 - 3000 kHz. Affected by ionospheric disturbance and polar cap absorption effects. Suitable for Arctic communication over medium distances. A MF carrier is capable of carrying one telephone circuit.

#### -High Frequency (HF)

Frequency band between 3 - 30 MHz. This band is seriously affected by ionospheric disturbance and polar cap absorption effects. Long distance communication capability is available using sky wave transmission mode. A HF carrier is capable of carrying one telephone circuit.

#### -Very High Frequency (VHF)

Frequency band between 30 - 300 MHz. Propagation mode is essentially line-of-sight but communication for short distances beyond the horizon is possible. A VHF carrier is capable of carrying a number of simultaneous telephone circuits.

#### -Ultra High Frequency (UHF)

Frequency band between 300 - 3000 MHz. Frequency band above 1000 MHz is commonly known as Microwave band. Propagation mode essentially rectilinear. Both line-of-sight and free space conditions are necessary for point-to-point communication. A typical range is about 30 miles between stations. A UHF carrier is capable of carrying a large number of simultaneous telephone circuits.

#### -Super High Frequency (SHF)

Band covering the frequency range 3 - 30 GHz. Characteristics similar to that of UHF.

#### FREQUENCY SHIFT KEYING (FSK)

A frequency change signalling method in which the frequency or frequencies are varied in accordance with the signals to be transmitted and characterized by continuity of phase during the transition from one signalling condition to the other.

#### HF SYSTEM (As used in text)

Any radio communication system which uses an RF carrier frequency between 3 kHz - 30 MHz.

#### IONOSPHERIC SCATTER PROPAGATION

This is a type of electromagnetic wave transmission which permits communication in the frequency range 25 - 60 MHz and over distances from about 600 to 1200 miles. It is believed that this type of propagation is due to scattering from the lower E layer of the ionosphere and that the useful bandwidth is restricted to less than 10 kHz. The greatest use for this type of transmission has been for teletype channels.

#### METEOR BURST PROPAGATION

This is an electromagnetic wave propagation technique whereby use is made of the reflection of a VHF signal from the ionized trails generated by meteors to establish intermittent communication over distances from about 250 miles to 800 miles or more. Low power VHF transmitter is adequate to meet the communication needs. This type of system is suitable for data transmission.

#### MICROWAVE SYSTEMS

Radio communication systems which use an RF carrier frequency of 1000 MHz or higher.

## MODULATION

The process of varying some characteristics of the carrier wave in accordance with the instantaneous value of samples of the intelligence to be transmitted.

### -Amplitude Modulation (AM)

The form of modulation in which the amplitude of the carrier is varied in accordance with the instantaneous value of the modulating signal.

### -Frequency Modulation (FM)

The form of modulation in which the instantaneous frequency of a sine wave carrier is caused to depart from the carrier frequency by an amount proportional to the instantaneous value of the modulating signal.

### -Pulse Code Modulation (PCM)

Pulse code modulation involves transforming continuously variable speech signals into a series of digitally coded pulses and then reversing the process to recover the original signal. The process requires sampling of the modulating waveform, quantizing, and coding of the resultant signal into binary digits.

## MULTIPLEXING

Method for organising a large number of telephone circuits for simultaneous transmission over a communication system.

## OPERATION

### -Broadcast

That type of operation in which a transmitting point emits information which may be received by one or more stations.

### -Duplex (full duplex)

A type of operation in which simultaneous two-way conversations, messages or information may be passed between two terminal points.

### -Half Duplex

A circuit designed for duplex operation, but which on account of the nature of the terminal equipment, only permits one-way messages to be transmitted at the same time.

### -Simplex (press-to-talk)

That type of operation which permits the transmission of signals in one direction at one time.

## OPEN-WIRE SYSTEM

A communication system which uses one or more pairs of uninsulated wires as the transmission medium between two points. More than one telephone circuit can be carried using suitable interface equipment.

## REPEATER

### -Active Repeater

A station in terrestrial or satellite systems where the signal is received, frequency changed, amplified, and re-radiated. An active repeater, in addition to its relay function, can have demodulation facilities.

### -Passive Repeater

An intermediate station in a line-of-sight radio relay system where the radio signal is reflected to the next repeater station. This technique is used effectively in mountainous terrain to reduce the number of active repeaters required to overcome obstacles between two relatively close active repeaters or terminals.

## SATELLITE

A body rotating about another body (such as a planet) and having a motion primarily and permanently determined

by this body's force of attraction.

### -Synchronous Satellite

A satellite for which the mean sidereal period of revolution about the primary body (in this case the Earth) is equal to the sidereal period of rotation of the primary body about its own axis (23 hrs - 56 min for Earth).

### -Stationary Satellite

A synchronous satellite with an equatorial, circular and direct orbit. A stationary satellite remains fixed in relation to the surface of the primary body.

### -Satellite Transponder

An active radio repeater located in the satellite.

### -Communications Satellite

A communication satellite includes a number of satellite transponders for the reception, amplification, and re-transmission of broadband communication or television channels.

## SYSTEM CAPACITY

The total number of 4 kHz telephone circuits which can be transmitted simultaneously by the communication system without causing a serious degradation of the service.

### TELEPHONE CIRCUIT

A frequency band 4 kHz wide carrying audio frequencies between 300 - 3400 Hz, considered to be the voice frequency range of an average speaker.

### TERMINAL

An end section of a system. Terminal stations are the "interfaces" between the communication system, which is the bearer of information (telephone, telegraph, television, data, etc.) and the related equipments which make the information available to the ultimate users.

### TROPOSPHERIC SCATTER PROPAGATION

Propagation involving scattering or partial reflection from the troposphere. Troposcatter systems operate in the VHF, UHF and SHF frequency bands and are capable of carrying a large number of simultaneous telephone circuits over distances up to 300 miles per hop. High powered transmitters and large antenna systems are required.

### TRUNK CIRCUIT

A single circuit (narrow or wideband) between two points both of which are individual distribution points.

### UHF SYSTEMS (As used in text)

Radio communication systems which use an RF carrier frequency between 300 - 1000 MHz.

### VHF SYSTEMS

Radio communication systems which use an RF carrier frequency between 30 - 300 MHz.



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