Short Papers and Notes

RADIO-WAVE AND ALTERNATIVE COMMUNICATIONS IN THE ARCTIC*

Introduction

Radio-wave communication in the Arctic has been studied and practiced extensively for many years, both in North America and Eurasia. In general, the objectives and requirements for polar communication circuits are identical with those desired in lower latitudes. In both, HF communication is directly dependent on the characteristics of the ionospheric reflecting regions involved.

In polar regions the ionosphere has rather different properties from those found elsewhere. These differences affect HF wave propagation in two important respects: (a) at frequencies below 30 mc./s., natural noise levels are lower than those existing in middle and low latitudes, and (b) the frequency of occurrence, duration, and severity of ionospheric disturbances is greater. The last factor is of major importance in designing arctic communication circuits.

Although formerly such factors as logistic support, station location, and station operation were of fundamental importance for the design and implementation of arctic communication links, the widespread use of aircraft has considerably reduced their importance. Modern industrialized nations possess the potential and the means of establishing transmitter and receiving sites anywhere in both polar regions, or on ice floes of the Arctic Ocean with little difficulty and with no great perturbations to their economy. Indeed, the increasing availability of nuclear power plants will permit the actual location of communications stations to be determined solely by technical considerations.

Existing communication networks

Careful planning already has allowed the establishment of several communication networks spanning the North American Arctic. A brief summary of the major recent links, constructed primarily for military purposes, is given in Table 1. No attempt has been made to include internal Canadian circuits, whether civil or military, or whether radio or land lines (*e.g.*, Winnipeg-Churchill). Similarly, the older networks spanning Alaska also have been ignored.

These circuits are considered as reliable and as having adequate capacity for *present loads*. The communication paths are both east-west and north-south, the latter from the Arctic into Canada and the U.S. Considering all available channels, signals can be transmitted from Alaska across the continent to northeastern Canada and Greenland (or vice versa), and from these sites southwards to middle latitudes.

In the design of these various systems emphasis has been placed on the use of scatter circuits, both tropospheric scatter (involving microwave frequencies and station separations of about 100 to 300 miles) and ionospheric scatter (using frequencies in the lower VHF region and station separations of about 1000 miles).

Although the present systems shown in Table 1 are confined to North America and Greenland, additional radio-wave links can provide some geographic expansion. Thus, for example, the Alaskan "White Alice" network can be expanded westwards into the Aleutian Islands chain. A similar expansion to

* Paper presented at the Winter General Meeting of the American Institute of Electrical Engineers, New York, N.Y., on February 2, 1962, and published in the May issue of *Electrical Engineering*. Reproduced by kind permission of the Am. Inst. of Elec. Engr.

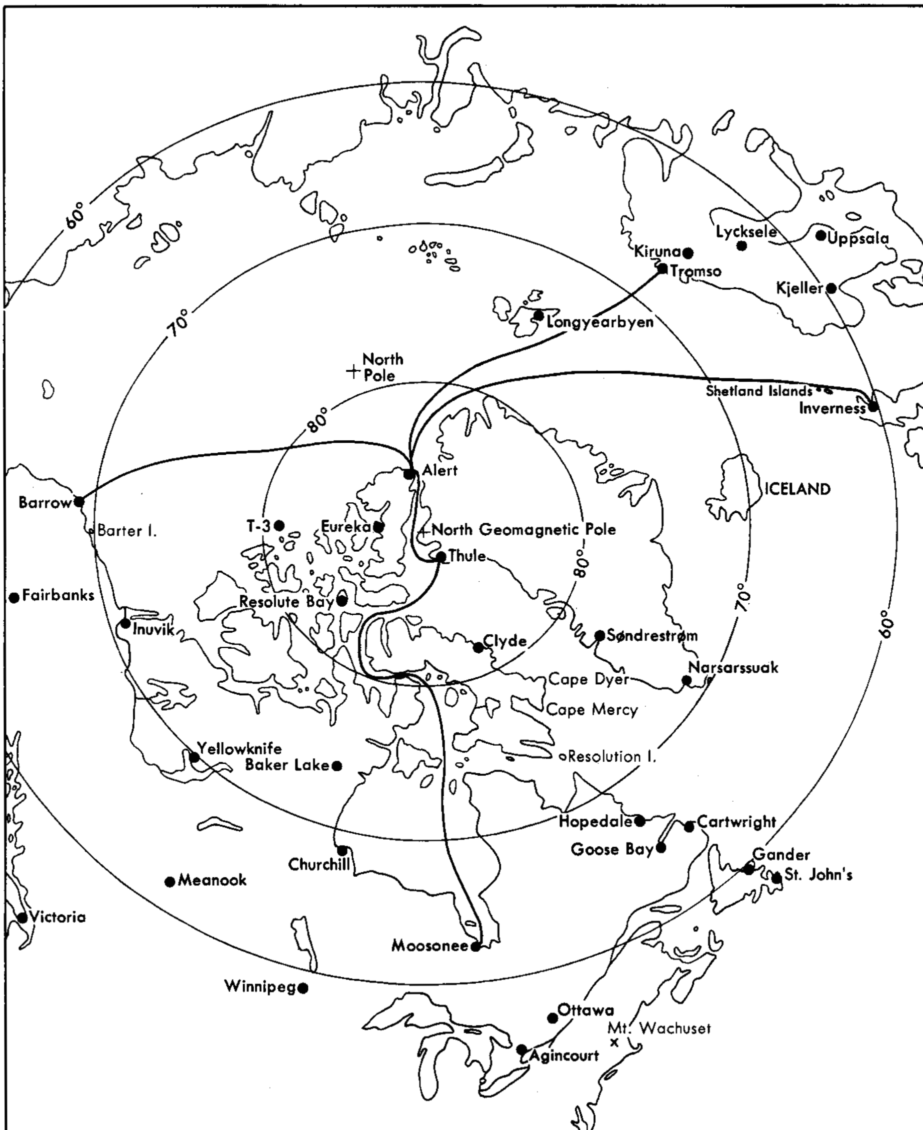

Fig. 1. Proposed submarine cable route for intra- and inter-arctic communications. The drops at Alert, Thule, Barrow, and Moosonee would integrate communication circuits already established. *Note:* Elipses represent geomagnetic latitudes.

the east (proposed by the International Civil Aviation Organization) would link the U.S. and U.K. Here an ionospheric scatter network would be employed using stations in Labrador, Greenland, Iceland, and the Shetland Islands.

Circuit reliabilities for the different links have been good. Tropospheric scatter circuits in the Arctic, as elsewhere, have the usual high reliabilities and provide wide bandwidths. However, ionospheric scatter circuits operating at lower VHF frequencies have been interrupted during periods of strong solar activity, which had not been expected originally. Use of higher frequencies would reduce this.

Speculations on future systems

Although present systems are well engineered, well maintained, and presumably are adequate for current traffic volume, it may prove interesting to speculate on other possible arctic networks. For example, an attempt can be made to link North America with Europe via the Arctic; thus this region a priori can be integrated with communication circuits of both continents. From Western Europe networks leading directly to both the east and west coasts of North America could be implemented.

First, however, the primary factors involved in designing arctic communications circuits may be listed and compared. Table 2 attempts such a comparison. It shows the expected reliability, bandwidth, interference, jamming potential, propagation interruptions (caused by polar blackouts, polar-cap absorption events, or auroral absorption), solar cycle effects, capital expenditures, and operating costs. Several typical circuits have been included: submarine cable, VLF, HF, VHF ionospheric scatter, VHF meteor scatter, and UHF tropospheric scatter. In Table 2 each factor has been evaluated on a scale of 1 to 9 for each circuit, where 1 indicates the best condition (lowest cost, maximum reliability, maximum bandwidth) and 9 the worst (most costly, least reliable, most interference prone). On this basis the total scores indicate the relative desirability of the different circuits. The smallest score indicates the most desirable, and the largest score the least desirable circuit.

It is recognized that the rating procedure adopted contains some inherent

Table 1. Some existing North American arctic communication networks.

Circuit	*Location*	*Type*	*Station locations*
White Alice*	Alaska	Tropospheric scatter	Anchorage-Fairbanks-Barrow-Nome- etc. Serves most important cities in Alaska
Dew Line	Arctic coast	Tropospheric scatter	East-west through Arctic; links U.S. and Canadian sites
		Ionospheric scatter	Southwards into Canada and the U.S.
Pole Vault	Greenland-Newfoundland	Tropospheric scatter	St. John's-Gander-Cartwright-Hopedale-Resolution Island-Cape Mercy-Cape Dyer
Bittersweet	Greenland-Massachusetts	Ionospheric scatter	Thule-Søndrestrøm-Goose Bay-Mt. Wachuset
ICAO**	Labrador-U.K.	Ionospheric scatter	Goose Bay-Søndrestrøm-Iceland-Shetland Islands-England

* A proposal has been made to extend the "White Alice" system to the Aleutian Islands.
** Proposed.

deficiencies. Thus, submarine cables may be cut, concentrated unintentional interference may develop, cost may be a minor factor during emergencies, etc. Nevertheless, Table 2 provides a basis for contrasting the relative merits and deficiencies of each method.

The results of Table 2 indicate that the most preferable methods are submarine cable, tropospheric scatter and VLF, and the least attractive circuit, as expected, is HF. With respect to submarine cable and tropospheric scatter, it might be noted that initial capital costs are about equal (about $10,000/mile, providing the tropospheric link is at least several hundred miles in length). However, maintenance costs are higher for the tropospheric scatter link. Some paths (*e.g.*, Greenland-Iceland) are too long for serious consideration of tropospheric scatter links.

Submarine cables also have inherent difficulties in the Arctic: (a) possible ice damage to the cable where it rises from the ocean floor to the land, and (b) earth currents. Earth-current storms within the polar cap region require additional investigation, but their intensity may be less than in the auroral zone. However, the cable, crossing the auroral zone approximately perpendicularly, would be expected to have a minimum of interruptions because of earth-current effects and these primarily during periods of maximum solar activity. A cable would provide reliabilities comparable to tropospheric scatter circuits, which are impossible over these routes because of the absence of islands or land masses.

Table 2. Probable relative performance of different radio circuits in the Arctic.*

Quality	*Submarine cable*	*VLF-LF*	*HF*	*VHF scatter*	*VHF meteor*	*UHF tropospheric*
Reliability	2	1	7	2	5	1
Bandwidth	2	6	4	4	4	1
Interference potential	1	2	4	3	2	1
Liability of being jammed	1	6	8	3	2	1
Solar cycle effects**	3†	2	6	3	2	1
Initial cost	6	4	3	6	5	6
Operating cost	2	1	3	3	3	6
Total	17	22	35	24	23	17

* Scale 1-9(1=excellent, cheapest, most reliable, etc.).

** Comparison of conditions at time of maximum solar activity as compared with conditions at time of minimum solar activity.

† Effect of earth-current storms.

Two potential submarine cable routes from interior North America to Europe via the Arctic are shown in Fig. 1. The cables, containing bandwidths of several megacycles, could undoubtedly provide the cheapest direct and reliable service from Europe to the West Coast and to Thule. Thule (or Alert, or both) would become a communication centre, serving as a junction for traffic between Europe and the western and central parts of North America. The cable from Inverness (or Tromsø) to Thule and Barrow could ultimately be extended to Hawaii.

The cable, roughly crossing the auroral zone perpendicularly, may be expected to have a minimum of interruptions on account of earth-current storms. The initial outlay for the proposed cable would be greater than that for a simple transatlantic cable between Europe and the east coast of North America; nevertheless, it would be cheaper than two independent cables from Thule to (a) the U.S., and (b) Europe. The actual laying of transarctic cables, although rather more difficult, is not impossible in an age where nuclear-powered icebreakers and submarines are available.

The Arctic is becoming increasingly accessible. Transpolar flights are routine. On a long-term basis there is little doubt that as civilization advances northward, additional communication circuits will be needed from middle latitudes of North America and Europe to the Arctic. In addition, more circuits will be required for intra-arctic use.

One final word may be said about arctic communications: all present long-range circuits may be replaced by satellite communication links if a sufficient number of communications satellites having polar orbits become available.

N. C. Gerson*

*Vice Chairman, Arctic Committee, U.S. National Committee for the IGY. Washington, D.C., U.S.A.

BRYOZOA FROM THE ARCTIC ALASKAN COAST

During a cruise in August 1953 the U.S. Coast and Geodetic Survey LCM *Red* travelled along the northern Alaskan coast from Barter Island to Barrow. On this occasion a scientific party, in cluding the ichthyologists N. J. Wilimovsky and H. Adair Fehlman, and the marine invertebrate zoologist Charles Horvath, was able to occupy a number of hydrographic and collecting stations.

The collections made on this cruise contain the first bryozoan material from the eastern arctic region of Alaska to reach the hands of scientists, except the one sample, containing *Eucratea loricata* and *Hippothoa hyalina,* taken by the Canadian Arctic Expedition 1913-18 in this area[1]. The collections are now at the Allan Hancock Foundation at the University of Southern California. Collections of two previous expeditions have been lost: the *Investigator* from which McClure collected in 1850-3, had to be abandoned; Stefansson had sampled in the area in 1913-14 during the Canadian Arctic Expedition, but the collections were lost with the *Karluk.*

The Bryozoa reported on here are parts of the samples taken with a small biological dredge at 15 stations listed in Table 1 (from ref. 2). Stations 1, 9, and 14 were shore stations and have therefore been omitted. The following details are added to the original information given in Table 1: gravel was present in the samples from stations 3, 4, 5, 6, 11, 12, 15, 17, and 18; clay was found at station 3; kelp (laminarioids) to which bryozoans attach were represented by fragments only in six stations[3].

In 12 stations 11 species of bryozoans were found. They have all been reported earlier from arctic Alaskan waters, specifically from the Point Barrow area[4,5,6], and most are common forms. This report establishes the presence of these species eastward beyond Point Barrow. *Hippothoa hyalina, Lichenopora canaliculata, Alcyonidium disciforme,* and *Vesicularia fasciculata* were reported for the first time off Point Barrow only in the last decade.

The distribution of the species varied considerably (Table 2). Samples rich in species were taken at stations 7 and 8. The species with the largest number of individuals and most widely distributed are *Alcyonidium disciforme* (9) and *Eucratea loricata* (7). One species is endemic *(Vesicularia fasciculata),* one is bipolar *(Lichenopora canaliculata),* and