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TELECOMMUNICATION DEVELOPMENT BUREAU

ITU-D STUDY GROUPS

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FOR ACTION

Question 10/2: Communications for rural and remote areas

STUDY GROUP 2

SOURCE: TELE GREENLAND A/S

TITLE: TELECOMMUNICATIONS IN GREENLAND

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Action required: The meeting is invited to make recommendations, as necessary.

Absract: This document was circulated at the WTDC-94 in Buenos Aires, 21-29 March 1994 (Document 22-E). Please find hereafter a revised version of this contribution. It describes briefly some of the special problems faced by TELE Greenland in establishing the communication systems, many of which are faced by other countries too, including many developing countries.

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EXECUTIVE SUMMARY

Greenland is a country of some 2 million km² - an area as large as the United Kingdom, Holland, Belgium, France, Germany, Austria, Switzerland, Italy, Spain and Portugal together. The population of only 55,000 lives in 16 towns and more than 70 settlements, all coastal. The capital city of Nuuk, with 13,000 inhabitants, is located on the south-west coast, where over 80% of the population lives. There are no roads or railways between the towns and the only modern forms of transport are ships and aircraft.

Perhaps of special interest to other countries, including many developing countries, is the Greenlandic experience of linking extremely small, highly scattered and remote settlements through the development of telecommunications under harsh physical and climatic conditions. The binding together of Greenlandic society can therefore be said to have taken place largely through the development of telecommunications - the only solution under the circumstances.

This paper describes briefly some of the special problems faced by TELE Greenland in establishing the communication systems, many of which are faced by other countries too, including many developing countries.

Today basic telephony is transmitted to all towns with direct connection to either the radio relay or the satellite system. Some of the strategies in the provision of communications to towns and large settlements (30 or more subscribers), to small settlements (2 to 30 subscribers), and to individual subscribers or settlements, are also described in the paper.

Due to the extreme physical/climatic conditions in Greenland, standard technical solutions have often proven inadequate. As a result TELE Greenland has frequently had to define essential requirements and sometimes even develop new systems. Some of the many considerations involved in the selection of appropriate technology are also described in the paper.

The challenge of building up communications in Greenland has been met with careful consideration given to the optimal appropriate technical and economical solutions. With the digitalisation of the overall transmission network and telephone exchanges, and establishment of the connections to the settlements, Greenland today has, despite the odds, a complete modern network. The costs have been high, but the benefits for the Greenlandic society have by far surpassed them.

Since 1979 Greenland has had Home Rule within the Kingdom of Denmark, with its own legislature and government pertaining to all internal affairs, under which TELE Greenland (TELE Attaveqaatit), is responsible for all telecommunications in the country. In 1998 TELE Greenland took over the responsibility for all communications in and out of Greenland. The Danish Government is still responsible for some external affairs in relation to Greenland.

The following article provides a brief description of the telecommunications network in Greenland. The major subjects, which are described are :

1. GREENLAND.

A description of the country, topography, and the history of telecommunications in Greenland**.**

2. A DIGITAL RADIO RELAY SYSTEM

During the period 1991-96 TELE Greenland has replaced the analogue radio relay system with a digital system. The special problems herewith are described**.**

3. SATELLITE COMMUNICATIONS

Greenland has used satellite communications since 1978. The development of the system is described.

4. TELEPHONE EXCHANGES AND DATA COMMUNICATION

All Greenlandic towns and larger settlements today have digital telephone exchanges installed. The equipment and some of the facilities in the network are described.

5. THE SETTLEMENTS

A major part of the Greenlandic population lives in small settlements. The special problems involved in providing telecommunications to them and some solutions are described.

TELECOMMUNICATIONS IN GREENLAND

1. GREENLAND

Greenland is situated in the North Atlantic between North America and Europe. Its 2,175,600 square kilometres make Greenland the largest island in the world. The ice-free territory covers an area of 341,700 km² - that is the size of the British Isles or eight times as large as Denmark. From North to South, Greenland extends some 2670 km.

Mountains up to more than 3000 meters high tower over large fjord systems cut from the inland ice to the sea.

All of Greenland has an arctic climate, with considerable variation from North to South. The temperature in the warmest month does not exceed 10° C and may fall below -50° C in the winter. Wind velocities occasionally exceed 190 knots (97 m/sec).

The country's 55,000 inhabitants live in 16 towns and more than 70 settlements on the West and East coast. The capital city of Nuuk, with 13,000 inhabitants, is located on the south-west coast, where over 80 per cent of the population lives.

Since 1979 Greenland has had Home Rule within the Kingdom of Denmark. Greenland has its own legislature and government to take care of all internal affairs.

Infrastructure in Greenland is that typical of most of the arctic regions. There are no roads or railways between the towns and the only modern forms of transport are ships and aircraft. This somewhat restrictive situation, together with the scattered population, has made telecommunication a decisive factor in developing Greenland into a modern society.

The Greenlandic experience of linking extremely small, highly scattered and remote settlements through the development of telecommunications under harsh physical and climatic conditions, may perhaps be of special interest to other countries, including many developing countries.

TELE Greenland

The Greenland Home Rule Government has its own tele company, TELE Greenland, which is responsible for all telecommunications in the country, such as :

- public switched telephone and data networks
- mobile telephone systems
- broadcast of TV and radio programs
- aeronautical and coastal radio services
- meteorological services

TELE Greenland employs a staff of approximately 600 persons. Since 1992 the company has also exported telecommunications products such as know-how and systems supply etc. to other parts of the world.

The total revenue of TELE Greenland in *1998* was 85 Million U.S.$.

The Past

Public telecommunication was first introduced in Greenland in 1925 when the Danish State established radio stations in four towns (colonies) and founded Greenland Telecom. Gradually every town got its own radio station. Until 1973 the domestic telecommunications network in Greenland and the international connection to Denmark consisted of this system of short-wave and long-wave radio only. The only means of using this system was by telegram, which for many years were transmitted by morse telegraphy. From the early 1960's, however, life was made somewhat easier thanks to the installation of protected telex systems.

A major step towards binding Greenland together as a single, coherent society was taken in 1972, when it was decided to build a 2 GHz analogue radio relay system along the south-west coast. Completed in 1977, the system provided coverage for 11 towns and stretched over 1500 kilometres, with 25 unmanned mountain top repeaters.

When the radio link system was established, four towns in North and East Greenland fell outside the area of coverage. It was therefore decided to employ satellite communications to serve these towns and at the same time provide a link to Denmark and the international gateway in Copenhagen. The first satellite station was installed in the capital city of Nuuk in 1978. In 1999 TELE Greenland operates 15 satellite earth stations, 14 in Greenland and one in Denmark.

Due to the extraordinary and varying demands in Greenland, TELE Greenland has often had to be on the cutting edge of technological development. On many occasions standard solutions have either lacked essential details or been totally inadequate. TELE Greenland has had to work closely together with manufacturers to provide the essential requirements or sometimes even develop new systems. Some of the many considerations involved in the selection of appropriate technology, described in the paper, are issues other countries face too, including many developing countries.

The Investment Policy

The expansion and operation of telecommunications in Greenland had depended on grants from the Danish Government since the beginning of 1925 until the end of the 70s. However, with the establishment of a modern Greenlandic communication network, TELE Greenland obtained an economic basis for operation and further development of a telecommunications company in Greenland. Today all expenses are financed by the subscribers.

The price paid for setting-up a modern, self-contained telecom is almost the highest tele prices in the world, even if it is a common aim for TELE Greenland to make them as low as possible. However, the population seems to be willing to pay the price it costs to be able to telephone, listen to radio and watch TV, even in the most remote settlements in a country where communication is very difficult and expensive.

Society and Telecommunications

The tying of 55,000 people together into one society within an arctic area of some million square kilometres, with the obstacles that topology and climate provide, is a task which can only be done with telecommunications.

Despite the odds, this task has now been completed in Greenland. During the latest decades, the establishment of a completely up-to-date telecommunications system has brought the vast country out of its former deep isolation. At the same time, telecommunications has shaped the foundation of Greenland's development into a community with services and standards of living at the same level as those of other countries in the Western world.

As we all know, no solution is the final one, least of all as regards telecommunications systems. Therefore, TELE Greenland works continuously for the expansion and development of the Greenlandic tele network, to the greatest extent possible, in accordance with the wishes and possibilities of the society.

2. A DIGITAL RADIO RELAY SYSTEM

Establishing a radio relay system in Greenland means building repeater stations in very remote areas, where buildings, masts and antennas must withstand extreme weather conditions during the winter. The only way to reach a repeater station on a mountain top, is by helicopter. If the weather is bad, it might take several days for the maintenance crew to get there. Therefore, especially the power plants in Greenland must be specially designed with high reliability.

The replacement of the analogue radio relay system was started in 1991 and was completed in 1997. The replacement took place in 6 phases. For each phase construction of buildings, towers and power plants was completed before the installation and line-up testing of the radio, supervisory and mux equipment took place.

The frequency bands used for the system are 7725-8275 MHz and 7425-7725 MHz. A medium capacity 34 Mbit/s radio system using a N+1 configuration was chosen. The bit rate is 34 Mbit/s in order to prevent the use of higher order modulation schemes. Using 34 Mbit/s and QPSK, most hops can be made without the use of space diversity, even though part of the hop is over water.

Infrastructure

The repeater stations in Greenland are located in very remote areas. The outdoor temperature is estimated to vary from -40 to +20 degrees Celsius and 300 km/h wind gusts may occur on some sites. In order to keep the temperature inside the buildings between 0 and 30 degrees Celsius the insulation , ventilation and heating of the buildings have to be very efficient. The power consumption has to be kept as low as possible. There are two buildings on each site:

- one for the radio relay equipment, batteries and lodging, and
- one for the two diesel generators.

Other sub-systems of the infrastructure are:

- antenna mast;
- solar panels;
- helistop;
- platform for landing of fuel tanks by helicopter;
- 4000 litre fuel tanks;
- wooden walkways, and
- cable pipes.

The station is unmanned and is powered by the batteries and any contribution from the solar panels. The supervisory system for the power plant will start one of the diesel generators automatically, only if the batteries need recharging or the temperature in the heat accumulation system of the engine building gets too low. If the first diesel generator fails to start the back-up generator will start automatically.

The elements for the construction of the buildings are designed for optimum insulation efficiency as well as low weight. The design is a sandwich construction using 0.5/1.0 mm steel plates on the inside and outside, and a polyurethane insulation layer.

To prevent any overheating of the equipment room in the repeater building, a heat exchanger is used. No additional heating is necessary if the power consumption of the radio equipment is 400 W or more. If the power consumption of the radio equipment is less than 400 W, electrical DC-powered heaters are installed.

The engine building is cooled by a ventilation system. When the diesel generators are not running, the room is heated by a heat accumulation system, i.e. a tank inside the building containing a blend of water and glycol. The liquid in the tank is heated electrically when the diesel generators are running. If the temperature in the heat accumulation tank drops below 50 degrees Celsius, one of the diesel generators will automatically start. The reheating of the liquid will continue until the temperature in the tank has reached 80 degrees Celsius.

If both diesel generators fail, the remaining energy in the heat accumulation tank will be sufficient to keep the temperature of the engine building above 0 degrees Celsius for another 4-8 days.

The batteries are only discharged to 60 % of their capacity before one of the diesel generators starts. If both diesel generators fail, the remaining 60 % of the battery capacity will be sufficient to power the station for a period of 4-8 days. This period might be extended by any contribution from the solar panels. During the summer this contribution can be significant. The maximum output from the solar panels is 3 kW, if 4 panels are installed.

The reserve capacity of the batteries and the heat accumulation tank is designed for 4 or 8 days, depending on how difficult it is to reach the station in wintertime.

Monitor and Control System

The supervision of the radio relay system is performed by two systems. One for the supervision of the engines and buildings, and one for the supervision of the radio and mux equipment.

The power plant can be remotely monitored and controlled via one supervisory system. All important test points are monitored and all main functions, such as diesel start, are controlled via the system. The remote stations will be polled from control terminals placed in the three supervisory centres in Greenland.

The three centres will be monitoring the supervisory system of the radio and mux equipment as well. At the main centre there is a 24 hours a day staff, and the possibility to monitor and control the other regions too. The three host computers are connected with the option of rerouting via satellite (EUTELSAT and INTELSAT), if the total fall-out of a station should occur.

Like the design of the power plant, the supervisory systems have been designed with redundant (back-up) systems for maximum reliability.

3. SATELLITE COMMUNICATIONS

Satellite Systems

Only very few satellite systems provide a reasonable coverage of Greenland. The best opportunity is the INTELSAT satellites in the Atlantic Ocean Region (AOR), but the only beam covering Greenland from these satellites is the Global Beam. Only a few transponders in each satellite are connected to the Global Beam antennas. It is the weakest of the beams and the most expensive for the user. The INTELSAT IX satellites in AOR will provide coverage of Greenland in Zone beam. These satellites are planned to be in orbit in the year 2001.

The EUTELSAT system was initially not designed to cover Greenland. However, the EUTELSAT II generation of satellites, upon request from the Signatory of Denmark, were designed to give a marginal coverage of southern Greenland. This has from 1991 been used as an alternative communication system out of Greenland.

Finally, there are the domestic Canadian and American satellite systems. Some of these can be seen in western Greenland. The Canadian ANIK system has often been considered as an alternative, but it has until now only been used for occasional TV reception. The American GE SATCOM system has some satellites designed to give coverage of western Greenland due to the location of American military bases there. Today one of these satellites is used by TELE Greenland.

The Earth Stations

In 1978 TELE Greenland established an INTELSAT Standard B satellite earth station in the Greenlandic capital Nuuk (Godthaab). This station was connected to the Nordic Standard A station in Tanum in Sweden. 20 circuits were transferred via an INTELSAT satellite in the Atlantic Ocean Region. The INTELSAT SPADE system was used for this service.

In order to increase the capacity of the system and to include remote areas in Greenland, TELE Greenland decided to develop a domestic satellite system in a leased transponder. Starting in 1990 with three Greenlandic stations operating at a 9 MHz segment of a Global Beam transponder the system has since expanded. As of today there are 14 stations located in Greenland, Denmark, Canada and Iceland operating at a space segment of totally 60 MHz at INTELSAT 601.

One of the main problems with geostationary satellite communication in arctic regions is the low elevation angles. The station in Qaanaaq (Thule) in Northern Greenland has an elevation angle of 1.6°. This means high margins in the daily operation, even at C-band. But it also means that the circuits to the station are interrupted in case of operation at an inclining satellite. This was the situation from 1989-92, when the station was taken out of service due to inclination at the INTELSAT satellite at 325.5°.

Equipment

The main purpose of the domestic Greenlandic satellite system is to establish communication between Greenlandic towns and between Greenland and the rest of the world. Two important decisions had to be made at the design phase of the system:

- selection of antenna size;
- selection of type of modulation.

Antenna size: The system was designed in the days of INTELSAT IV. These satellites were rather low-powered, especially in the Global Beam transponders. To obtain a balance between power and bandwidth consumption in the space segment very large antennas would be needed. Due to the extreme weather conditions and other logistic problems in Greenland (transport, availability of power etc.), it was regarded as unrealistic to build antennas larger than the Standard B type. All the antennas at the Greenlandic stations were initially 11 metres. From 1994 smaller earth stations, INTELSAT F3 and F2, have been added to the system.

Today, operating at INTELSAT VI, this antenna size gives a good balance between consumed bandwidth and power.

The system was initially analogue, using compounded FM SCPC, similar to the system used in the INTELSAT VISTA systems, but during the 1990’s all earth stations have been digitalized. The heavy traffic routes to Denmark are implemented as two-way 2 Mbits with DCME. For the traffic between the other Greenlandic stations 16 kbit low rate encoding (LRE) for the voice circuits. The data traffic, however, has in the past years become a still greater part of the system, due to many new services (ISDN, video conferencing, Internet etc.) which are being offered to customers.

Television

During the 1970's distribution of television in Greenland developed locally in many Greenlandic towns on a cooperative basis. When the radio relay system was established, it became possible for Greenland Radio (KNR), based in Nuuk, to get their programs distributed along the west coast. However, the programs produced in Denmark had to be taped and brought to Greenland by plane and the same procedure had to be followed for distribution to remote areas in Greenland.

For some special events a TV uplink, established in Denmark could be used for occasional transmissions of analogue TV. The problem with this was simply that the capacity requirement is too high. Due to the general limited capacity resources in the INTELSAT system, especially in Global Beam, it was not possible to get the necessary transponder capacity available before an INTELSAT VI satellite, with the double number of transponders in Global Beam compared to the older INTELSAT V satellites, was located at 325.5°

Although INTELSAT VI is 3 dB more powerful than its predecessor, it could be calculated that using this for analogue TV would give only a marginal quality at the Greenlandic stations. In 1992 TELE Greenland bought a newly developed digital TV compression system. This system could compress one TV and two audio channels to a digital signal at 6.6 Mbits. In this way it was possible to transfer two of these carriers within 18 MHz Global Beam capacity. On 1 November 1992 two digital TV channels were set in operation via the satellite. The digital compression equipment was replaced with MPEG-2 equipment in 1997.

4. TELEPHONE EXCHANGES AND DATA COMMUNICATIONS

The basic element in telecommunication in Greenland has initially been telephony, transmitted to the subscribers in various ways:

- subscribers in towns and in large settlements;
- subscribers in small settlements, and
- individual subscribers

Subscribers in Towns and Large Settlements

In all towns and large settlements, with direct connection to either the radio relay or the satellite system, basic telephony is transmitted by way of autonomous exchanges.

All of the exchanges have earlier been analogue, but since 1987 digital exchanges of the DIAX type have been established. In 1995 all exchanges had become digital.

Subscribers in Small Settlements

Subscribers in these settlements number from 2 to 30. Here the chosen solution depends on the number of subscribers as well as the anticipated future demand.

If the basic number of subscribers is low, and the prognoses indicate that this number will not increase substantially in the future, a solution of transmitting subscriber lines to another town is most frequently chosen by using smaller radio transmission systems (systems from 1 to 20 channels).

Individual Subscribers

Telephone to locations with only one single subscriber has been established through a single-channel radio connection between the nearest exchange and the subscriber. In 1999 a WLL system for sheep farmers in southern Greenland will be brought in operation.

Choice of Exchanges for Greenland

To fulfil/solve all the tasks described above, TELE Greenland has chosen a small ruggedized telephone exchange for the following reasons:

- the demand for small telephone exchanges in the Public Switched Telephone Networks;
- the very small number of various hardware modules in the exchanges, limiting the number of spare parts to a degree where decentralised stocks can be established;
- the possibility of controlling the stocks locally, or from remote places, resulting in great flexibility in the construction of a service organisation;
- instalment of autonomous exchanges prevents a town or a settlement from being totally isolated, if the back-bone net should break down, and
- the exchange concept is well secured for the future, the operator can combine ordinary PSTN and ISDN-subscribers in the same exchange.

Data Communications

In spite of being so far in the north, with a population of approximately 55,000 people only, Greenland nonetheless utilises a lot of data communication.

This of course is due to the fact that all major companies with several regional offices in Greenland have continuously built-up data communication solutions particularly intended for those jobs within scattered communities.

The strategy naturally has influenced the policy of TELE Greenland with regard to data communication, as most companies have a domestic as well as international demand.

Internet

Like anywhere else in the world where it has been introduced, the Internet has become a great success in Greenland. During the past two years TELE Greenland has installed Internet servers in all major towns and the backbone network has been modified to comply with the increasing demand for transmission due to this. All fixed-line telephone subscribers in Greenland are offered access to the Internet.

Mobile Telephony

The Nordic Mobile Telephony (NMT) 900 system was introduced in 1992. A mobile exchange was installed in the capital and one base station was installed in each major city on the west coast. Like anywhere else mobile telephony soon became a very important part of the Greenlandic communications network.

In 1998 the GMT system was started up. It will be built out to all of Greenland during 1999 and 2000. The telephone exchange is located in the capital.

5. THE SETTLEMENTS

As described in section 4, there are different groups of settlements, basically based on the size or number of inhabitants (subscribers). However, in each case it is important that a reliable connection is established between the settlement and the outside world. If the settlement is located within clear view of a town or a radio relay site, a minilink for telephony and television has been established.

However, this is not always the case. In some cases it is necessary to use unmanned repeaters. These repeaters will often have to be located at very inaccessible sites. The size and type of the repeater may vary from small units which are self-supplying with energy, from solar cells and batteries to large pieces of equipment, similar to the repeaters which are described in section 2.

TELE Greenland has developed a small repeater, operating on solar cells and batteries, to be used together with a radio relay connection to a settlement. This repeater is designed for unmanned 24 hour a day operation, with one maintenance visit per year, mainly due to battery check.

Some settlements are located in such a way that it can be difficult to reach them even with two or three repeaters. In this case a satellite earth station, specially developed for Greenlandic settlements, is used. This earth station is described in a separate paper.

NB: Another document (Document 17-E) entitled “large remotely located satellite earth stations” was distributed at the Valetta Conference. It is available on the WEB at the following address: *http://www.itu.int/itudoc/itu-d/wtdc/wtdc98/docs/17.pdf.*

Figures: