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Agenda item: 3.1 **PLENARY MEETING**

TELE Greenland A/S

LARGE REMOTELY LOCATED SATELLITE EARTH STATIONS

Abstract

With the purpose of providing satellite communications to Greenlandic settlements TELE Greenland has developed a satellite earth station, which is cheap, flexible, independent of equipment suppliers, remotely controlled and complies with INTELSAT specifications. Some of these earth stations have now been in operation for a couple of years. This paper describes the problems with the development of the station and the experiences we have gained with them during operation. An estimate of the cost per traffic minute and some general conclusions and recommendations are also given.

TELE Greenland

Services

TELE Greenland is a telecommunications service provider, 100% owned by the Greenlandic Home Rule. It provides telecommunications services to all of Greenland, including:

– switched telephony and data;
– land mobile communications;
– VHF and MF shore-to-ship;
– radio and TV broadcasting.

The overall fixed communications network in Greenland is fully digitalized, complying with the standard and availability in any industrialized country. All expenses for operation and development of the network are completely financed by subscriber fees.

The total turnover of TELE Greenland was 92 million dollars in 1996. Approximately 25% of the turnover is invested every year in further development of the network. The net profit is used to reduce the telephone rates in Greenland. From 1995 to 1997 the total reduction in rates has been 20%.

Customers

Greenland is the largest island of the world, approximately 2 million km^2, of which 80% is permanently covered by ice. The population (55 000) lives in 18 towns and 60 settlements along the coast. The number of fixed-line subscribers is 22 000, which gives a telephone penetration of 40% in Greenland.

In 1993 the Greenlandic Home Rule decided that all Greenlandic towns and all settlements with a population of more than 50 people should have fixed telecommunication and radio and TV before the year 2000. Based on this TELE Greenland worked out a plan for the development of telecommunications services to Greenlandic settlements. Although most settlements can be reached by terrestrial communications it was in some cases advantageous to use satellite. For this reason a special satellite earth station was developed.

Satellite communications in Greenland

TELE Greenland has used satellite communications since 1978, and today satellites are the only way of connecting Greenland to the outside world and interconnecting various areas of Greenland together. Three satellite systems are used:

– INTELSAT;
– EUTELSAT;
– GE Americom.

A map of Greenland showing the three systems with the earth stations is shown on the following page. INTELSAT is the most important of the three systems; today TELE Greenland has leased 72 MHz transponder capacity in Global Beam at position 325.5° E.

There are 13 satellite earth stations operating at this space segment, eight Standard B (one in Denmark), two Standard F3, one Standard F2, one Standard D1 and one 9.3 m TVRO. The reason for the relatively large antennas to be used in a domestic satellite system is that INTELSAT Global Beam is the only satellite beam covering all of Greenland.

A satellite earth station for a settlement

Requirements

The requirements for an earth station to be used in a settlement could be identified as:

– ability to receive and transmit one digital carrier for telecommunications;
– ability to receive a 4.8 Mbit digital signal for TV and radio broadcasting;
– compatibility with INTELSAT and other international specifications;
– remotely monitor and control;
– high reliability;
– operation under extreme weather conditions;
– low power consumption and small volume;
– low price!

Realities

In 1993 TELE Greenland sent out a request for quotation for a settlement earth station.

Our basic requirements were:

– an antenna of 6-7 metres (INTELSAT F2);
– two LNAs (LNCs) of 45 K;
– one low power SSPA (e.i.r.p 60 dBW);
– frequency conversion to 70 MHz IF;
– digital modems (INTELSAT IESS-308);
– reception of digital TV and radio;
– interface to a monitor and control system.

The responses we got were not encouraging. Some suppliers did not answer at all. Of the answers we got only one was reasonably close to what we considered to fulfil our minimum requirements. The price level was generally too high.

By analysing the various quotations we found out that combining one antenna with one set of SSPAs and one satellite modem from another quotation we could get almost the earth station we wanted.

After having confirmed with the different bidders, asking for separate prices, we also found out that by buying the station in separate units instead of as an integrated earth station, the price we would have to pay for the equipment would drop to between 33 and 50% of the prices which we got in the first quotations.

Final configuration

The configuration we ended up with was:

– one fixed 7.3 metre antenna;
– one 5 W SSPA;
– two 45 K LNC (C to L-band);
– one set of up/down converters (70 MHz IF);
– one satellite modem (IESS-308);
– one receiver for digital TV;
– a monitor and control interface.

Except for the modem, the TV receiver and part of the monitor and control all the units were to be located in the antenna hub. This simplified the installation and made use of the SSPA capability more efficient (no waveguide loss).

The following was not included in the station:

– antenna tracking and motors;
– antenna de-icing;
– redundancy.

A tracking system and motors are not needed when operating a 7 metre earth station at a non-inclining INTELSAT satellite. Installation of the antenna is much more simple, although it can last a little longer finding a satellite, using a handwheel!

De-icing is not needed at many locations in Greenland due to the low elevation angles and the low temperatures (powder snow). In any case, very few power plants in Greenlandic settlements would be capable of supplying a de-icing system for a 7 metre antenna. In case of wet snow in the antenna the population in the settlement knows how to remove it manually.

Giving up the requirement for redundancy is one of the most efficient ways of reducing the price of the earth station. With the MTBF figures of modern electronic equipment this was not considered to be a problem.

Other equipment

In order for a system to facilitate telecommunications and TV/radio distribution to a community it is necessary to include other equipment in the total system. This includes:

– multiplexing equipment, including LRE;
– a rural telephone exchange;
– broadcast transmitters for radio and TV;
– no-break power supply;
– shelter and foundations.

Although this equipment is irrelevant for the satellite communications, some of it has to be included when the circuit price is calculated.

Installation and engineering

The time for engineering, installation and commissioning system as described above was estimated to be approximately six man-months. This included all the extra trouble which comes up at a remote site in Northern Greenland (expensive transport, no roads, no cranes, limited power, severe weather conditions etc.).

Actual prices

The most important figure to know is the price per circuit per minute. In this value the following costs are included:

– satellite communications equipment;
– other relevant equipment;
– establishment costs;
– satellite capacity;
– operation and maintenance costs.

By "other relevant equipment" is meant the equipment needed for telecommunications. Radio and TV broadcast equipment is not included as it is financed by other sources.

We had the following prices for the station (all in $US 1 000).

Establishing costs

Satellite earth station	120
Other equipment:	
– multiplex	
– telephone exchange	
– no-break power supply	
– shelter and foundations	
– subscriber network	240
Engineering and installation	45
Allowances and transport	30
Total	435

Yearly expenses and traffic

Establishing (7 years, 8%)	83.5
Satellite capacity	
– (2*192 kbit in an INTELSAT Global beam transponder)	28.0
Operation & maintenance	7.5
Total expenses per year	$US 119 000

Traffic

TELE Greenland always attempts to dimension its trunks to achieve a rejection rate of 1% during busy hour. In order to facilitate 5 Erlangs in this period for the settlement, we have, by means of Erlangs formula, calculated that 11 circuits will be necessary to keep a rejection rate for the calls as low as 1%.

This has shown to be sufficient, but not more. Furthermore, we have measured that the total number of traffic minutes per year for the settlement is 735 000. As the total number of minutes in a year is 525 600 (365 days) the average traffic running over the station is 1.4 Erlangs.

Price per circuit per minute: 119/735 = $US 0.16

This figure does not include the fact that the telephone exchange also facilitates local calls in the settlement. As TELE Greenland also charges its subscribers for this the minute cost price for incoming and outgoing calls at the station is even lower than the $US 0.16 calculated above.

Finally it has to be mentioned that the number of circuits is set by the traffic requirements and not by the earth station design. The station is capable of transmitting a 512 kbit carrier to a Standard B earth station via a Global beam transponder. As variable bit rate modems are used, the capacity of the station can be increased without any hardware changes to the satellite earth station.

If the need for capacity is higher, the circuit price will drop. Capacity requirements above 512 kbit will just require a larger SSPA (10, 20 or 50 W).

Experiences during operation

The first of four earth stations has been in operation for three years now. The experiences with this station were generally so good that three more stations of a similar design were brought in operation the following year. (Two of these stations were not located in a settlement.)

Further installation of additional earth stations has been pending due to lack of satellite capacity in INTELSAT Global beam.

Generally it can be stated that the stations have been operating with a higher availability than expected. We had estimated an availability of at least 98%, but the actual availability is at the same level as the rest of the Greenlandic satellite communications network which complies with INTELSAT recommendations for IDR circuits.

The system design initially caused trouble for us in two ways. There was a regular error in the up converter causing decreasing output e.i.r.p. It was possible to compensate for this via the remote control system until a maintenance visit could be arranged. The equipment supplier has accepted this problem as a design error in the unit itself.

The other problem was caused by the FM audio transmitter which interfered in the station up converter at IF level, causing radiation of a false carrier over the satellite. This was corrected by moving the frequency of the FM transmitter and adding extra attenuators.

This problem caused us to redesign the remote control system, so it became possible to switch off the earth station with automatic power-up of the station after five minutes. One of the major problems with monitor and control of these systems is that the M&C facility is lost if the satellite link is interrupted.

Beside the problems mentioned here unscheduled maintenance visits to the site have been limited to special occasions, caused by other circumstances (change of satellite transponder, change of TV system, etc.).

Conclusions and recommendations

Conclusions

The general conclusions from our experiences with satellite communications for the Greenlandic settlement programme can be summarized as follows:

1) It is possible to design and build a cheap satellite earth station, complying with international specifications and capable of operating at existing geostationary satellites in orbit.

2) If equipment from various suppliers is combined, and the user takes over the overall system responsibility the price of the earth station can be reduced to between 33 and 50% of the price of a turn-key system.

3) Giving up the redundancy concept of a station does not affect the overall availability of the earth station significantly.

4) A well functioning remote monitor and control system is essential for proper operation of the station if maintenance visits are to be minimized.

5) The minute cost price for a circuit over the station via an INTELSAT Global beam transponder can be kept as low as 16 cents. This includes all expenses, including the subscriber network.

Recommendations

Based on our experiences we can recommend the following to operators in countries with a lack of communications to rural areas:

1) Define the traffic requirements to the towns or areas where the communications systems are to be established.

2) Find a suitable satellite system at which operation is to be done. Do not use an inclining satellite.

3) Find out which type of satellite earth station can give the best balance between the consumption of transponder power and bandwidth in order to obtain the most favourable economic solution.

4) Use international specifications in earth station design. This makes the station compatible with an existing network and limits the dependence of equipment suppliers.

5) Connect the earth stations to a computerized remote monitor and control system.

6) Redundancy on the earth station is not necessary. Keep a centrally located set of spare parts on stock.

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