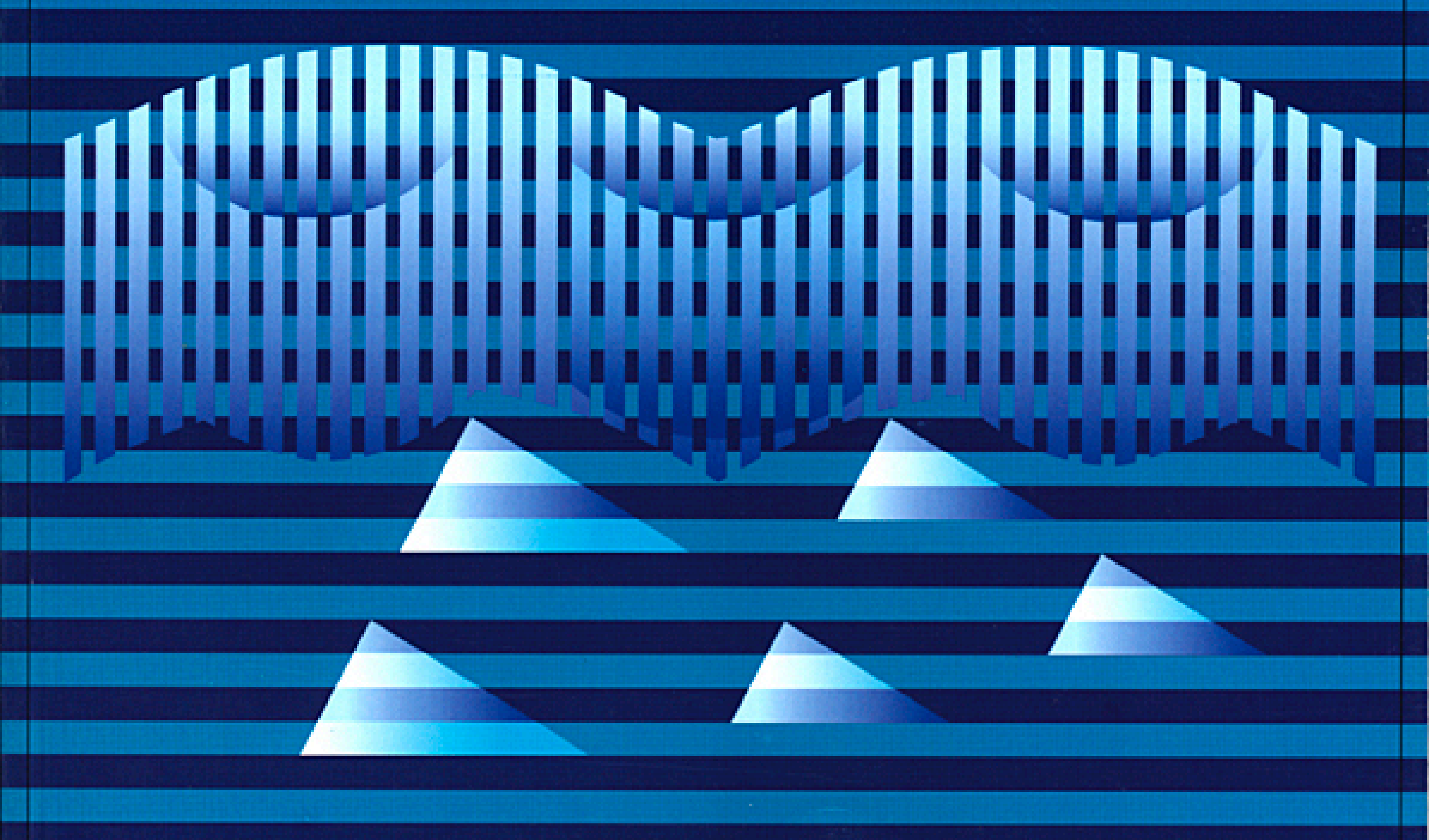
Telektronikk 3.94

Arctic telecommunications



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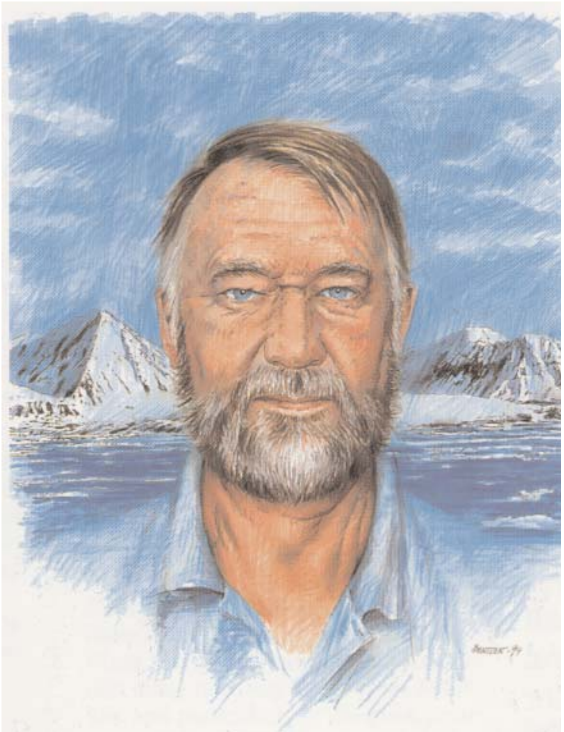
Tele RESEARCH

Guest editorial

BY JAN HASSEL

In this issue of Telektronikk the focus is set on the development and history of telecommunication in the Arctic. Activities in three different areas are reported: Greenland, where Greenland Telecom serves a very long coastline of this enormous island; Svalbard, with its long tradition of wireless communication covering large parts of the Arctic Ocean; and the Russian–Norwegian project for reconstruction of the telephone network in the Barents area.

Telecommunications in the Arctic region have a great potential and are increasingly important. Over the decades there has been a growth in capacity and services according to the technological development of telecommunications and the demands for communications in the area. At Svalbard, we offer high quality telecommunication services to all nations. This is to continue and be extended in accordance with demands in the region.



Svalbard is sometimes referred to as an international part of Norway. Even though Norwegian laws and regulations apply, the Svalbard Treaty gives rights to all countries who have signed the treaty to operate at Svalbard. For more than 80 years the policy of Norwegian Telecom has been to offer modern telecommunications to everyone concerned in the Svalbard region.

In the Arctic, excellent telecommunications is of the utmost importance. It is provided at Svalbard and it can be in other Arctic regions. What to do, and the guts to do it, still often depends upon far-seeing directors and pioneers as in former days. The digitization of the telephone network at Longyearbyen in 1990 gave a very significant rise of quality and performance. This was a result of decisions made by today's pioneers. There is, however, still a demand for NMT or GSM for commercial and safety reasons.

The existing infrastructure and the geographical position of Svalbard provide excellent conditions for communication via satellites in polar orbits. Satellite passages are frequent and observation times long. Large amounts of data can be interchanged and transferred on-line for processing anywhere in the world. The satellite connection up to 80 degrees latitude, which was established in 1969, was a technological breakthrough for geostationary satellites – moving the limits of what was thought feasible at the time.

Telecommunications to Svalbard started in 1911, when the wireless telegraph service was established and offered to all nations operating at Svalbard and the surrounding areas of the Arctic Ocean. The coastal radio service is still of importance for communication and safety to ships, trawlers, explorers and others who travel and trade in the area.

The telecommunication technology has become fundamental to man. And man is always behind the technology. Usually, people are not mentioned when we report on technology, solutions, progress, development, and milestones. In this issue of Telektronikk we also try to highlight the daily life of those who have served in Arctic telecommunications through the decades.

The Arctic is still a challenge to expeditions and loners. Thanks to the development of telecommunications, today's expeditions are far from being as risky and lonesome as in those early days when the first pioneers were travelling. A recent one-man walk to the North Pole, supported by Norwegian Telecom, is reported here. Pioneers still exist.

Telecommunications in the Arctic

BY MATHIAS BJERRANG

When Roald Amundsen reached the South Pole on December 14, 1911, he had to wait until he had returned to Hobart, Australia, on March 7, 1912, before he could telegraph that the South Pole had been reached nearly three months previously.

When Børge Ousland reached the North Pole on April 22, 1994, after 52 days of walking across the ice from Kapp Arktichesky in Siberia, he could immediately inform of his achievement via the ARGOS satellite transmitter.

During the 80 odd years separating these two events, telecommunications have advanced tremendously and have been of great importance to both shipping and aviation, as well as for the development of communications in Arctic regions as well as everywhere else in the world.

Telecommunications before 1911

At the beginning of this century there was much exploration activity in the Arctic regions. Journeys were undertaken to the North Pole on skis, by plane and by air ship, as well as commercial expeditions searching for profits in whatever the Arctic had to offer. The company AS Spitsbergen of Tønsberg was established with a whaling station at Finneset at Green Harbour, Svalbard in 1905. Tourism and coal industry were in their infancy. Vesteraalens Dampskibsselskap (steam ship company) built their own hotel at Hotellneset in the Advent Valley in 1896, while the American Arctic Coal Company started extracting coal in 1906. At this time Svalbard was "No-man's land", and nobody had the responsibility for what went on there.

Until 1911 communications between Svalbard and the mainland was largely done in writing, and the letters were sent by boat in the summer. The Post Office was first established in the summer season of 1897 with the post office Advent Bay. More post offices appeared after a while: Bell-Sound 1907, Green Harbour 1908. Spitsbergen Radio's telegraph managers took on the all year round job of post office clerk from 1911 onwards, with an annual wage of NOK 200.

First radio contact Svalbard – Norway 1911

Telecommunication with radio waves started in the early 1900s. Norway had the second radio telegraph connection in the world; that was the connection between Røst and Sørvågen opened on May 1, 1906. It was the important fisheries in the area which prompted the opening. Not long after, radio telegraphy to ships in the open seas was started.

On May 3, 1911, the Storting (Parliament) instructed Norwegian Telecom to build a radio station at Svalbard. Already on November 22 the same year the first radio telegraphy signals from Spitsbergen Radio were received at Ingøy Radio near Hammerfest, and the first telecommunications between Svalbard and the mainland were established. The station played a vital role when Norwegian industry and habitation made headway in the years to follow, and particularly in the great polar years of the 1920s. That was when the radio station was in the focus of the entire world press. The fact that Norwegian Telecom and the Post Office were already established at Svalbard was one of the most important arguments for Norway obtaining custody of the whole archipelago at the peace conference in Paris in 1920.

Ships to and from the mining communities, fishing and hunting vessels, polar expeditions, cruise liners, weather observations, post office; these were the most important jobs of Norwegian Telecom at Green Harbour radio station, in addition to contact with the mainland.

Development to the present day

Until 1949 all radio communications to and from Svalbard were transmitted as radio telegrams; no voice communication was possible. A radio telephone point-to-point connection on short-wave radio was established in 1949 between Svalbard Radio and Harstad Radio. This finally included Svalbard in the Norwegian national telephone network.

In 1978 communication by satellite to the mainland was established and finally, in 1981, Svalbard was connected to the national and international subscriber dialling telephone system.

The offer of telecommunication services at Svalbard today is the same as on the mainland, with the exception of mobile telephone – that will probably never be developed at Svalbard. The telecommunication services have been made possible via a satellite in a geostationary orbit keeping it over the same point (some 36,000 km over the equator) on earth all the time (ref. Figure 2).

Radio wave distribution and northern lights

When the radio technique came into public use in the inter-war years, it was soon experienced that radio communication at latitudes in the extreme north was very difficult during bursts of northern lights. Radio communication over distances greater than 300 km are based on the atmosphere's ability to reflect radio waves from areas where there are free electrons in sufficient amounts, the ionosphere.

Figure 2 shows the earth in relation to satellite orbits and the atmosphere which we assume is some 400 – 500 km in thickness and which only makes up the thickness of the line in the circle illustrating the earth. Figure 3 shows a small detail of the atmosphere with reflecting layers.

The atmosphere receives enormous amounts of energy from space and from the sun in the form of electric particles and radiation. Gases in the atmosphere are electrically charged and various types and degrees of ionization occur at different heights. When the radio waves penetrate these layers they are partly deflected

Figure 1 Post marks from Svalbard ca. 1900

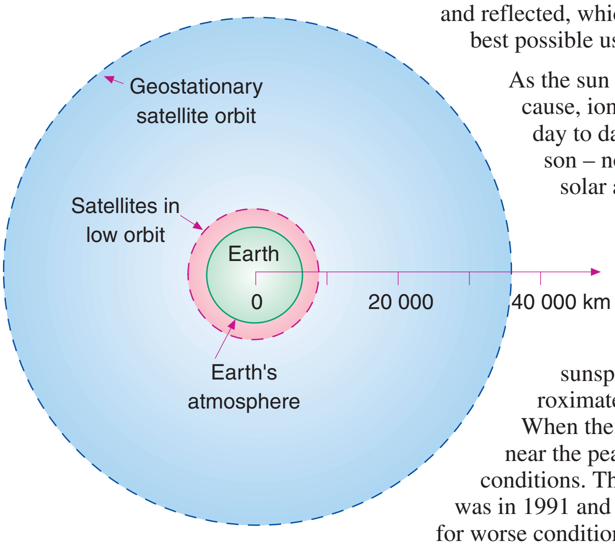


Figure 2 The Earth with atmosphere and satellite orbits

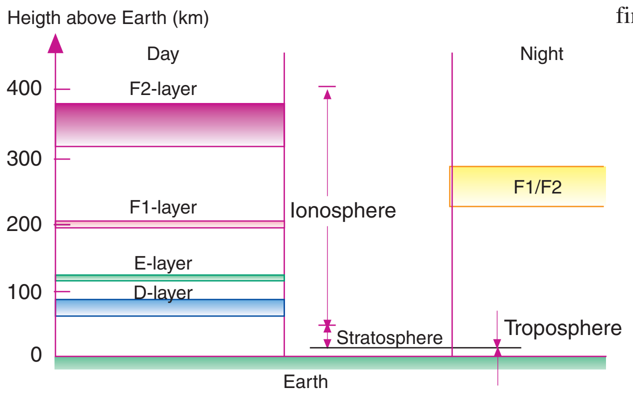


Figure 3 The atmosphere and reflecting layers

and reflected, which we try to make the best possible use of.

As the sun is the main ionization cause, ionization will vary from day to day, from season to season – not least because of solar activity. When sunspot activity is high the radiation from the sun is high and a stronger ionization will occur in the atmosphere. The sunspot activity peaks approximately every 11 years. When the sunspot activity is near the peak we have good radio conditions. The last sunspot peak was in 1991 and we are now heading for worse conditions for short-wave communications. As the sun rotates around its own axis in 27.5 days, the sunspot activity will change over the same period of time.

We divide the atmosphere into three spheres, see Figure 3. The nearest is the *troposphere,* which extends some 10 km out. This is where we find winds, cloud formations, storms and great variations in temperature. The *stratosphere* extends between 10 and 50 km from the earth, and the temperature here is more or less constant. Long distance flights normally fly in this layer. The *ionosphere* extends from 50 km and out to 500 km, and as the name indicates, this is where we find the ionized layers reflecting radio waves. The lowest is the D-layer at a height of some 80 km, then the E-layer at about 120 km, and furthest out is the F-layer, which we have divided into the F1-layer at about 200 km and the F2-layer between 300 and 400 km from the earth. This is the daytime status, but after dark the influence from the sun ceases; the D- and E-layers disappear and the F1- and F2-layers merge into one layer at a height of some 250 km.

Figure 4 shows how transmitted radio waves are reflected in the ionized layers. Space waves at high frequency VHF/UHF/SHF are normally not reflected, but pass right through and disappear into space. Space waves in the 1 – 5 MHz frequency will, in the daytime, first hit the D-layer which absorbs and reflects these frequencies. Strong solar outbursts may lead to the D-layer becoming so strongly ionized that all signals are absorbed. What we call SID (Sudden Ionospheric Disturbance) then occurs, and we may have a total break-down in radio communications. SID may last from a few minutes to several hours. The F1-layer destroys some of the wave distribution by absorbing radio waves which otherwise would have been reflected in the F2-layer. The F2-layer naturally extends furthest, as it is on the outside.

In the Arctic there are areas of northern lights which consist of ionized air caused by electron bombardments in the earth's magnetic field. There is a close link between solar outbursts and northern lights / aurora. The northern lights occur at a height of some 80 – 110 km, and in the daytime they are in the same height as from the D-layer and nearly as high as the E-layer. At night, they are also in the 80 – 110 km area and almost "replace" the D- and E-layers, and only have the merged F1/F2-layer above. Radio signals reflected from the northern lights belt are strongly distorted and difficult to read. Telegraph signals sound like a pulsating crackle.

Figure 5 shows the degree of disturbances from the northern lights zone with Rogaland Radio in the centre of an azimuth map. Because of Rogaland Radio's location close to the northern light zone, several areas will be disturbed. This mainly applies to connections along the border of the northern light zone in the sector 20 – 40 degrees east, and along the border of the sector 280 – 320 degrees west. Secon-

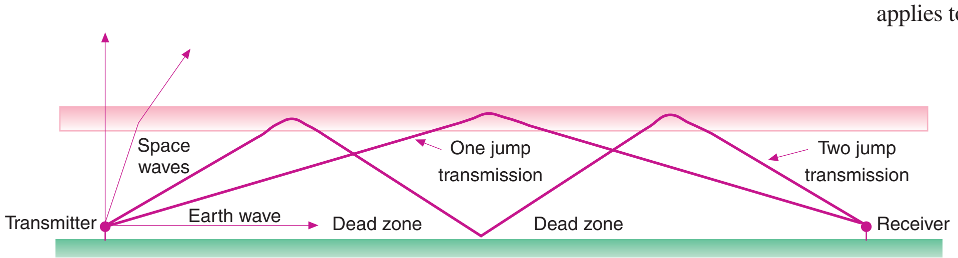


Figure 4 Various paths between transmitter and receiver

daristically, it applies to connections through the northern light zone in the sector 320 degrees west to 20 degrees east.

Outbursts of aurora may be predicted with a high degree of certainty, because sudden bursts of solar activity are accompanied by ejection of charged particles from the sun. They travel in various directions, and some enter the earth's atmosphere, usually 24 to 36 hours after the event. When the solar particles enter the earth's atmosphere, they may react with the magnetic field to produce a visible or radio aurora, the former if their time of entry is after dark. The visible aurora is in effect fluorescence at E-layer height – a curtain of ions capable of refracting radio waves in the frequency range above approx. 20 MHz. D-layer absorption increases on lower frequencies during auroras. The exact frequency range depends on many factors: time, season, position with relation to the earth's auroral regions and the level of solar activity at the time, to name a few.

Before I was hired for the job of responsible for communications for Radio 1's North Pole expedition in 1993, the planners thought it would be possible to use satellite communications from the North Pole directly to Radio 1's studio in Oslo. The aim of the expedition was to celebrate their 10 years anniversary by becoming the first commercial radio station in the world to transmit directly from the North Pole.

Following my briefing on radio conditions in polar areas, one of the recurring questions from my employer was "Can you guarantee our radio connection with the North Pole?" Naturally, I could not, but as we got nearer to departure for the Pole and I had studied the propagation forecasts as well as aurora status for date of landing, I indicated a 70 – 75 % chance of a connection. Luckily, I was not mistaken. Two days later I attempted to do some amateur radio operation on short-wave from Resolute Bay, but at that time aurora conditions were bad, and the result was poor.

On our North Pole expedition we used a short-wave radio with a 600 Watts transmitter, inverted V dipole antenna and a transmitting frequency of 12.3 MHz via Rogaland Radio, and from there by telephone to Radio 1's studio. We transmitted directly for two hours and had acceptable conditions for about 80 % of transmission time.

During 1994, I made agreements with two North Pole expeditions to be their communication link at Svalbard: Børge Ousland, who set out alone from the Russian side, and the NAPE expedition (Mørdre & Co) from the Canadian side. Both expeditions had the same type of short-wave radio equipment (Racal BCC 39B with 50 Watts), the same antenna and the same type of Lithium batteries (24 Volt 15 Ah). I was in contact with the NAPE expedition only once, while they were in training camp at Frobisher Bay on Baffin Island, plus once from Eureka after they had abandoned their expedition. I was in contact with Børge Ousland twice a week during the whole of his 52 day trip.

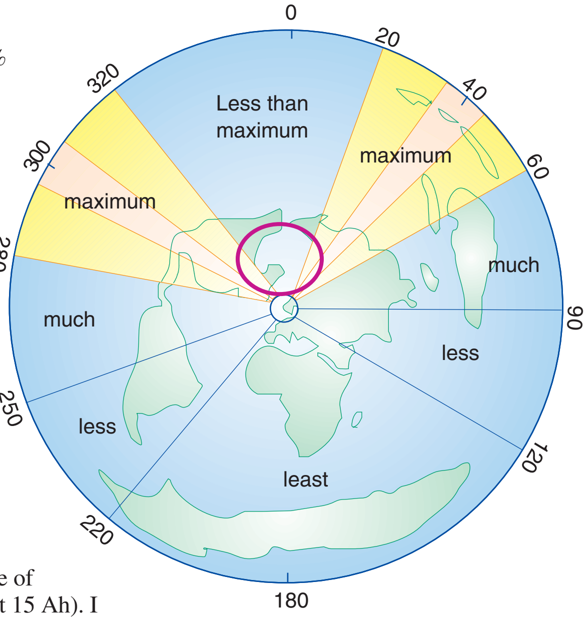


Figure 5 Degrees of disturbance from the Northern Light zone

Sometimes conditions were so good that he could have radio telephone conversation of acceptable quality via Svalbard Radio with his family and his spokesman.

Photo: Mathias Bjerrang

Figure 6 Børge Ousland in Sibiria, testing the radio equipment before setting out

Photo: Wayne Emond/Kawartha Post Card Co.

Figure 7 EUREKA weather station 80° 00' N 85° 56' W

Photo: Mathias Bjerrang

Figure 8 Radio tent on the North Pole

The distances from Svalbard to both expeditions were largely the same, some 1,300 – 1,400 km in a straight line. Why were conditions reasonably good eastward from Svalbard, while radio contact westward from Svalbard was rather poor? We tried various frequencies at various times of the day and night, but nothing worked towards west, only towards east did we obtain contact. In my own time north of the Arctic circle with over 60,000 logged radio amateur contacts, I have experienced that when the northern lights are in the south-west or directly overhead, contact eastward to Japan, Australia etc. is fairly easily obtainable, but westward towards the USA is almost impossible. When the northern lights are overhead or east of Svalbard, contacts are difficult in all directions. However, we may sometimes have reflections from the northern lights so that radio contact is possible to northern Norway, but these contacts are not to be trusted because the northern lights often move at great speed and thereby the reflection point changes constantly and the contact is cut off. During long-lasting and strong northern lights we may at Svalbard experience total black-outs on all short-wave bands. This condition may last for several days, and before Svalbard had its satellite connection, we could only obtain contact via radio telegraphy to Norway on very low frequencies (about 150 kHz) under such conditions.

As will be known the northern lights occur in a ring around the North Magnetic Pole in Canada. The NAPE expedition was always some 800 km north of the North Magnetic Pole, while Ousland was some 2,600 km west of the North Magnetic Pole, which is probably the reason why he was less troubled by northern lights, although they were occasionally visible in the west.

Satellite communications have made great progress since first taken into use in 1962. The maximum range for satellites in geostationary orbits is 80 degrees north and 80 degrees south, but that requires the down-link equipment in these areas to be connected to a very large and fixed reflective antenna. At Isfjord Radio, Svalbard, just over 78 degrees north, the antenna is 13 metres in diameter. At Eureka, Canada, near 80 degrees north, the antenna is 25 metres in diameter, but still the military base at Alert, some 83 degrees north, has a satellite connection because radio relay is used (between Alert and Eureka) placed on the highest mountains on the Ellesmere Island. Ships in Arctic areas with satellite equipment on board often have difficulties communicating via INMARSAT; the further north they get, the poorer the connection naturally becomes.

Satellites in low polar orbits are today used for navigation, positioning, etc. Some time in the future it may become possible to cover the whole of our planet with satellite connections, but to date this is not possible. Arctic communications are still dependent on short-wave communications and probably will be for a long time yet. The arguments against satellite coverage are hardly of a technical kind, but rather that this type of communication has little economic use, as there are very few people north of 80 degrees north and south of 80 degrees south.

Mathias Bjerrang is Head of Svalbard Radio, Longyearbyen.

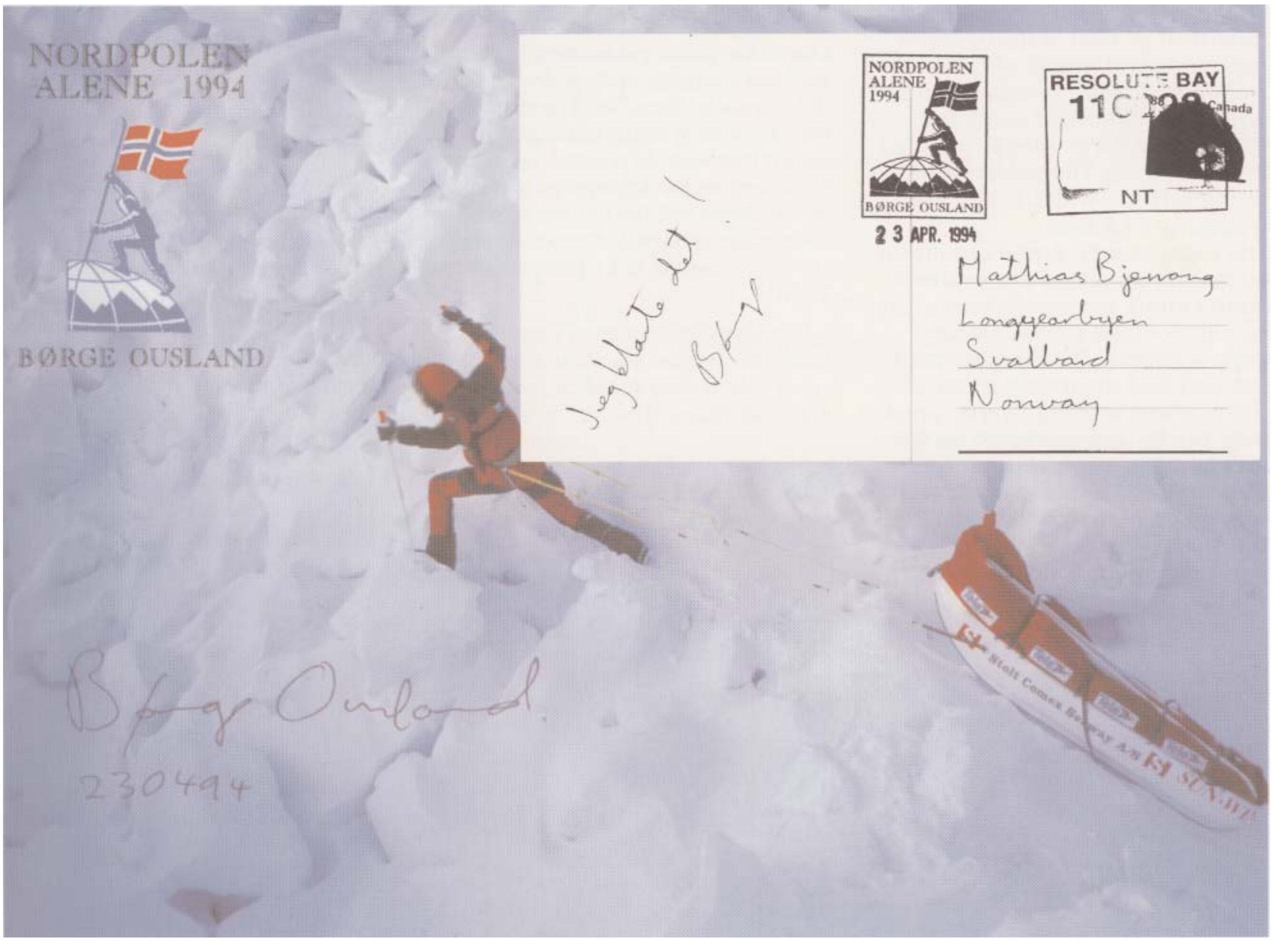


Photo: Kjell Ove Storvik / Brevig Forlag as

Figure 9 Børge Ousland on his lonely trip to the North Pole

Measurements of atmospheric effects on satellite links at very low elevation angle

BY ODD GUTTEBERG

This article is a reprint of a report published in 1984. It describes experiments and results obtained from propagation measurements with the Orbital Test Satellites (OTS) at the Arctic islands of Spitsbergen (78° N). The elevation angle to the satellite was 3.2° and the frequency 11.8 GHz.
The experiments carried out included measurements of atmospheric scintillations, cross-polarisation discrimination and space diversity improvements. The measurements showed that the distributions of the received satellite beacon amplitude can be approximated by Rice-distributions. Large diversity gain was obtained by using horizontal spacing of 1 km. A wide-band (TV) transmission experiments was also performed with good result.

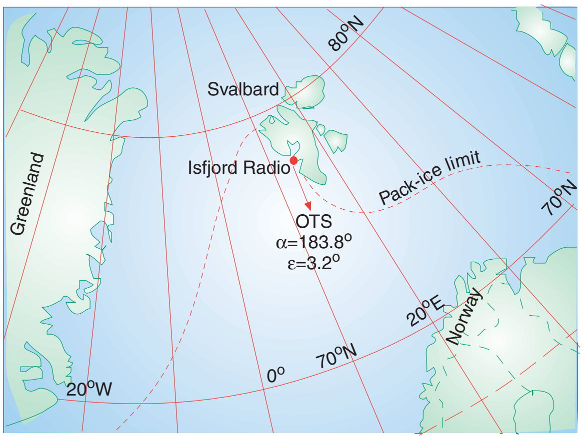


Figure 1 Location of the experimental site, Isfjord Radio, 78°N, 13.6°E. Elevation and azimuth angles are given for OTS positioned at 10°E

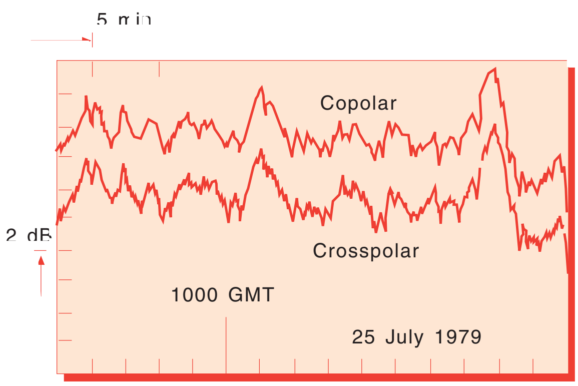


Figure 2 Plots of co- and cross-polar signals at Isfjord Radio, 25 July 1979. XPD ≈ 38 dB

1 Introduction

One of the prime parameters in geostationary satellite system design is the margin in signal level needed to take account of signal attenuation by the atmosphere. At present, attention is focused on the knowledge of climatic variations and the influence of elevation angle on signal attenuation and cross-polarisation at frequencies above 10 GHz (1).

A considerable amount of data has been collected on attenuation and cross-polarisation statistics, measured at mid-latitudes. However, relatively little is known on the characteristics of low-elevation paths to high-latitude stations, such as statistical properties of the fading, seasonal variations, cross-polarisation degradation and possible space diversity improvements.

To gain knowledge of these characteristics, propagation experiments at 11 GHz have been performed at Isfjord Radio, Spitsbergen (78°N, 13.6°E), Figure 1, using the Orbital Test Satellite (OTS).

The different experiments were conducted during the period from April 1979 to August 1982. Some of the results have been presented earlier (2).

Table 1 Stations characteristics

Location:	Isfjord Radio, Spitsbergen
Coordinates:	13.64°E / 78.06°N
Elevation angle (OTS, 10°E):	3.2°
Azimuth angle (OTS, 10°E):	183.8°

	Station type:			
Station parameters	**A**		**B**	**Units**
Beacon frequency	11.786		11.575	GHz
Polarisation	Circular		Linear	
Antenna system				
Antenna type	Cassegrain		Cassegrain	
Diameter	3		1	metre
Gain	49.5		39.6	dB
Beamwidth	0.6		2.0	deg
Cross-polarisation isolation	> 35		-	dB
De-icing power	8		none	kW
Receiving system	**Copol**	**Xpol**		
Clear sky signal level at receiver input	~-104	~-139	~-123	dBm
G/T	20.5	24.7	11.6	dB
Noise temperature	800	300	630	°K
Level detector type	PLL	PLL	PLL	
Locking range	± 200	± 200	± 40	kHz
Dynamic range	~20	~25	~15	dB
Post detection bandwidth	10	1	1	Hz
Data acquisition system				
Sampling rate	10	1	2	Hz
Tape recorder	Tandberg TDC-3000		Tandberg TDC-3000	
Strip chart recorder	Gould 816		hp 7130A	

2 Description of experiments

The OTS satellite is positioned at 5°E (until 14 April 1982 at 10°E), which means that the satellite is almost seen at the maximum elevation angle from Isfjord Radio. The geometric elevation angle is 3.2°, with an average ray bending of 0.2°. Assuming a tropospheric height of 8 km, the ray propagates through more than 120 km of the troposphere. One should therefore expect the received signal to be influenced by scattering and reflections due to turbulent air masses. At this very low elevation angle, temperature inversions could also cause duct transmissions.

The first experimental earth station was put into operation in April 1979, receiving both the co- and cross-polar components of the 11.8 GHz circularly polarised satellite beacon. The station was equipped with a 3 metre Cassegrain antenna and phase-locked receivers. The station characteristics are summarised in Table 1 (station A).

During the spring of 1982 two additional small earth stations for site diversity measurements were installed. The two equally small OTS terminals were receiving the linear polarised telemetry beacon at 11.6 GHz. The stations were equipped with 1 metre Cassegrain antennas and phase locked receivers. Other station characteristics are given in Table 1 (station B).

Low angle space diversity measurements performed in Arctic Canada at 6 GHz (3,4) showed poor diversity gain with horizontal spacing up to 500 metres. In our experiment it was therefore decided to use a spacing of more than 1 km.

For a further investigation of the scintillation phenomena, an acoustic sounder (SODAR) were used during the diversity experiment at Spitsbergen in the summer of 1982. The SODAR was placed almost under the beam, 7 km away. Thus the radio and the acoustic beams intersected at an approximate height of 450 metres.

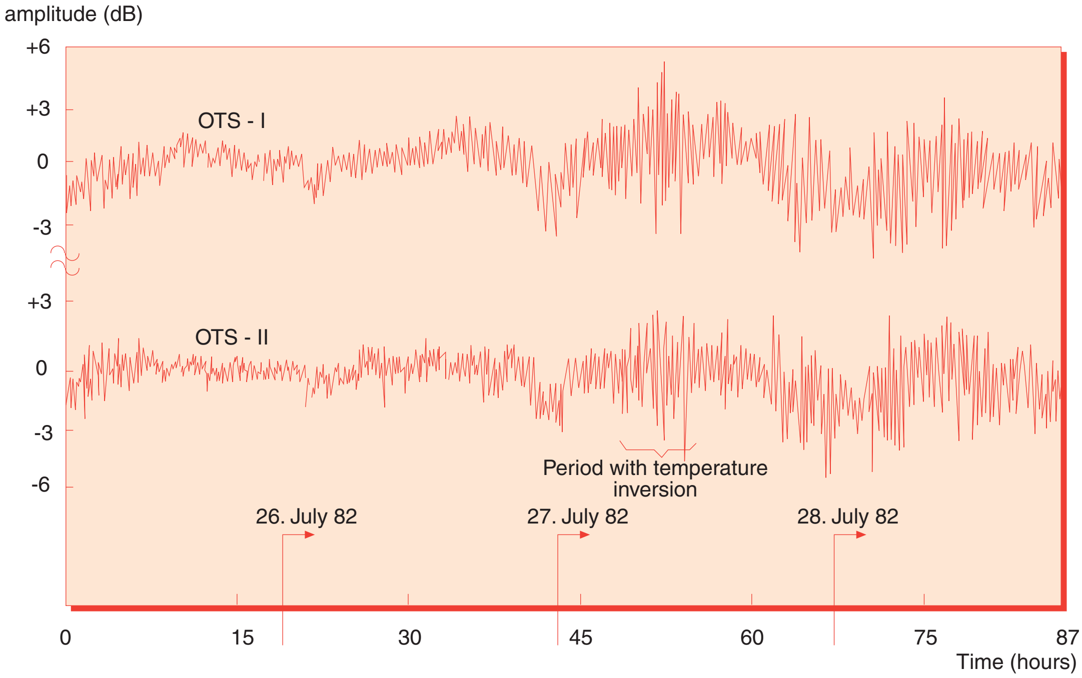


Figure 3 Time-plot for OTS-I and OTS-II
Start: 25 July 82, 0500 GMT Stop: 28 July 82, 2045 GMT
Recording time: 5265 mins Sampling: 2 samples/sec
Smoothing: 5 sec Each: 100 points

The beacon measurements at Spitsbergen in 1979 and 1980 showed large scintillations of the received signal. However, there existed little knowledge of the possible coherent bandwidth that could be received at such a low elevation angle. Therefore a wide band experiment was performed during July 1982. A frequency-modulated TV signal with 27 MHz bandwidth was transmitted via OTS and received at Isfjord Radio. The receive earth station used in this experiment was a modified version of station A, Table 1.

3 Experimental results

3.1 Atmospheric scintillations

Due to variations of the temperature and humidity within small volumes of the atmosphere, the refractive index profile will, at certain heights, depart from its normal exponential decay. This may cause bending, scattering and reflections of the ray. At very low elevation angle one should therefore expect the received signal to be heavily influenced by turbulent air masses.

Figure 2 shows an example of the recorded co- and cross-polar signals at Isfjord Radio. This is a typical plot of the signal variations (scintillations) during the Arctic summer months (July/August) with peak-to-peak variations around 5 dB. A compressed time plot of the received signal for an 87 hours period, is shown in Figure 3.

In Figures 4 and 5 are shown the cumulative amplitude distributions of the scintillations. As seen, there are large annual variations. During the Arctic winter (October–May), maximum fadings are only about 5 dB. This is also expected since the atmosphere is quite stable during the Arctic winter. However, in summer, deep fadings up to 20 dB are experienced. This may be due to high refraction index gradients.

The distribution for July/August 1979 is well above the distributions for the summer period 1980, probably due to the exceptional high mean temperature (7.6°C) during July 1979. The 30 year July average is 4.9°C.

It would have been of great help for the planning of earth stations in the Arctic, if one could find a correlation between the fading level and a simple meteorological parameter, e.g. the ground temperature.

In Figure 6 is plotted the fading level at 99.99% availability versus the mean tem-

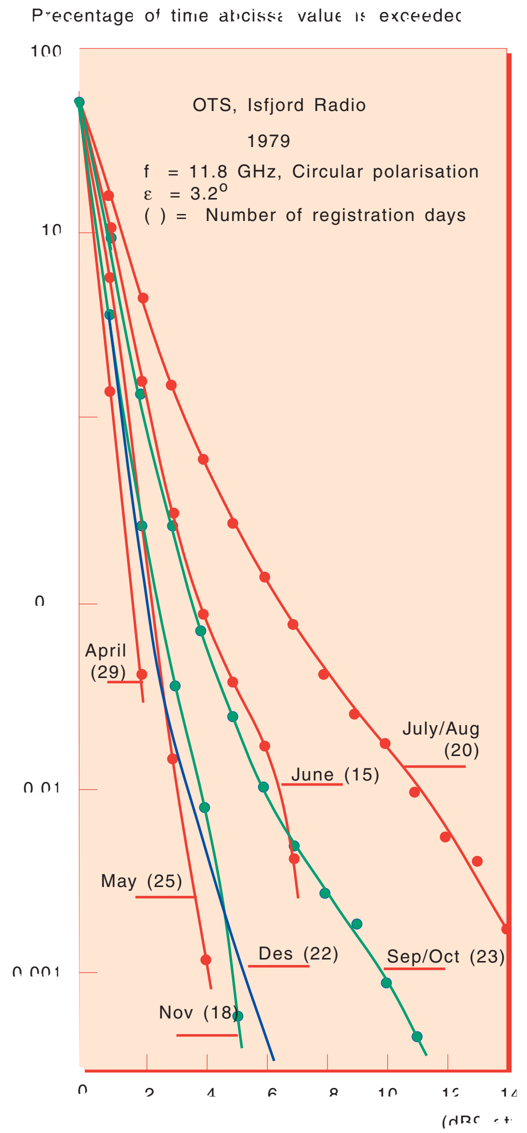


Figure 4 Cumulative distributions of scintillations (1979)

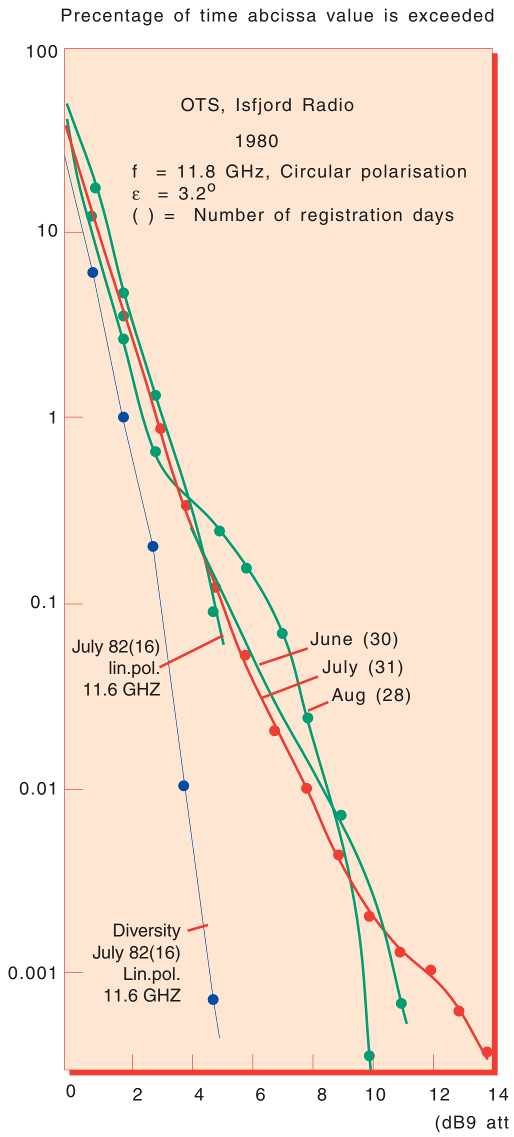


Figure 5 Cumulative distributions of scintillations (1980 and 1982) and diversity (1982)

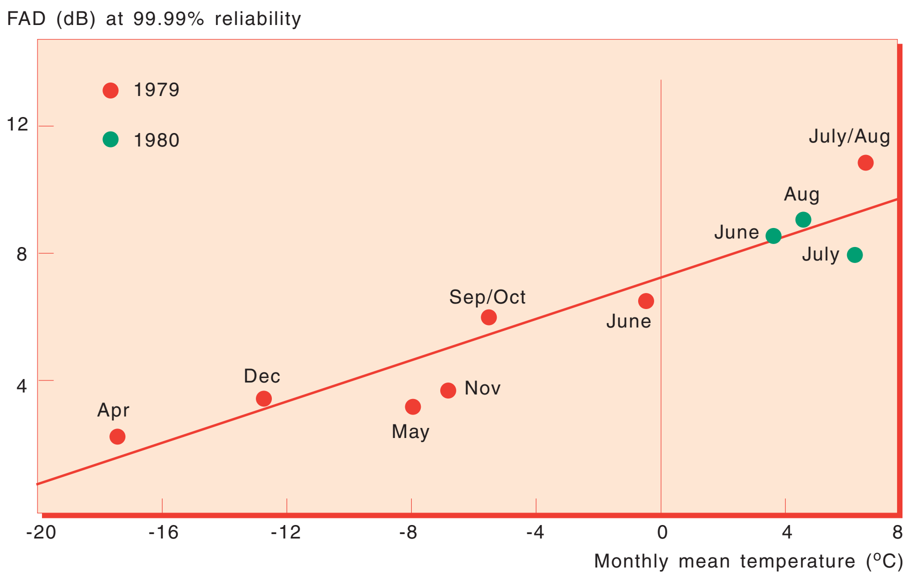


Figure 6 The fading level at 99.99% of time versus monthly mean ground temperature

perature for each month. There seems to exist a strong dependency between the scintillations, at a certain reliability level, and the monthly mean ground temperature (or N_0). To a certain extent, we are therefore able to predict the fading level, knowing the mean ground temperature.

The received signal will consist of a direct one plus a scattered signal due to turbulence activity. If we assume that the scattered field consists of several components with random amplitude and phase, then the resulting signal distribution could be described by a Rice-distribution, i.e. a constant vector plus a Rayleigh distributed vector.

Rice-distributions with different values of *K*, where *K* is the ratio of power in the random component relative to the steady component, have been drawn in Figure 7 together with the monthly and "worst day" distributions. It is seen that the "worst day" distributions fit quite well a Rice-distribution with $K = -10$ dB. The monthly distributions, which is a sum of Rice-distributions with varying standard deviations, will generally not be a Rice-distribution. This is especially the case for large values of *K*, i.e. the summer months. If the scattered components, however, is small relative to the direct component, the distribution will be similar to a Normal-distribution. Therefore, the distributions for the winter months will closely follow Rice-distributions with small values of *K*. This supports the assumption that the received signal consists of one direct component and several scattered components, and that the fadings are not due to beam bending effects.

Looking at the corresponding recordings from the OTS receivers and the SODAR, one can see that the large peak-to-peak values of scintillations are clearly associated with the existence of temperature inversions at about 200 metres above sea level. During periods when no temperature inversions were detected, the scintillations were much smaller. Figure 8 shows an example of recordings from the SODAR, and the corresponding recording of the beacon signal. We can see two temperature layers above each other. When they disappear at approximately 1330 GMT, the signal variations drop from approx. 6 dB peak-to-peak, down to less than 1 dB peak-to-peak. Another example is shown in Figure 3, where a temperature inversion layer at 200 metres height existed from 0720 – 1220 on 27 July 1982.

3.2 Cross-polarisation due to sleet and snow in the path

Cross-polarisation measurements were only systematically done during the summer months of 1979 at Spitsbergen.

Figure 1 shows a recording of the co- and cross-polar signals on 25 July 1979 at Isfjord Radio. As seen, the scintillations of co- and cross-polar levels are equal. This is generally the case, and there is no degradation of the XPD. However, during overcast and sleet/ snow in the path, the XPD becomes worse. In Figure 9 is shown the cumulative distributions of the cross-polarisation discrimination. Also for the XPDs the summer months are the worst months.

The resulting distributions of attenuation and XPD for the period May– August 1979 have been calculated. Using these distributions, the XPD value corresponding to the co-polar value for the same probability level, has been plotted in Figure 10. It is seen that there seems to exist a statistical relationship between the attenuation *(ATT)* and cross-polarisation discrimination *(XPD)* due to sleet/snow in the path, given by the equi-probability equation:

$$XPD \text{ (dB)} = 27 - 8 \lg ATT \text{ (dB)}$$

3.3 Space diversity

For investigation of the space diversity improvement, two “mini”-OTS terminals were installed at Isfjord Radio in the summer of 1982, receiving the linear polarised telemetry beacon from OTS. One terminal was located at the radio-station (OTS-I) and the other (OTS-II) with a horizontal separation of 1,150 metres, see Figure 11. The vertical separation was approximately zero. The measuring period was from 14 July to 2 August 1982.

The acoustic sounder (SODAR) was put up under the beam of the OTS-II terminal, thus the acoustic radar and the earth station were “seeing” a common volume of the atmosphere.

Examples of the received satellite signals from the two stations are shown in Figures 3, 8, and 12. In Figure 12, where the paper speed is 4.5 cm/min, we can clearly see that the short time variations of the signals are uncorrelated. The sig-

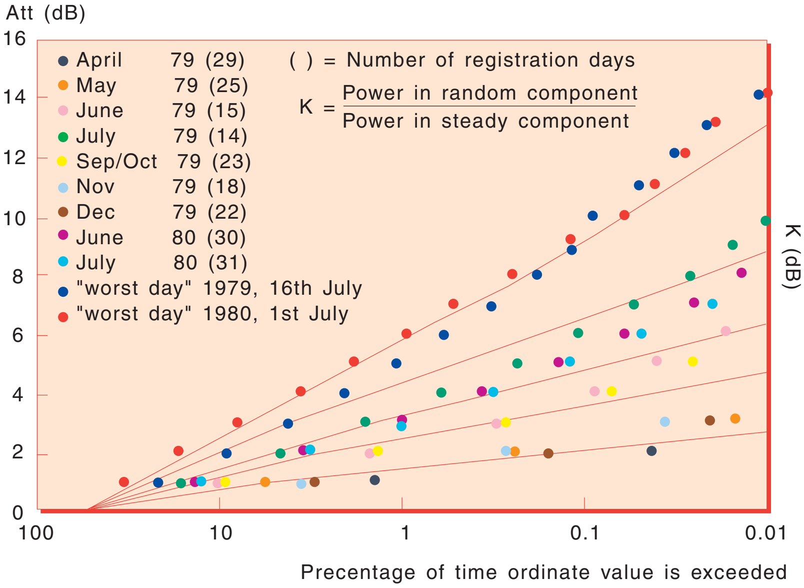


Figure 7 Rice-distributions for different values of K. Measured distributions are plotted

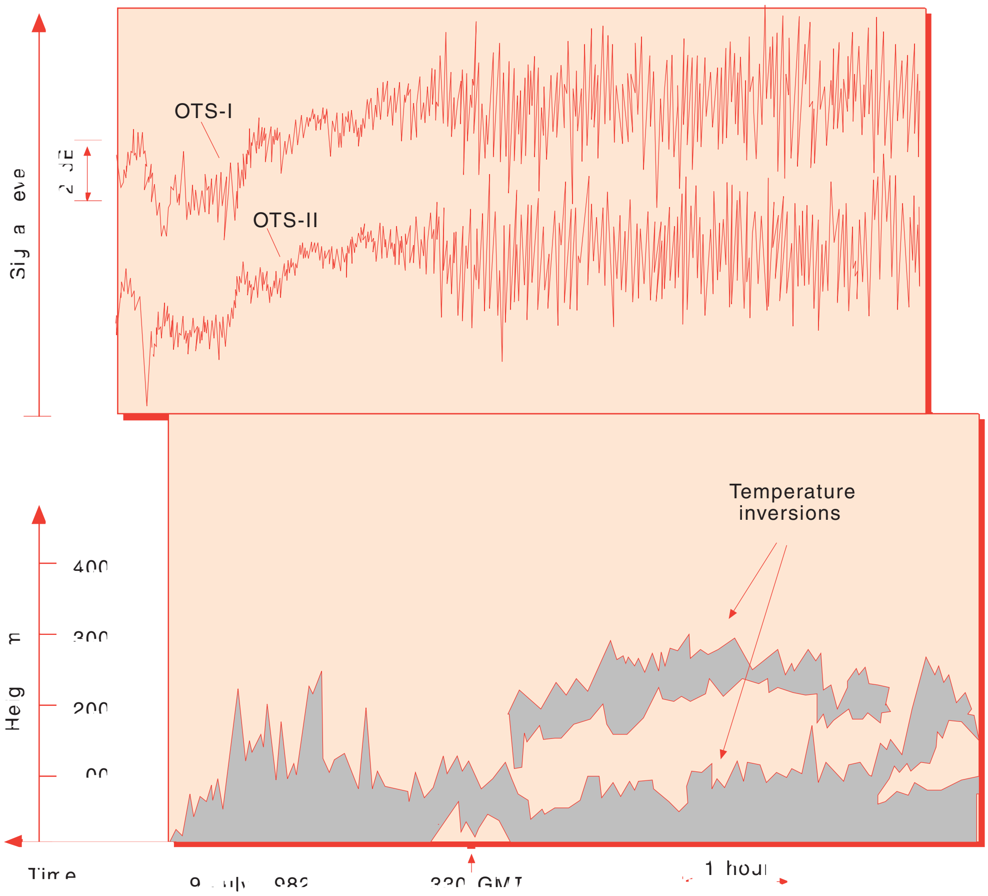


Figure 8 Recordings of the signal levels from OTS-I and OTS-II and corresponding SODAR registration. Isfjord Radio, 19 July 1982

nals were also recorded digitally on magnetic tapes, and cumulative distributions of the signal levels, both for each station and for the site diversity system were calculated. The 87-hour period shown in Figure 3 is representative for the whole measuring period. The cumulative distributions for this period is shown in Figure 13.

The single site distributions (OTS-I and II) are almost identical, as the scintillations are random by nature, whereas a substantial site diversity improvement is achieved. For example at a 3 dB fading level, the single site reliability is 99%, and the site diversity reliability is 99.92%.

The distributions for the total measuring period (17 July – 2 August 1982) is shown, together with the other distributions, in Figure 5. Since the distributions for OTS-I and II are almost identical, only one single site distribution is plotted. Again it is seen that at a 3.2 dB fading level the availability improves from 99% to 99.9%, due to site diversity.

3.4 Wide-band transmission

As previously mentioned, little knowledge exists of the characteristics of selective fading at very low elevation angle. Comprehensive measurements of selective fading could be done by using multi- or swept frequency techniques. However, due to the limited time for planning and performing such experiments, it was decided to perform a direct experiment, involving the reception of a wide-band signal (FM-modulated TV signal) at Isfjord Radio. As previously shown, the most severe fading is confined to the Arctic summer months. Accordingly, this experiment was conducted during July 1982.

The transmit station was Goonhilly Downs in England. A frequency modulated TV signal (PAL) saturated one of the wide-band transponders of OTS to give a receive frequency of 11.6 GHz. The frequency deviation used was 13.5 MHz/V and receive filter bandwidth was 27 MHz. The link budget is given in Table 2.

Due to the signal scintillations, the received C/N-ratio had large fluctuations. On 20 July 1982 the following values were measured between 2110 and 2225 GMT:

C/N_{max} = 12.3 dB

C/N_{min} = 8.7 dB

The TV transmissions took place 13–23 July, approximately 3 hours per day, containing colour bars, pulse and bar and video film sequences. Two hours were recorded on video tape. The picture quality was judged to be fair (Q = 3), and from observations of the colour bar spectrum, there seemed to be no severe selective fading during the experimental period.

4 Conclusions

In polar areas with low elevation angle (< 5°) the predominant type of fading is scintillation. The fading seems to be caused by a combination of scattering and reflections from turbulent air masses. Deep fadings are, however, associated with temperature inversions in the atmosphere. The monthly distributions of the scintillations can be approximated by Rice-distributions with average values of the power ratio of the random component

Table 2 Link budget, OTS-Spitsbergen

Transmit station:	Goonhilly Downs, England
Receive station:	Isfjord Radio, Spitsbergen
Frequencies up/down:	14262.5/11600.0 MHz
Satellite:	OTS, 5°E
Transponder:	Channel 4 bar (saturated), gain step 7
Modulation:	FM, frequency deviation 13.5 MHz/V, energy dispersal 1.2 MHz peak-peak

EIRP (sat)	47.5	dBW	(1)
Aspect angle loss	6.8	dB	(2)
Down path loss	206.1	dB	
Atmospheric absorption	1.0	dB	(3)
Earth station G/T	24.0	dB	(4)
Pointing loss	0.1	dB	
Up-link noise	0.2	dB	
Total link C/T	-142.7	dBW/K	
Receiver BW (27 MHz)	74.3	dBHz	
C/N at receiver	11.6	dB	

Notes:

(1) Beam centre EIRP; OTS report on in-orbit measurements vol 1; p255 and 219.

(2) With OTS at 5°E, re-orientated in pitch bias by 0.4°, ref Interim EUTELSAT, private correspondence.

(3) Calculated using equivalent height of oxygen 6 km and water vapour 1.5 km, ref CCIR report 719, Geneva 1982.

(4) Measured value, assuming an antenna noise temperature (clear sky) of 100°K and an antenna gain of 49 dB.

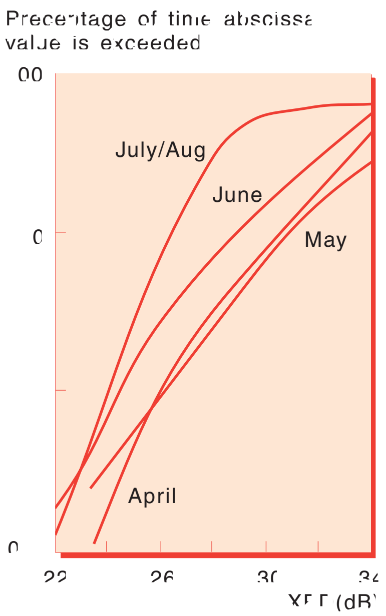


Figure 9 Cumulative distributions of cross-polarisation discrimination, 1979

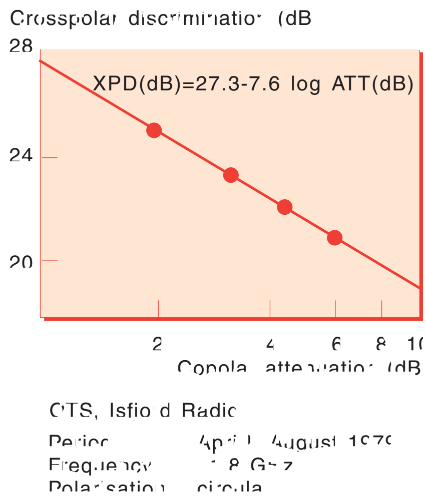


Figure 10 Statistical relationship between attenuation and cross-polar discrimination

to the steady component of -20 dB, -13 dB and -10 dB for the best month, worst month, and worst day, respectively.

At very low elevation angle, large improvement by using space diversity can be obtained. With a horizontal separation of the two stations of approximately 1 km, the availability is increased from 99% to 99.9% at a 3 dB fading level.

In areas with little rain, as the polar areas, cross-polarisation due to sleet and snow in the path may be the most dominant effect. In the measurements at Spitsbergen, a statistical relationship (equi-probability equation) between attenuation (ATT) and cross-polarisation (XPD) were found.

$$XPD \text{ (dB)} = 27 - 8 \, lg \, ATT \text{ (dB)}$$

Selective fading over 27 MHz bandwidth was not observed at Spitsbergen, and reception of frequency modulated satellite TV signals down to elevation angles of at least 3° is possible with good quality.

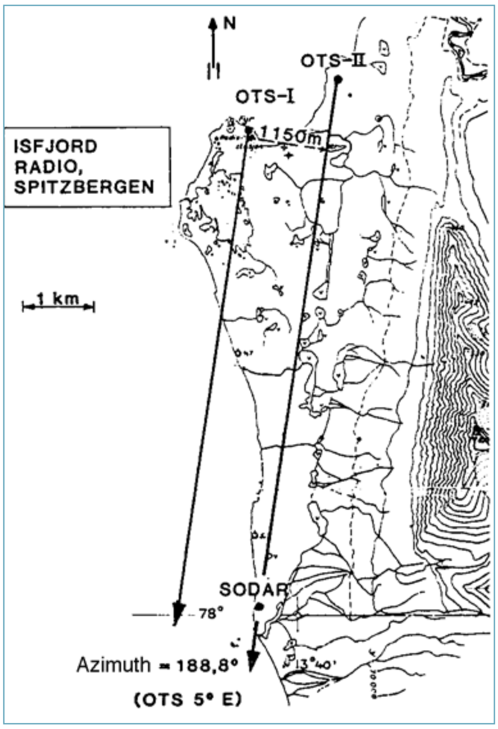


Figure 11 Geometry of the space diversity experiment at Isfjord Radio, 1982 (OTS 5°E). Both stations' heights above sea level: 7 metres

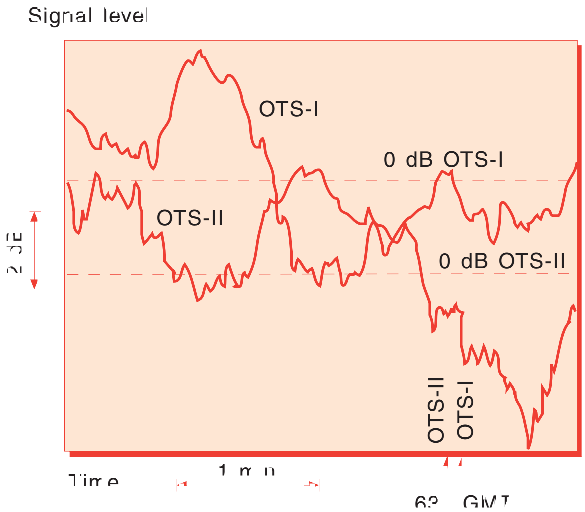


Figure 12 Registration of the linear polarised beacon from OTS. Space diversity experiment, Isfjord Radio, 14 July 1982

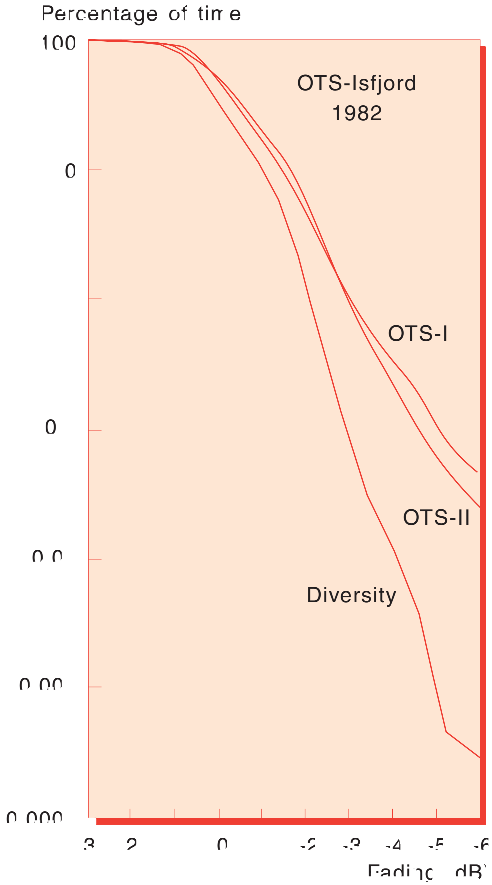


Figure 13 Cumulative distributions of scintillations for single sites (OTS-I and OTS-II) and the diversity system.
Period: 25–28 July 1982 (5265 mins)
Time-plot for the same period is shown inFigure 3

5 Acknowledgements

The author expresses his sincere appreciation to M Osmundsen for valuable assistance with all parts of the experimental work; to the staff at Isfjord Radio and Goonhilly Downs for excellent co-operation, and to the National Meteorological Institute for supplying the meteorological data. Thanks also to T Tjelta, N Åtland and T Heggelund for assistance with analyzing the site diversity data.

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NORSAT – Isfjord – a satellite station in the wilderness

BY MARTIN JARL LODE AND JOHN R VEASTAD

This article was first published in *Telektronikk* in 1981. The reprint gives a short historic back-view of a technology that has become the most important in long distance telecommunications throughout the world.

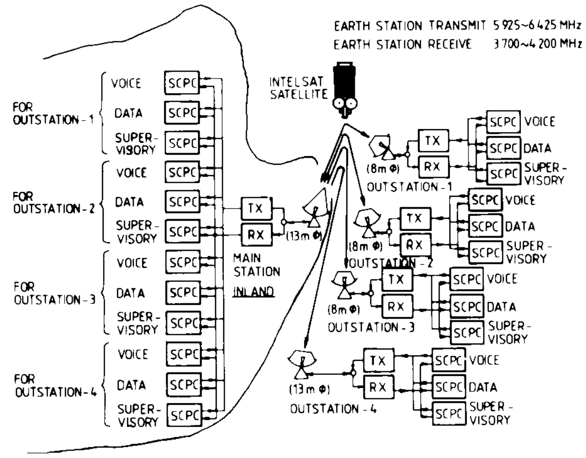

Figure 1 Block diagram of the NORSAT system

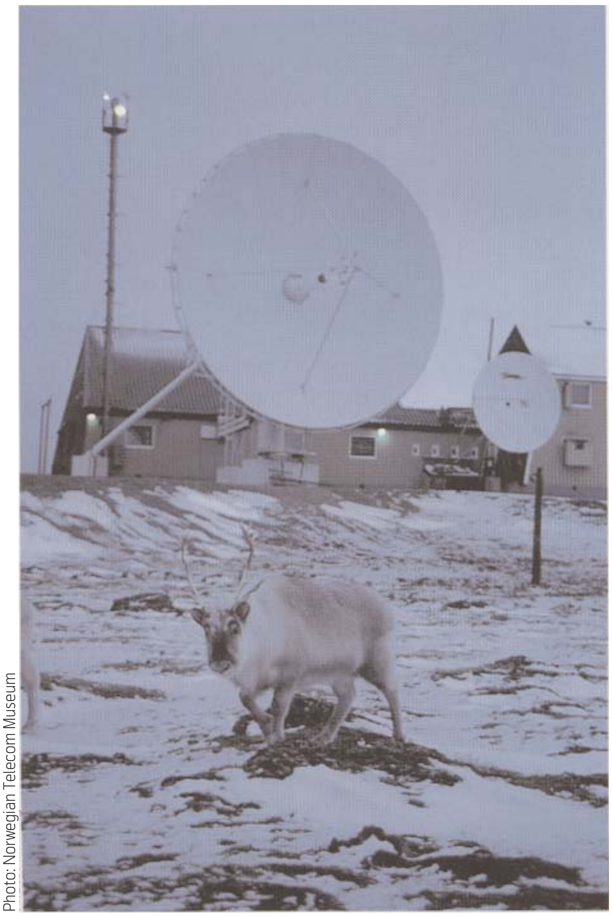

Photo: Norwegian Telecom Museum

Figure 2 Isfjord Radio

1 Introduction

Norwegian Telecom today operates an earth station at Isfjord Radio at Svalbard (Spitsbergen). The earth station is a part of the NORSAT system. This article is an explanation to the background for the satellite station and how it was built.

2 The NORSAT system

When the oil companies drilling in the North Sea started to establish production platforms it became clear that conventional radio connections could not cover their communication needs. The platforms would need telephone, telex, telefax and transfer of data. They would also require a high level of reliability – 99.9 % or better. As distances could vary between 150 and 600 kilometres there were only two possible alternatives that could meet their requirements:

- troposcatter
- satellite system.

Norwegian Telecom chose a satellite system. In the long run this would be the least costly alternative, it is adaptable and there was a recognition of the possibilities for connecting Svalbard to the automatic telephone network in mainland Norway. This was in 1974.

NORSAT employs half a transponder in one of INTELSAT's satellites. Norwegian Telecom leases the half transponder on a "preemptible basis", i.e. INTELSAT may shift NORSAT's allotted space around as INTELSAT's primary services need satellite capacity. The main station in the system is at Eik in Rogaland. The system employs delta modulation of the speech signals, so that necessary capacity for a telephone channel is 32 kbit/s. The digital information then modulates the phase to a carrier, 2-PSK. Each channel has its own carrier, i.e. SCPC (Single Channel Per Carrier), and the carrier is switched on only when speech takes place – speech activation. The effect of the NORSAT system is limited, with a capacity of 130–150 telephone channels (two-way). At present, 38 two-way telephone channels are in use.

Operation statistics so far have shown that the earth stations in the satellite system have a mean accessibility of

- Eik 99.96 %
- Ekofisk 99.89 %
- Frigg 99.56 %
- Statfjord 98.91 %.

We note that the remote stations have a relatively low accessibility. In many cases, interruptions in accessibility have been caused by conditions related to the drilling operation. On some occasions, drilling mud has got into the antenna so that it had to be cleaned.

3 Telecommunications with Svalbard

The archipelago of Svalbard obtained telecommunication connections with Norway in 1911 when Spitsbergen Radio at Green Harbour dispatched their first telegram to the mainland. In 1930 the station was moved to Longyearbyen, and Isfjord Radio was built in 1933.

Public telephone traffic was opened in the spring of 1949. The connection has previously been based on short-wave communication. The transmitter and receiver plant at Svalbard has been located at Longyearbyen and, since 1975, also at Isfjord Radio at Kapp Linne. From 1975 the capacity has comprised:

- 3 telephone connections
- 4 telex channels.

Longyearbyen has some 1,000 inhabitants and the local telephone network, which is owned and run by Store Norske Spitsbergen Kulkompani AS, has approximately 450 subscriber lines. Trunk traffic between Svalbard and the mainland has been operator handled.

Telecommunications between Svalbard and the mainland can be said to have been unsatisfactory. Svalbard is so far north that radio signals have to travel through the so-called northern light belt. This produces disturbances in the distribution conditions for the signals, so that long break-downs may occur. Even if Norwegian Telecom constantly have improved the technical equipment for short-wave communications, the quality cannot be improved beyond certain limits. These limits are given by nature, and are determined by the location of the archipelago and ionospheric conditions, among other things. As a consequence of these disturbances the short-wave connections cut out for 10 % of the time. In the worst cases these "cut-outs" may last for several days. The result used to be hour-long waits, either because of overload, or because of poor radio connections.

While a similar mining community in Norway, Sulitjelma, in the 1970s had 20 reliable connections to the national telephone network, the Svalbard community had three connections of varying quality at their disposal. The fact that this did not lead to strong reactions had several reasons. In the years 1911–1949 the only form of communication was by telegram. When the telephone connection was opened in 1949 it was seen as a tremendous step forward. The effort and will of the telecom personnel to utilize the connection in the best possible way may also have contributed, most important, though, was the fact that the customers themselves had a down-to-earth attitude and great understanding for the limited possibilities available. In 1975 this attitude changed. Much of the reason for this was the knowledge that permanent connections of good quality could be established via NORSAT. Store Norske Spitsbergen Kulkompani had for years urged Norwegian Telecom to provide modern communications. So had the fishing fleet, as fishing activities around Svalbard were increased in the 1970s and thereby the needs for communication with the mainland. In 1975 an airport was built which required access to the telephone network on the mainland and permanent direct connections to other locations in the air traffic service. On the basis of this, Norwegian Telecom assumed that there was a need for a radical increase in the number of connections to Svalbard. There were three alternatives:

I Troposcatter with an intermediate station on Bear Island

II Increase the number of short-wave connections

III Establish connection via NORSAT.

For economic and operational reasons the troposcatter alternative was abandoned quite early on, and a comparison between the two remaining alternatives showed that handling the traffic with the help of short-wave communication offered a far poorer solution because it was quite costly, waiting would be longer, and the degree of service would be lower. The short-wave connections have poorer speech quality and reliability. Because of the very few available frequencies the possibilities for capacity expansion are very limited. Last, but not least, the telephone and telex services cannot be automated with the mainland.

4 Problems connected to building an earth station at Svalbard

Even if the satellite alternative was the most favourable, a few problems were foreseen in connection with building an earth station at Svalbard.

Isfjord is located at 78° 04' N and 13° 38' E. This implies that the antenna at best has an elevation angle of 3° towards a geostationary satellite. Because of the location of satellites the station ought to be able to operate with an elevation angle as low as 1°. Geostationary satellites are normally not employed for elevation angles smaller than 5°. Consequently, there was little documentation available on the expected distribution conditions. The signals from the satellite have a long distribution path through the atmosphere and are exposed to atmospheric attenuation, refraction and fading. These were conditions that had to be quantified.

In the summer of 1974 Norwegian Telecom demonstrated that it was possible to use satellite connection for telephony. This was achieved by establishing a connection between Tanum and Svalbard with the help of a small, mobile earth station at Isfjord. Measurements were carried out at this station for two consecutive summers – 1974 and 1975. In 1975 the distribution measurements were expanded and Norwegian Telecom erected an experimental station with an antenna 4.5 metres in diameter. These measurements, which were then started in 1975, lasted until April 1980. Tracking signals from the Symphonie satellite and from one of the INTELSAT satellites were used. In this way, two elevation angles were measured: 3° and 1.7°.

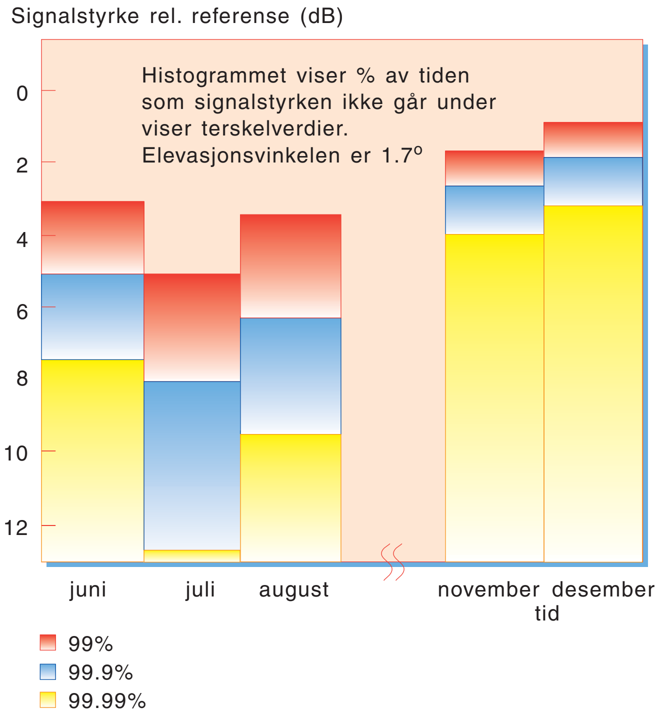

Figure 3 Diagram of the fading conditions at Isfjord during a time span of five months

At an elevation of 1.7° the atmosphere causes a refraction giving a directional error less than 0.03°. At elevation angles larger than 1° the deflection is approximate to a linear function of the refraction index measured on the ground. The refraction index is dependent on meteorological parameters, e.g. temperature. As it is fairly cold at Isfjord, sufficient direction accuracy can be achieved by letting a basic microcomputer steer the direction of the antenna. Antenna steering at Isfjord will take place according to:

- manual steering
- program steering
- step track (at times this is unsuitable because of fading).

The atmospheric attenuation is also very dependent on temperature. On the basis of temperature measurements carried out at Isfjord, atmospheric attenuation was estimated at approx. 1.5 dB at 1° elevation. The biggest obstacle was assumed to be the fading conditions. As a consequence of temperature and dampness fluctuating considerably within small volumes of the atmosphere, the signal is

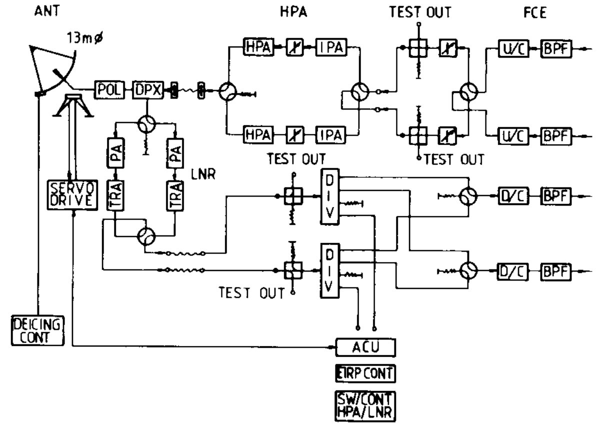

Figure 4 Block diagram of the radio frequency equipment at Isfjord

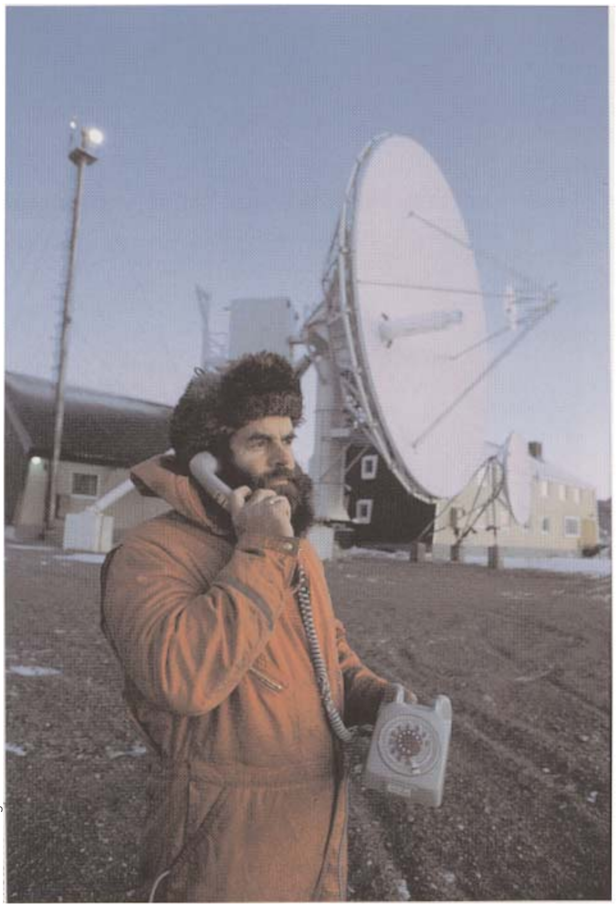

Photo: Norwegian Telecom Museum

Figure 5 The earth station antennas at Isfjord

deflected, scattered and reflected. The signal that reaches the antenna will consist of the direct and the scattered signal. Depending on phase and amplitude conditions of the scattered signal, rapid variations in the received signal level may arise. Fading conditions are, as expected, worst during the summer months. The collected volumes of data are being studied, but there has been an early indication that it was possible to obtain 99 % accessibility on the down-link with a fading margin of approx. 4 dB at 1.7° elevation.

Up-link fading is another problem – it may be solved by varying the effect from the antenna in relation to fading: up-link effect control.

Access to Isfjord Radio is by boat in the summer and by snow scooter in the winter. Helicopter may be used all the year round, weather permitting. This may cause problems for the operation of the earth station. It is for example difficult to transport large objects. Operational staff are recruited among technical engineers in Norwegian Telecom. Normal time of employment is one or two years, but a third year may be applied for. Because of the relatively short employment period it is difficult and expensive to give the engineers special training in the operation of the earth station; it is even unrealistic because all other types of equipment need to be maintained as well. It has therefore become necessary to make specific considerations for the reliability of the equipment.

5 The earth station at Isfjord

Based on the tests, Norwegian Telecom entered in May 1978 into a contract with Elektrisk Bureau, division NERA, on the building of an earth station at Svalbard. On July 1, 1979, the equipment arrived at Isfjord Radio and the earth station was completed by December 1 the same year.

A Cassegrain antenna with a diameter of 13 metres is employed, on a foundation anchored to the permafrost. The low noise amplifiers are uncooled, parametric amplifiers and have a noise temperature less than 45 K. Considering Norwegian Telecom's reliability requirements, two amplifiers are mounted in parallel, one of them serving as a warm reserve. Low noise amplifiers are usually mounted directly on the antenna. This is done in order to minimize the noise contribution from the feeder cable, i.e. one tries to minimize the length of the wave conductor from the antenna to the amplifiers. With the weather conditions expected at Isfjord, it would have been very difficult to carry out maintenance on the amplifiers if they were mounted in the antenna. The decision was therefore made to mount them in a cabin some distance from the antenna.

The station has a quality factor, G/T, better than 32.7 dB/K at 4 GHz and 10° elevation. At 1.7° elevation G/T = 31.5 dB/K at 4 GHz.

The rest of the equipment has been housed in a new extension to the station building. The transmitter consists of redundant klystron tube amplifiers with an output effect of 1.5 kW. The frequency converter equipment is also redundant and employs double converting. Isfjord has the same channel equipment as the other remote stations, i.e. the oil production installations.

This is decided by the modulation method in the NORSAT system, and so far, only Fujitsu can deliver this equipment (July 1980).

A high degree of reliability will most of all demand reliable power supplies. At Isfjord power has to be generated on the spot. Because of the difficult access, diesel may only be bunkered for short periods of the year; a large diesel tank is therefore necessary. The tank at Isfjord is 400 m^3.

The station is powered by a 200 kVA diesel generator. De-icing of the antenna also requires a generator, and there is another joint reserve generator. So altogether there are three similar diesel generators.

The power is connected via an inverter device which provides non-stop power, with a stand-by battery producing power should the generators cut out. The power supply is probably the most sensitive system component at Isfjord.

6 Telecommunication services via satellite to Svalbard

The satellite connection with Svalbard was opened by Prime Minister Nordli on December 19, 1979, and the station has since been open for public traffic. Telephone traffic to Svalbard operates at present over 8 connections. 5 of these are connected to Gjøvik trunk exchange. The remaining three are connected to the trunk exchange in Oslo. Operator trunk calls are available to the staff at Svalbard Radio, and telephone traffic *from* Svalbard is handled this way. Traffic *to* Svalbard is manually set up via Oslo trunk exchange. During the first four months of 1980, 18,299 calls were handled from Svalbard – this may be compared to the 7,400 calls handled in the same period in 1978 over the short-wave connections, i.e. an increase of some 250 %.

The earth station has suffered from some "teething trouble", yet its accessibility has reached 99.58 %. There are also spare radio connections should the earth station cut out. We may therefore conclude that telecommunications with Svalbard are very reliable. Test operation of a small number of telephone channels via the experimental station was started in December 1978. Traffic handling in the period from December 1978 up till now has shown that fading conditions are under control.

The earth station has given Norwegian Telecom the possibility to connect Svalbard to the automatic telecommunications network on the mainland. The telex service is planned to be automated by September 1980. The telex lines will be connected to Oslo Telex III (new exchange). The telephone service will be automated when Longyearbyen gets its new automatic exchange in 1981.

The transmission of radio programmes from the mainland to Svalbard via satellite has for some time been considered. Norwegian Telecom has run a test operation in a telephone channel and thereby confirmed that it is possible. The transmitted programme has not had a satisfactory quality during the test operation; music has particularly suffered. Norwegian Telecom are now working on an offer to the Norwegian Broadcasting Corporation of permanent transmission of radio programmes. Contained in the offer is a plan to increase bandwidth in order to improve the quality. The leased satellite capacity is large enough to handle this. The case is somewhat different regarding transmission of television programmes. In order to do that, more capacity in the satellite will have to be leased. With the lease of an additional half a transponder, preliminary estimates show that the fading margin will be negligible. However, Norwegian Telecom aim to carry out tests in order to ascertain whether it is technically feasible to transmit television to Svalbard. A possible transmission may be costly: INTELSAT are asking for NOK 2.5 mill per year per half transponder. A broadband link between Isfjord and Longyearbyen would also be necessary.

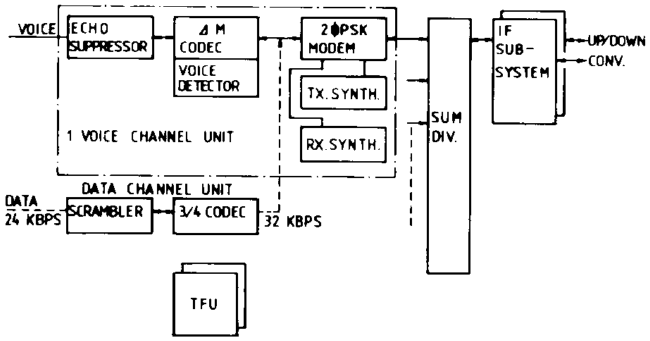

Figure 6 Block diagram of a channel unit in the NORSAT system

Photo: Norwegian Telecom Museum

Figure 7 Isfjord Radio seen from the south-west. The earth station equipment is placed in the building on the left. The diesel tank can also be seen

Svalbard still does not have the same offer of telecommunication services as the mainland, but a leap forward has been taken to achieve it.

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John R Veastad is a Consultant working for the Satellites unit of Norwegian Telecom.
Martin Jarl Lode is an Engineer who, when this article was first published, was working in the Technical Department of Norwegian Telecom.

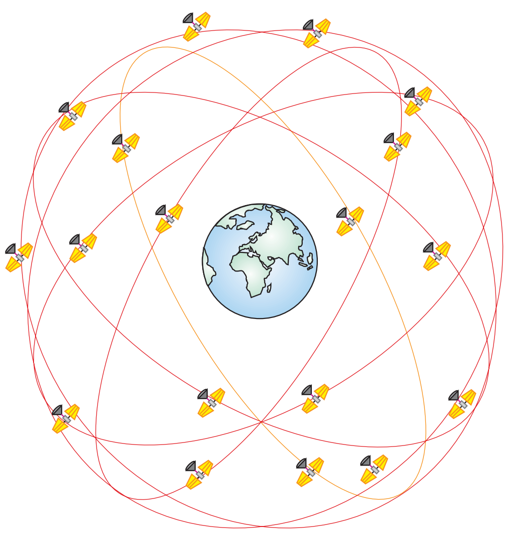
Satellite navigation and positioning

BY INGAR SKJØNHAUG

The satellite based Global Positioning System NAVSTAR, developed by the Department of Defense in the USA and the Norwegian implementation project SATREF are described. Availability and accuracy of positioning depend on national data processing and broadcasting of reference (correction) data. The Geodetic Institute, a part of the Norwegian Mapping Authority, in co-operation with Norwegian Telecom, are designing a complete national network for GPS. This includes a reference station at Spitsbergen, offering research and commercial positioning facilities.

Description of NAVSTAR GPS

NAVigation System with Timing And Ranging (NAVSTAR) Global Positioning System (GPS) is a satellite based navigation and positioning system developed on behalf of the US Department of Defense (DoD). The system is expected to be operative by the end of 1993 with a constellation of 21 operative satellites plus three active ones in reserve, distributed in six different orbits. There will be four satellites in each orbit with an inclination angle in relation to the equatorial plane of 55 degrees (Figure 1).



- 21 satellites, plus 3 active spares
- 6 orbit planes
- 12 hour period
- 20 000 km height
- full coverage (24 hours per day everywhere in the world)

Figure 1 GPS constellation in 1993

For civilian use the system will have an accuracy of approximately plus/ minus 100 metres in the *x*, *y* plane and 150 metres in altitude for kinematic use. For stationary geodetic applications (static use) it is feasible by way of various post-processing techniques to achieve an accuracy in the millimetre level. The satellite constellation enables the system to have a global coverage 24 hours a day with four to eight observable satellites simultaneously, with an elevation angle of >15 degrees over the horizon. NAVSTAR GPS may be used for navigation at sea, on land, and in the air in addition to positioning offshore and onshore.

NAVSTAR GPS may be divided into three segments:

- Space segment
- Control segment
- User segment.

The space segment

The space segment consists of a satellite constellation as mentioned in the introduction. The satellites orbit approx. 20,200 km above the earth and has an orbital speed of approx. 12 “sidereal hours” (star time). In relation to Universal Time (UT) this means that the satellites (in a given geometric position) will be in the same position four minutes later each day.

There are three classes or types of GPS satellites. These are Block I, Block II, and Block IIR satellites. Eleven Block I satellites with a specific weight of 845 kg were launched in the period 1978 to 1985. The life span for the Block I satellites was estimated at approx. 4.5 years, but some of these satellites have proved to have a much longer life span. Three Block I satellites are actually operative today (SV9/ PRN13, SV10/PRN12 and SV11/ PRN03). All satellites have their own unique PRN (PseudoRandom Noise) code in addition to an SV (Space Vehicle) number, and the oldest of these satellites was launched in June 1984. The Block I constellation is different from Block II, as the orbital plane is 63 degrees in relation to the equatorial plane, while the Block II constellation has an inclination of 55 degrees.

28 Block II satellites have been designed and produced for the first official operational constellation. Of this total, 24 will be launched (21 will be active, while three will be reserve). The Block II satellites have an estimated life span of approx. 7.5 years and a specific weight of some 1,500 kg. Price: approx. NOK 3 mill. each. It is worth noting that while the signals from Block I satellites were fully accessible to civilian users, the signals from Block II satellites are “classified” (signals may without further notice be encrypted). (General GPS constellation status from GPS-INFO BULLETIN 06/93, Geodesic division of Norwegian Mapping Authority is shown in Figure 2.)

Block II satellites will gradually be replaced by Block IIR satellites (R stands for Replacement) with an estimated life span of some 10 years. The development of these satellites is still going on and is estimated to be completed in 1995. The specific weight of these satellites will be approx. 2,000 kg, but the price is thought to be half of what Block II satellites cost. While Block II satellites have two rubidium and two cesium clocks on board (stability of 10^{-13} in one day), Block IIR satellites will have four hydrogen clocks with considerably greater accuracy (stability of 10^{-15} in one day). The clocks make up “the heart” of the satellite, as they produce the L-band frequency of 10.23 MHz (f_0), which is fundamental in the GPS signals (Figure 3).

The signals from the GPS satellites are based on the spread spectrum technique which ensures a higher communication safety (the signal is distributed over a larger bandwidth than necessary). The GPS signals consist of two components, Link 1 ($L1$) with a centre frequency of 1575.42 MHz (154 f_0) and Link 2 ($L2$) with a centre frequency of 1227.60 MHz (120 f_0). Both $L1$ and $L2$ are modulated with a P-code (Precision code) which is equal to f0, while $L1$ is also modulated with a C/A-code (Coarse/ Acquisition code), which is a tenth of f_0. The modulated signals are equated as follows:

$$L_1(t) = a_1 P(t)\, D(t) \cos(f_1 t) + a_1\, C/A(t)\, D(t) \sin(ft)$$

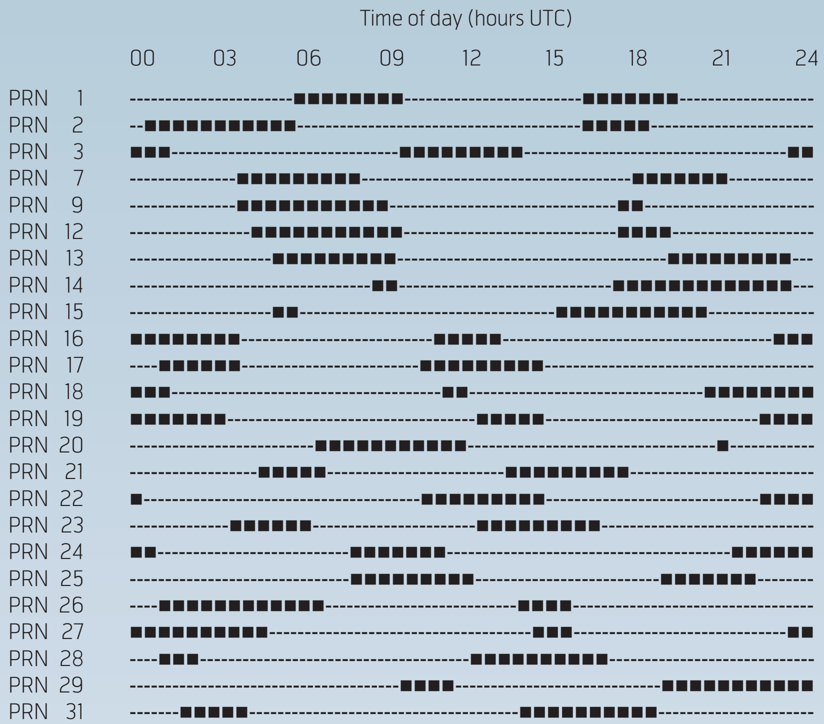
$$L_2(t) = a_2\, P(t)\, D(t) \cos(f_2 t)$$

Various types of satellite data or messages are sent. The messages contain data on things like clock correction, orbit parameters, PRN number, the “general health” of the satellite, GPS time, etc.

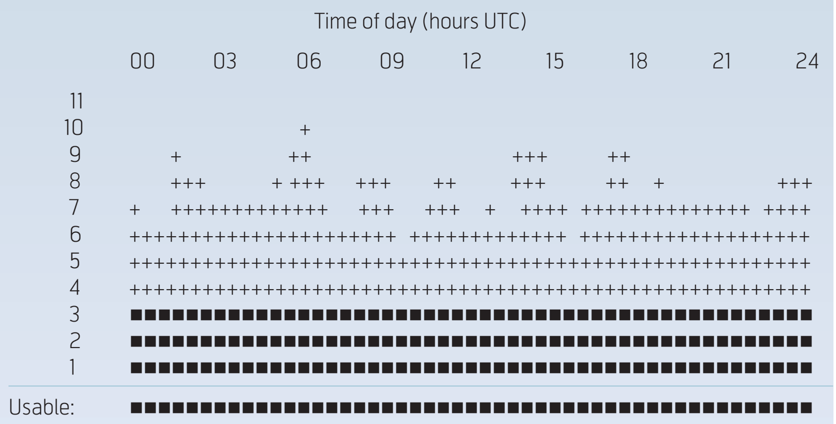
There are mainly two methods of preventing civilian users gaining full access to the GPS system by encryption of signals: Selective Availability (SA) and Antispoofing (A-S). The SA method means that the clock frequency (dithering) of the satellites are regulated from a master control unit, in such a way that publicly available accuracy decreases. The second method (A-S) to prevent full access to the GPS signals, is by encrypting the P-code with a Y-code. This ensures that only C/A code receivers may be used.

Global Positioning System satellites availability chart

Availability for Friday July 9, 1993 (MJD 49177)
Latitude: 60.00 deg, Longitude: 10.00 deg, Height: 0 m
Analysis interval every 30 minutes
Acceptable DOF less than 6
Mask angle 10.00 deg
24 transmitters (24 SVs) plus altitude aiding available



Number of satellites available



n: Required minimum number of satellites available
+: More than enough satellites available

Figure 2 a)

Control segment

The control segment is an operational control system consisting of a Master Control unit situated at Colorado Springs, USA. In addition to the main control station there are five monitoring stations all over the globe, receiving signals from all visible satellites. Slave control stations (basically a transmission system with antenna) is situated near to the monitoring stations and make up the transmission link to the satellites. By knowing the position of the monitoring

PRN No.	SVN No.	NORAD No.	COSPAR No.	Remarks
04	01	10684	1978 020A	No longer active
06	03	11054	1978 093A	No longer active
07	02	10893	1978 047A	No longer active
08	04	11141	1978 112A	No longer active
05	05	11690	1980 011A	No longer active
09	06	11783	0980 032A	No longer active
11	08	14189	1983 072A	No longer active
13	09	15039	1984 059A	
12	10	15271	1984 097A	
03	11	16129	1985 093A	
14	14	19802	1989 013A	
02	13	20061	1989 044A	
16	16	20185	1989 064A	
19	19	20302	1989 085A	
17	17	20361	1989 097A	
18	18	20452	1990 008A	
20	20	20533	1990 025A	
21	21	20724	1990 068A	
15	15	20830	1990 088A	
23	23	20959	1990 103A	
24	24	21552	1991 047A	
25	25	21890	1992 009A	
28	28	21930	1992 019A	
26	26	22014	1992 039A	
27	27	22108	1992 058A	
01	32	22231	1992 079A	
29	29	22275	1992 089A	
22	22	22446	1993 007A	
31	31	22581	1993 017A	
07	37	22657	1993 032A	
09	39	22700	1993 042A	

The satellite that would have been known as NAVSTAR 7 failed to achieve orbit. The satellite that will be known as NAVSTAR 12 will be used as an experimental platform and not part of the GPS constellation.

Figure 2 b)

Figure 2 a), b) and c) General GPS constellation status (from GPS-INFO BULLETIN 06/93)

stations it is possible to estimate errors in measuring the distance to the satellites. This information is used by the Master Control station, where errors in ephemerides (satellite orbit data) and the satellite clocks are estimated. The slave stations then receive the corrections and transfer this information to the GPS satellites via an S-band radio link once daily (Figure 4).

User segment

There are two main groups of users: military and civilian. The development of NAVSTAR GPS was originally related to the US Department of Defense programme for a national defence plan. All military aircraft, ships, ground vehicles, and groups of infantry were to be equipped with GPS receivers in order to co-ordinate military activities. Part of this strategy was actually put into operation during the Gulf War in 1991. SA, which up till then had been activated, was switched off so that "ordinary" civilian hand receivers could be used in the desert regions. The reason for this was the fact that at that point there were not enough military receivers available.

The GPS receiver is passive and must receive signals from at least four satellites simultaneously. The receiver is equipped with a program carrying out the necessary calculations. By multiplying the time delay (from the signals are transmitted from the satellites until they are received) by the speed of light *(c)*, we have the distance measurements to the satellites (R_i). The position of the receiver may then be found by using the known positions of the satellites. The following navigation equation can be done,

$$(x_i - u_x)^2 + (y_i - u_y)^2 + (z_i - u_z)^2 = (R_i - cb)^2 \qquad i = 1,2,3,4$$

where x_i, y_i, and z_i are the positions of four satellites. These positions are transferred from the satellites in the navigation message and may be regarded as known quantities. u_x, u_y, and u_z are the unknown quantities in the position of the receiver.

Up-to-date GPS receivers tend to use a crystal clock which is set approximately to GPS time. The clock in the receiver will therefore have an offset from the GPS time in the satellite, and because of this the distance to the satellite will be longer or shorter than the "real" distance. This distance to the satellite is called pseudo-range *(R)* and consists of a "real" distance plus/ minus an extra distance *(b)*

General status for GPS constellation

The general status of the Navstar GPS constellation as at 30 June 1993 is as follows. Note that all mention of future launches has been removed from this table, since current information is unclear.

Satellite No.			Launched	Plan	Clock	Status
SVN01	BLK.I-10	PRN04	22.02.1978			Withdrawn
SVN02	BLK.I-02	PRN07	13.05.1978			Withdrawn
SVN03	BLK.I-03	PRN06	06.10.1992			Withdrawn
SVN04	BLK.I-04	PRN08	10.12.1978			Withdrawn
SVN05	BLK.I-05	PRN05	09.02.1980			Withdrawn
SVN06	BLK.I-06	PRN09	26.04.1980			Withdrawn
SVN07	BLK.I-07	-	18.12.1980			Accident
SVN08	BLK.I-08	PRN11	14.07.1983			Withdrawn
SVN09	BLK.I-09	PRN13	13.06.1984	C1	Cesium	Operational
SVN10	BLK.I-10	PRN12	08.09.1984	A1	Rubidium	Operational
SVN11	BLK.I-11	PRN03	09.10.1985	C4	Rubidium	Operational
SVN13	BLK.II-02	PRN02	10.06.1989	B3	Cesium	Operational
SVN14	BLK.II-01	PRN14	14.02.1989	E1	Cesium	Operational
SVN15	BLK.II-09	PRN15	01.10.1990	D2	Cesium	Operational
SVN16	BLK.II-03	PRN16	18.08.1989	E3	Cesium	Operational
SVN17	BLK.II-05	PRN17	11.12.1989	D3	Cesium	Operational
SVN18	BLK.II-06	PRN18	24.01.1990	F3	Cesium	Operational
SVN19	BLK.II-04	PRN19	21.10.1989	A4	Cesium	Operational
SVN20	BLK.II-07	PRN20	24.03.1990	B2	Cesium	Operational
SVN21	BLK.II-08	PRN21	02.08.1990	E2	Cesium	Operational
SVN22	BLK.II-18	PRN22	03.02.1993	A2	Cesium	Operational
SVN23	BLK.II-10	PRN23	26.11.1990	E4	Cesium	Operational
SVN24	BLK.II-11	PRN24	04.07.1991	D1	Cesium	Operational
SVN25	BLK.II-12	PRN25	23.02.1992	A2	Rubidium	Operational
SVN26	BLK.II-14	PRN26	07.07.1992	F2	Cesium	Operational
SVN27	BLK.II-15	PRN27	09.09.1992	A3	Cesium	Operational
SVN28	BLK.II-13	PRN28	10.04.1992	C2	Cesium	Operational
SVN29	BLK.II-17	PRN29	18.12.1992	F4	Cesium	Operational
SVN32	BLK.II-16	PRN01	22.11.1992	F1	Cesium	Operational
SVN37	BLK.II-20	PRN07	13.05.1993	C4	Cesium	Operational
SVN39	BLK.II-21	PRN09	26.06.1993	A1	Cesium	-

Figure 2 c)

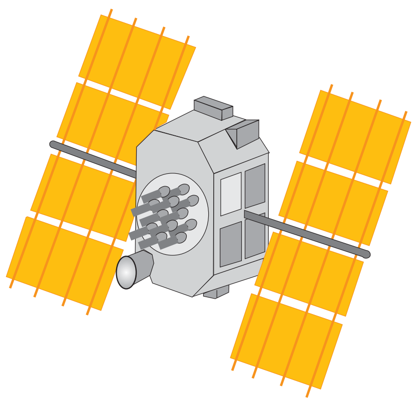


Figure 3 A GPS satellite

because of clock error in the receiver and bias as a consequence of atmospheric, stratospheric and ionospheric interference. Other errors may be integral interference in the receiver, orbital errors, errors in the satellite clocks which may eventually influence the navigation accuracy. Using differential GPS increases this accuracy considerably.

There are many different GPS receivers on the market today for civilian users, at an increasingly favourable price. GPS receivers may be divided into three groups: C/A code pseudorange, C/A code carrier phase, and P-code carrier phase. P-code receivers are the most accurate, and are reserved for military and authorised users, while C/A-code receivers, being less accurate, are used for civilian applications (Figure 5).

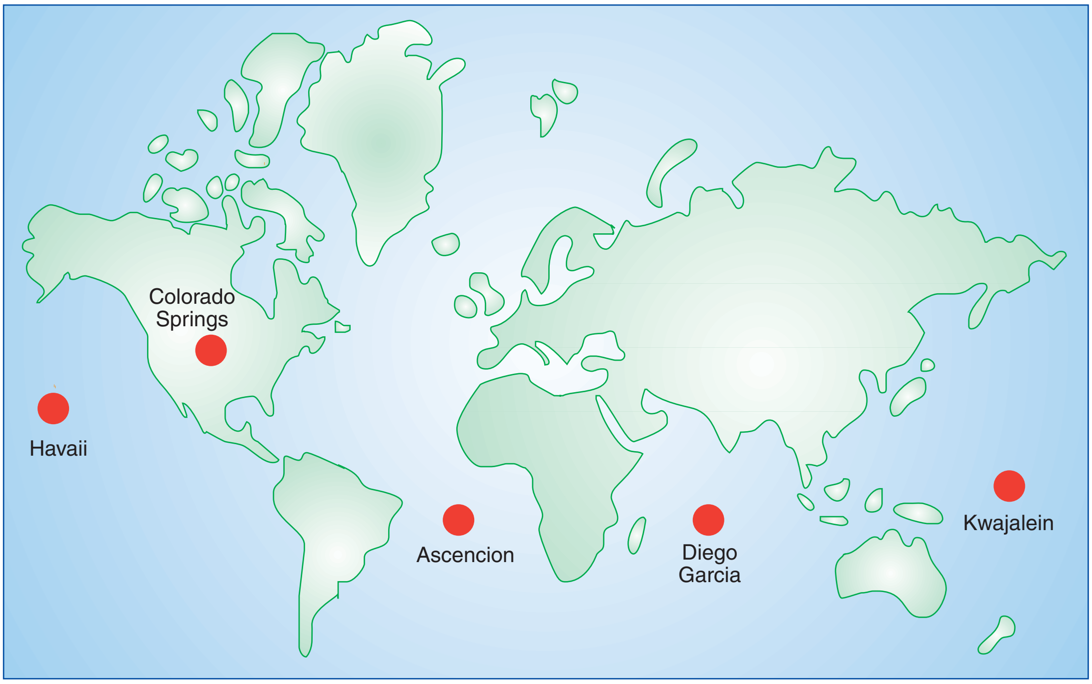


Figure 4 GPS control stations

Differential use of NAVSTAR GPS

Differential GPS (dGPS) is a technique whereby a GPS receiver placed at a known point (point of reference) is used for determining errors/inaccuracies in the satellite measurements (reference data). A dGPS user will then be able to utilise the reference data (or correction data) for correcting his own measurements within a distance of several hundred kilometres around a reference station. This will improve the user's positioning accuracy to better than 5 m (kinematic use). As mentioned above, GPS alone has an accuracy of plus/minus 100 m.

By employing two static receivers it is possible to calculate the distance between them very accurately. (Tests have shown accuracies in the millimetre region on measurements of more than 180 km.) Such measurements utilise the phase measurement on the carrier wave of *L*1 and *L*2.

The dGPS will be increasingly used within the field of surveying, both geodetic and other, and definitely within navigation on land, at sea, and in the air. SATREF (SATellite based REFerence system) will become such a service for users of dGPS and will offer data to increase the accuracy and reliability, and reduce costs connected to positioning (Figure 6).

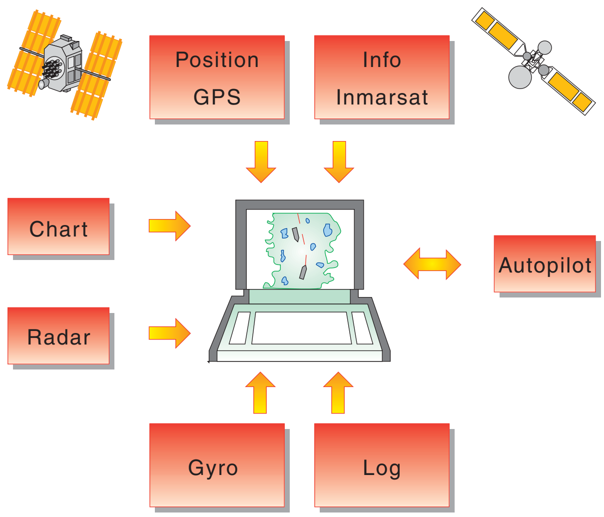


Figure 5 Electronic navigational chart system

SATREF – Satellite based reference system

Summary

The idea of a national satellite based reference system was launched in 1989 in the form of the public development project SATREF. Today, SATREF is almost completed and will now gradually move into an operational phase. Eleven reference stations in some Norwegian cities and at Spitsbergen will be completed by 1993. Nine reference stations and control centres are already in operation on a test basis, and SATREF can therefore offer some services by arrangement.

Introduction

SATREF was started up in 1989 by the Geodetic Institute of Norwegian Mapping Authority as a development project aiming at establishing a national satellite based reference system. Co-operation partners have been the Norwegian Industrial and Regional Development Fund and the company Seatex in Trondheim. The Norwegian Mapping Authority is technically and economically responsible for further development and operation of the system.

In 1991 a business plan for SATREF was drawn up. The conclusion of the plan is that there is a basis, both in terms of

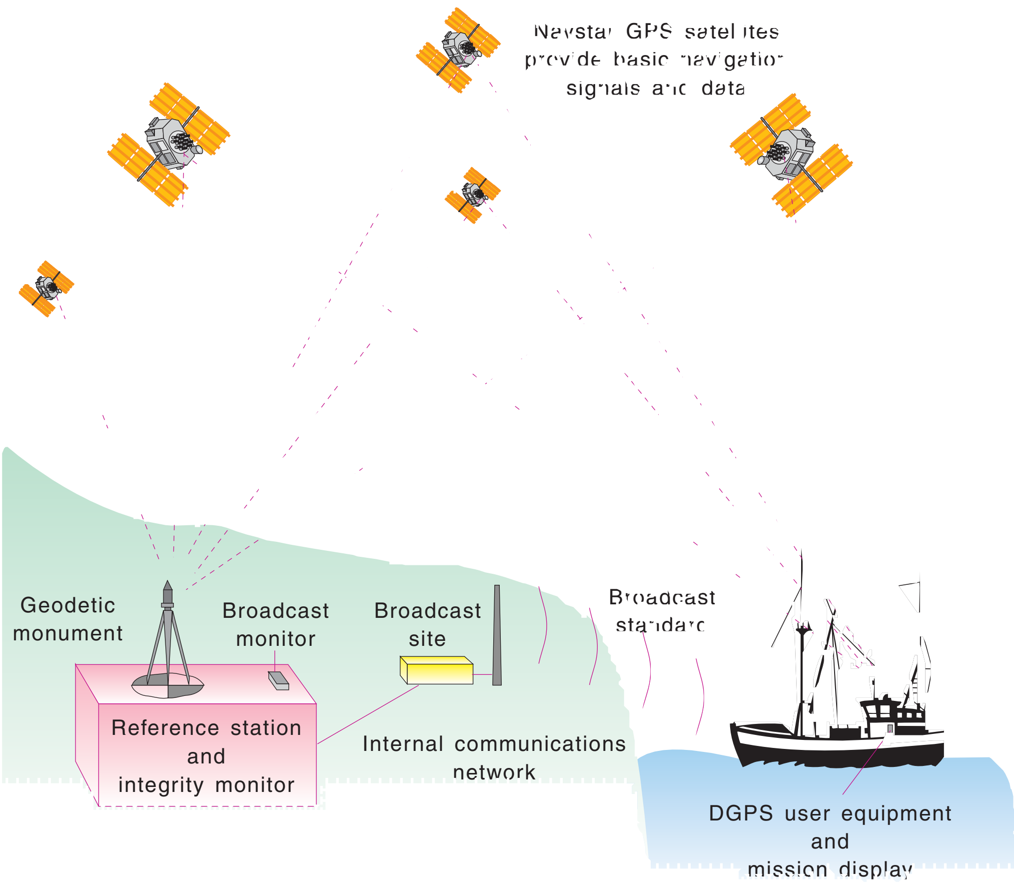


Figure 6 Major elements of a dGPS service

users and economics, to implement a public dGPS service. A national system offering reference data to a wide spectrum of users would be beneficial in terms of efficiency because many different user groups may use the same system. Quality and integrity control will be an important function in order to safeguard satisfactory data and services.

Business idea

The business idea is to offer data and services in connection with the use of dGPS, which will increase accuracy and reliability and reduce costs related to positioning. The area of business is both real time use (navigation) and data for post-processing, and will thereby cover a wide spectrum of accuracy levels. The distribution of data should be based on solutions satisfying the requirements of individual users.

On its own, as well as in co-operation with public partners, the Mapping Authority will offer data and services directly to the end user and to private firms who can carry out value added services based on SATREF. The main area of services will be SATREF reference data and unprocessed GPS data, but the SATREF organisation will also be able to offer various specialised products and services.

The need for improving the safety of navigation is considerable, and SATREF will be a vital service together with the Mapping Authority's efforts in *electronic maps*. The system will be based on users having to pay for the products and services offered by SATREF, but this has not yet been finalised.

Organisation

Two specialised groups in the Geodetic Institute work with SATREF on a daily basis. The specialised group SATREF is responsible for sale, marketing, and daily operation. The specialised group Technological Development (TU) work on further development and technical operation of the system. Altogether, the specialised groups consist of 10–11 people. In addition to this, SATREF may draw on the Geodetic Institute's considerable GPS knowledge.

Background

SATREF is based on NAVSTAR GPS as described above. The GPS system will offer signals and data for two types of users, i.e. military and civilian. The military part of GPS is the most accurate and is called PPS (Precise Positioning Service). The use of PPS requires access to encryption equipment. Civilian users may use SPS (Standard Positioning Service). Using a satellite receiver, SPS users will acquire a 100 metre navigation accuracy in two dimensions.

However, this is insufficient for a great many users. With the help of a reference network SATREF will improve accuracy and assure the quality of the data for its users. Typical figure for differential accuracy is 5 metres.

Reference network

The reference network SATREF consists of six main elements (Figure 7): Reference station, transmitter, monitor station, control centre and communication lines connecting the various components. In addition, there are user units, which is equipment enabling the use of SATREF in connection with positioning and navigation. Such a unit may either be based on the reception of reference data in "real" time, or be equipped with storage capacity for post-processing.

The reference stations (Figure 8) consist of GPS receivers and processor units for the calculation of corrections. The stations will be connected both to transmitters and to a control centre with permanent communication lines. Reference data from a reference station may be distributed to one or more transmitting units.

The reference stations will be continuously monitored by the control centre which assures the quality of all transmitted data. The stations will also pass on messages generated by the control centre. These messages may contain information on status, activities connected to the operation of the system, the "general health" of both the GPS and the SATREF system and on expected accuracy and performance.

The Mapping Authority wish to utilise data from the reference stations in its scientific work, within the fields of research and global environmental changes, among other things. This means that the reference network must satisfy the strict requirements to this type of activity. This applies to both the technical design, the localisation of reference points, and to accuracy. Therefore, advanced GPS receivers of the Turbo Rogue type have been brought forward, which have very good pseudo range measurements on all reference stations.

The *transmitter unit* will provide distribution of SATREF reference data (corrections) in close to "real" time. The objective is to make SATREF data available for many types of users all over the country 24 hours a day.

Continuous *monitoring* of transmitted data will be done with the help of monitor stations. The monitor stations will be able to alert the control centre when critical errors are about to occur, and to report the quality to the transmitting units and the control centre.

The *control centre* (Figure 9) will be connected to all the reference stations and the monitor stations via high-speed communication lines. Both GPS observations, correction data, and status information will be sent to the control centre from the individual reference stations in close to "real" time. This will safeguard quality assured data to the users.

The control centre will also receive reports from the monitor stations, so that the quality of the distribution system can be monitored. Reports on expected accuracy and performance of the SATREF system may thus be generated in the control centre. Together with other information, these reports may be distributed to the users in close to "real" time via the reference stations and the transmitting units.

Both the GPS observations and the corrections will be stored in a data base for on-line inquiry and storage. The control centre will thereby also be able to serve clients with a need for later GPS observations and/or corrections. This applies to data both for positioning and for more scientific use like ionospheric research, satellite orbit calculations, etc.

If necessary, the control centre will be manned 24 hours a day in order to satisfy users' requirements.

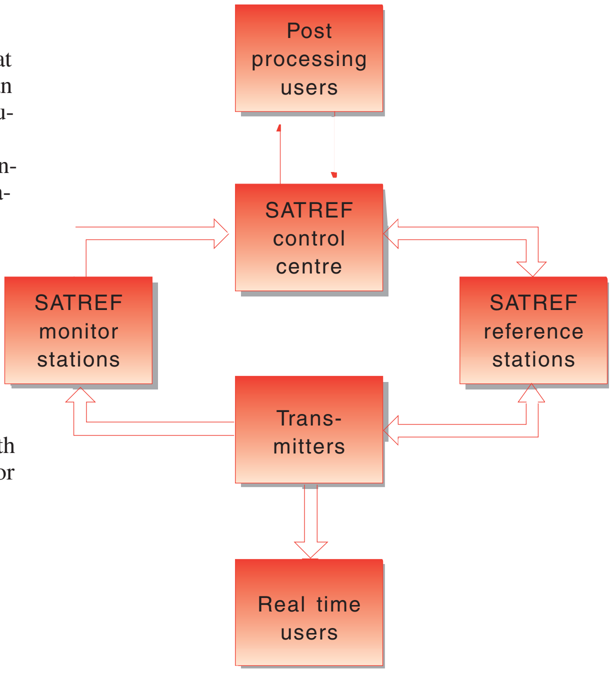


Figure 7 General outline of the main components in SATREF

Photo: Norwegian Mapping Authority

Figure 8 Reference station

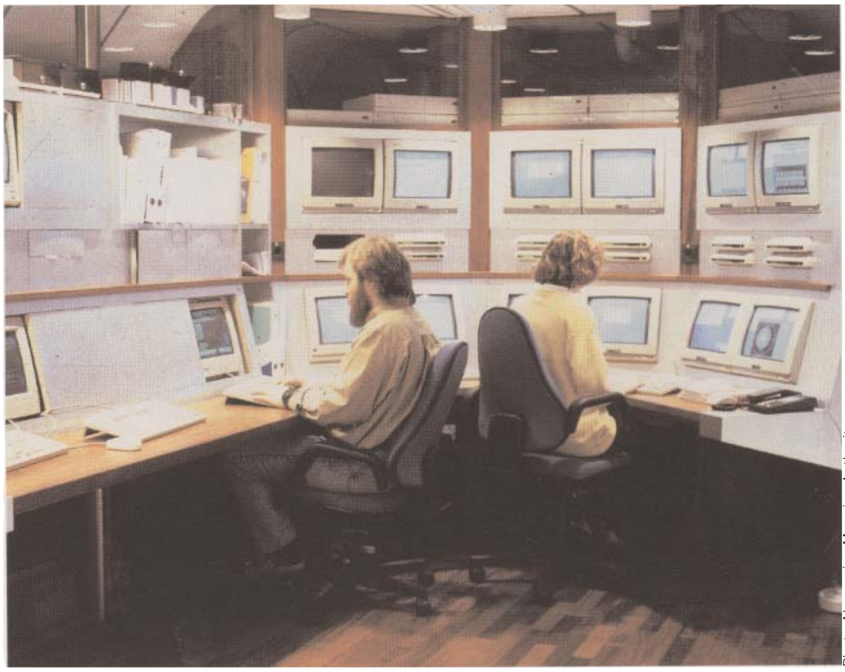


Photo: Norwegian Mapping Authority

Figure 9 Control centre

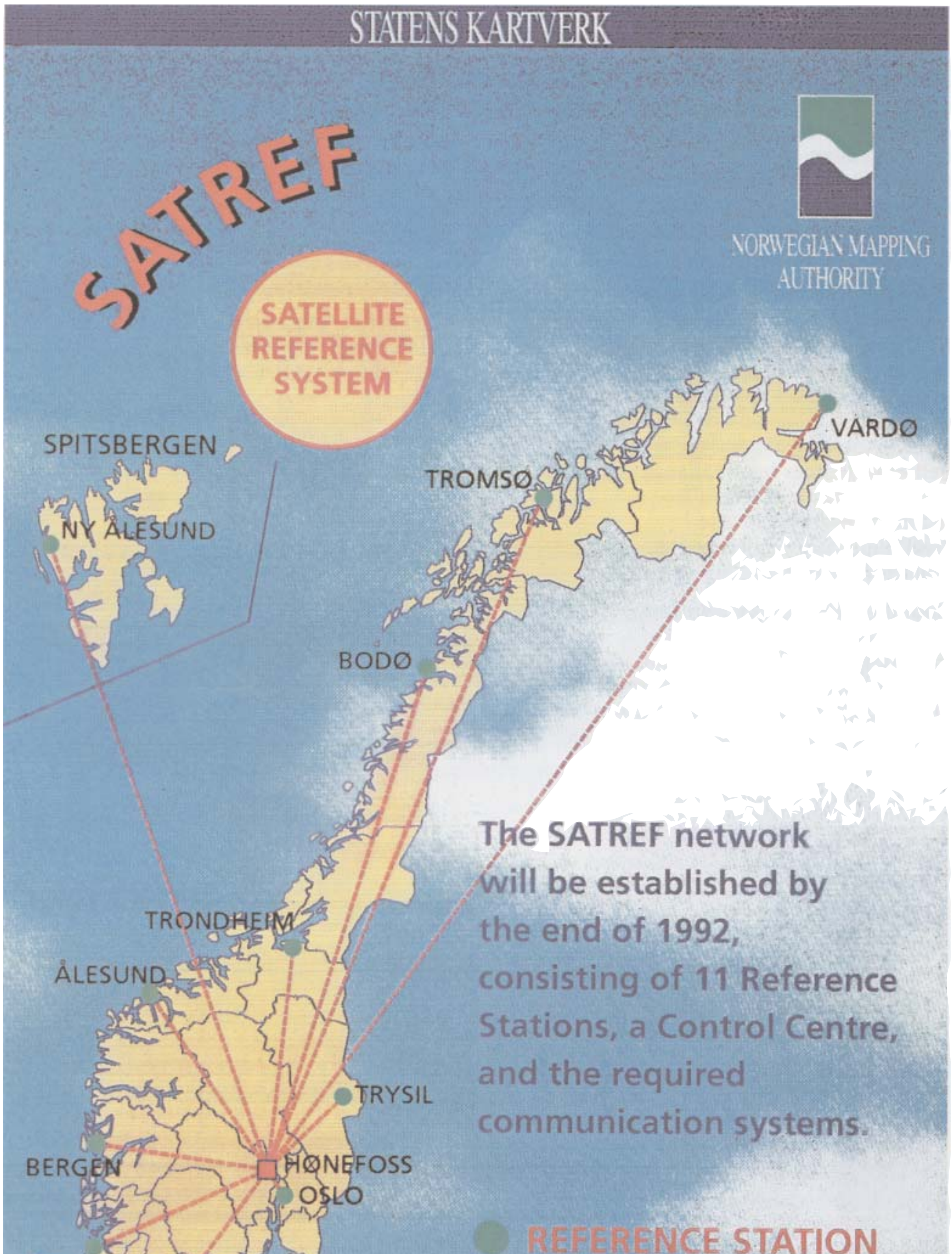


Figure 10 The SATREF network

The Norwegian Mapping Authority plans to have ten reference stations distributed around the Norwegian mainland, as well as one at Ny-Ålesund, Spitsbergen. All stations will be put into operation during 1993. In this period the control centre at the Mapping Authority's main office at Ringerike will be further developed in order to satisfy the various needs, see Figure 10.

Distribution of SATREF data

Distribution of data should mainly be based on existing or planned communication systems.

The Coast Directorate today operates maritime radio beacons used by ships for radio direction. The beacons make up a national system of permanent installations which in a simple and relatively inexpensive way may be upgraded to transmit both radio direction signals and SATREF data to the surrounding waters. This concept is in line with work currently carried out in the international maritime fora. The Mapping Authority and the Coast Directorate have established a co-operation on the distribution of SATREF data via maritime radio beacons. So far, the beacons at Halten, Utvær, Utsira, and Færder have been adapted to this task.

It will be necessary to use several "real time" distribution systems with various properties and coverage areas in order to satisfy the various user environments on land, at sea, and in the air. The Mapping Authority and Norwegian Telecom have therefore set up an agreement with the intent of utilising the national FM and AM transmission network for the distribution of satellite data. This will give users data for accurate positioning for navigation, transport management, and surveying and will give a higher degree of safety and efficiency in these fields on land, at sea, and in the air.

A "test transmission" of data is now taking place over a new data channel in the FM and AM band (described as DARC and AMDS, respectively). The data channel in the FM band has a great capacity, and results so far show that it is very well suited to mobile use. Testing of a national distribution of SATREF data is expected during 1994. The Mapping Authority and Norwegian Telecom are co-operating with Japan and Sweden, where work is being done to use the FM band for a similar purpose.

Major users with a need for SATREF data for navigation, e.g. Statoil, participate in the testing which will stretch into autumn and winter. Parallel to this, work will be done to develop and produce user equipment, a field where the involvement of Norwegian industry is welcome.

FM transmission covers almost the whole of Norway including coastal regions, while the AM transmission will be particularly suited to the surrounding waters and the northern regions. Through the distribution of data over these networks users all over Norway, on land, at sea, and in the air, will be able to utilise accurate positioning data.

DARC (DAta Radio Channel)

A few years ago (around 1990) NHK (Nippon Hoso Kyokai) Science and Technical Research Laboratories in Tokyo, Japan, started developing a new channel for transmitting data on the FM band. The data channel DARC (DAta Radio Channel) is a 76 kbit/s FM Multiplex transmission system with a new digital modulation method, "Level controlled Minimum Shift Keying" (L-MSK), which is equal to ordinary MSK modulation.

This system is "multipath-proof", has a gross transmission capacity of as much as 16 kbit/s and is compatible with Radio Data System (RDS) because a different frequency band is being used. Besides, the system is very well suited to mobile use, the very reason being the modulation method. Since existing infrastructure within the transmission network is adapted to FM transmission, an introduction of this new sub carrier wave would represent relatively small costs.

The frequency of the sub carrier wave is 76 kHz and it is locked to the fourth harmonic by the pilot frequency at 19 kHz. (As will be known, the frequency of the RDS carrier wave is 57 kHz and it is locked to the third harmonic by the pilot frequency.)

Svensk Rundradio AB (SVRR) of Sweden is working on a similar system in co-operation with MHK of Japan. Tests giving positive results have been carried out both in Japan and in Sweden. Norwegian Telecom and the Norwegian Mapping Authority (SK) have entered into a formal co-operation agreement on the testing of this system in Norway, with a view to the system becoming a national distribution system for differential GPS correction data (dGPS) on land, at sea and in the air. SVRR and NHK are positive towards the Norwegian plans and wish to participate in the further development. This is also important in connection with a possible internationalisation process which is necessary in order to have a standardised navigation system (distribution system) across national borders.

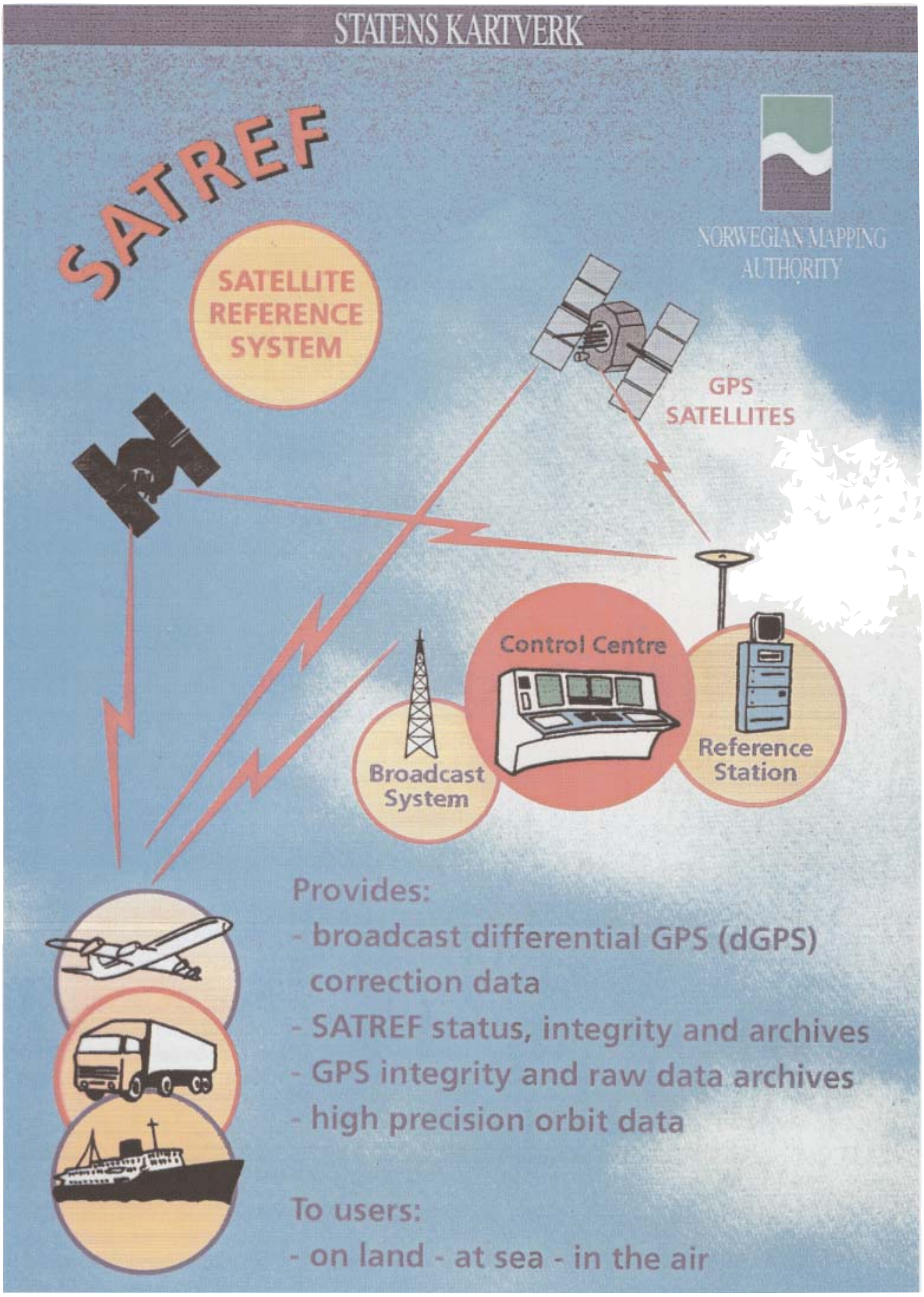


Figure 11 SATREF applications

SATREF applications

The areas for applying SATREF products and services are on land, at sea, and in the air. For the first few years the greatest need is expected to be within maritime activities (Figure 11).

The Mapping Authority will concentrate strongly on assisting the development of safer and more up-to-date navigation through the combined use of electronic charts and dGPS. The concept was tested in the autumn of 1990 in the Seatrans project, whereby a comprehensive prototype was tried out onboard a vessel on a shuttle route between Hamburg and Skogn in the county of Nord-Trøndelag. Seatrans, the shipowner, Norwegian

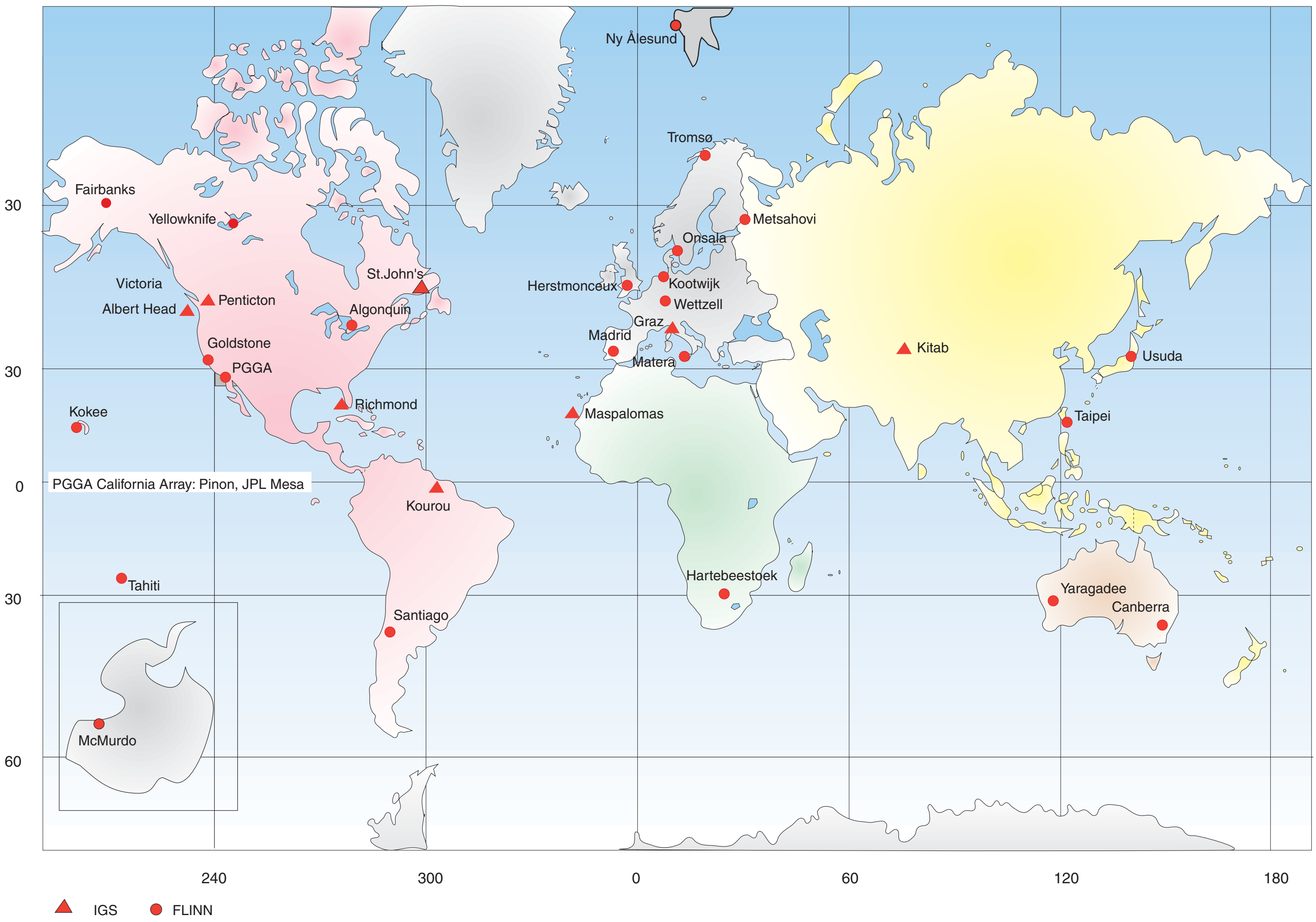


Figure 12 The global network IGS – International GPS Geodynamics Service

equipment suppliers, the Mapping Authority, the Maritime Directorate, the Coast Directorate, the Norwegian Veritas, and the research institute MARINTEK, all played vital parts in the project.

The vessel has still got the equipment onboard and uses SATREF to position the ship along the western coast of Norway within an accuracy of ±5 metres. The Seatrans project demonstrates modern navigation methods of the future which may contribute to increasing navigation safety along the coast.

Speed boats and ships carrying hazardous cargo are expected to become dGPS users, having stricter requirements to the navigation facilities than the general shipping along the coast of Norway. The Mapping Authority aims its work at offering a satisfactory product to such users.

Today, dGPS is applied within the offshore industry. The SATREF services and products will be adapted as well as possible to the needs of the oil companies, so that private firms may use data and services from SATREF and carry out value-added services in the offshore market.

In connection with the establishment of data bases for roads, line/cable ducts etc., kinematic surveying based on the dGPS technique is an interesting field. We will encounter some problems when GPS is taken into use on Norwegian territory. Buildings, trees, and the configuration of the country will be in the way of the GPS signals. However, these problems may be solved by introducing a support system, like e.g. inertia navigation platform or odometer. The foreseen accuracy levels are in the area 20 centimetres to 2 metres. The Mapping Authority have been working on these problems for a while, chiefly in order to arrive at a method for surveying roads in Norway.

dGPS may become a future help for the positioning of vehicles, but certain factors, particularly the cost of equipment, will determine how widespread dGPS will be used. One of the most interesting areas for the use of dGPS positioning is in connection with control systems giving a general view of where important resources are located at any given time. In this connection the Mapping Authority have carried out tests to find out how SATREF may be applied in these areas.

For many years GPS has been used in the Mapping Authority's surveying. Permanent reference stations have not been suitable in this activity because of stringent requirements to accuracy and quality control. However, we assume that SATREF can become a useful help in efficient positioning in many types of registrations where the requirements to accuracy are lower than in surveying; the charting of vegetation and geology, glaciological research, work on property boundaries, and archaeological registrations, to name but a few.

SATREF may be used in navigation in the air as well as at sea, but this requires a transmission system covering the areas in question. Helicopters and small aircraft could be the first users within this field. SATREF is in contact with the Civil Aviation Administration, whose main interest it is to utilise dGPS in the calibration of navigational aids at airports.

The Mapping Authority is building up a GPS network satisfying geodetic and scientific requirements and forming a part of a global system. This entails strict requirements being made to the equipment used, and to the construction and location of the GPS stations. By combining a Norwegian high quality GPS network with other precision instruments used in geophysics and geodesy, among other subjects, Norway could be an important contributor in international research on global changes in the environment. Monitoring global changes in the environment requires the determination of satellite orbits, absolute sea level, and earth movement, and the efforts of the Mapping Authority will be important in these connections.

Receivers and communication in polar regions

The Geodetic Institute of the Norwegian Mapping Authority started its GPS activity in full in 1987 with the purchase of five 2-frequency (L1 and L2) P-code TI-4100, 4 channel satellite receivers. As early as November 1987 the Mapping Authority placed two such receivers in permanent satellite tracking stations, one at Tromsø satellite station in the grounds of the Northern Lights Observatory, and one at Onsala Rymd Observatorium (Space Observatory) in Sweden. This was Norway's contribution in the very infancy of establishing a world-wide satellite track network for the calculation of precise orbital data. The old receivers have now been replaced by P-code Rogue SNR8, 8 channel satellite receivers. (Department of Space related Research in the Geodetic Institute is the unit in charge of satellite orbit calculations.)


Photo: Norwegian Mapping Authority

Figure 13 Ny-Ålesund

For high precision applications including the calculation of satellite orbits, the Mapping Authority assumes a particular responsibility in the polar regions. At Ny-Ålesund, Spitsbergen, effort is being put into the establishment of a geodetic laboratory. At the end of 1990 the Mapping Authority placed a Rogue SNR8 GPS receiver at Ny-Ålesund, and together with the above mentioned receivers this has been included in the global network IGS (International GPS Geodynamics Service), see Figure 12.

In 1990 the IAG (International Association of Geodesy) decided to establish IGS. The aim is to establish a service able to deliver high quality GPS products for geodetic and geophysical research activities.

The main tasks of IGS is to collect, store and deliver GPS data. In addition, the IGS calculation centres calculate the GPS satellites'


Photo: Norwegian Mapping Authority

Figure 14 Ny-Ålesund

Photo: Norwegian Mapping Authority

Figure 15 The parabolic antenna on top of the Zeppelin mountain near Ny-Ålesund

orbits with high precision and the co-ordinates of the stations in the IGS network.

GPS data and SATREF data may be post-processed utilising the high precision satellite orbits. The Mapping Authority uses the global GPS data from the IGS network in order to make its own calculation of the satellite orbits and to calculate co-ordinates for GPS receivers with great accuracy. Some of the SATREF stations will have a geodesy laboratory status and will be included in the IGS network, among them are Tromsø and Ny-Ålesund. (The satellite receivers at Tromsø and Ny-Ålesund are important in the calculations of satellite orbits because of their geographical positions.)

Data from all GPS receivers in the IGS network are collected daily and stored in a global data base. The collection of data from the Rogue receivers at Tromsø, Ny-Ålesund, and Metsahovi in Finland is the responsibility of the Mapping Authority. At present, this is done by switched connections and modems on ordinary telephone lines via satellite. From Onsala in Sweden the data are collected by INTERNET.

GPS receivers in polar regions (Ny-Ålesund) have shown that the satellite coverage is good and that their calculations show as good a result as those installed on the mainland (Norway). Relatively large amounts of data are transferred and at times the communication with the Ny-Ålesund station has been difficult.

By establishing a Geodesy Laboratory and a SATREF station as permanent installations at Ny-Ålesund, the Geodetic Institute has had to consider other communication options. It has therefore been decided that the NORSAT-B system is the one to be used in the future as permanent communication between Norwegian Mapping Authority, Ringerike and the research centre at Ny-Ålesund, Spitsbergen, see Figures 13 and 14.

In co-operation with Norwegian Telecom International a 3.3 metre parabolic antenna has been mounted on top of the Zeppelin mountain near Ny-Ålesund (Figure 15) at an altitude of 550 metres above sea level. A similar antenna has been mounted on top of the Mapping Authority's buildings at Ringerike. In the years ahead SATREF and the Department for Space related Research at the Mapping Authority will be dependent on a safe and reliable communication with the northern regions, and particularly with Ny-Ålesund. The Mapping Authority co-operates with various other research activities in the northern regions at the same time as preparations are made also for these activities to utilise the NORSAT-B system. As a consequence of this, it will be possible to obtain a direct access to INTERNET (International data network) from Ny-Ålesund, and thereby to all data banks world-wide.

(PS: Geodesy means the study of the shape and size of the earth.)

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Very Long Baseline Interferometry in the Arctic

BY BJØRN RAGNVALD PETTERSEN

The Geodetic Institute of the Norwegian Mapping Authority is establishing a major research facility in Ny-Ålesund, Spitzbergen. A geodetic observatory will be equipped with several satellite receiver systems (GPS, GLONASS and PRARE) as well as a 20 metre diameter fully steerable parabolic antenna equipped with dual-frequency VLBI-receiver and data acquisition electronics. Very Long Baseline Interferometry (VLBI) is a radio technique involving the simultaneous use of several antennas, usually located on different continents, to observe astronomical radio sources (quasars) in the universe. Correlation techniques and further data processing allows the determination of precise positions of the participating observatories. The drift of continents relative to each other was detected with the VLBI technique a decade ago, thus giving support to the theory of tectonic plates. Current research topics focus on vertical motions due to tectonic processes, volcanic and other active geological phenomena, and post-glacial rebound effects resulting from the previous ice-age. It is important to understand such effects when considering climatic changes in, for instance, absolute sea level. The use of several high precision techniques, as implemented at the Ny-Ålesund geodetic observatory, is a useful approach in determining errors and error sources. Satellite-based techniques refer to the mass centre of the Earth while VLBI has an astronomical reference frame. This is an essential consideration in a long-term observing programmes that may last for several decades.

Introduction

Space geodesy provides us with powerful, modern techniques for precise determination of three dimensional co-ordinates. In fact, the precision levels are so high that the dynamic nature of many phenomena now can be detected. Time thus enters as a fourth necessary parameter to describe the instantaneous position of objects on the surface of the Earth, of ships, oil rigs and other installations on the surface of the Oceans, and of aeroplanes at various heights and locations in the atmosphere. Several countries have implemented space geodetic techniques for navigational purposes. High precision results (at the cm and sub-cm level) still require extended measurement series and individual planning of the observing programme. Scientific applications include topics like the relative shifts of continents, regional monitoring of earthquake behaviour, and local short term effects of earthquake activity and volcanoes. Future research topics, perhaps requiring even further refinement of some techniques, are studies of the continental shift, vertical and horizontal movements in Scandinavia and the Arctic as a result of the post-glacial rebound effect from the last ice age, and determination of vertical land motion as local corrections to sea level measurements in a global effort to study and understand long term climatic effects and their causes.

High precision space geodetic techniques use optical or microwave observations of either satellites in Earth orbit or astronomical objects in the universe. In methods based on orbital motions of satellites, the point of reference for all co-ordinates and orbital analyses is the centre of mass of the Earth. Satellite geodetic systems presently in use by the Norwegian Mapping Authority include the American NAVSTAR *Global Positioning System* (GPS) and the Russian *Global Navigation Satellite System* (GLONASS). In geodetic *Very Long Baseline Interferometry* (VLBI) a selection of astronomical objects in all parts of the sky defines a co-ordinate system of its own These objects are so far away that any space motion is negligible as seen by an observer on Earth. The astronomical reference system is thus a very good approximation to an inertial system.

Because fixed GPS satellite receiver antennas have distorted views when the satellites are observed close to the horizon (technically referred to as a multipath problem) the error bar of the vertical co-ordinate component is usually 2–3 times larger than the uncertainty of each horizontal co-ordinate. Some countries supplement the user friendly GPS microwave technique with optical laser ranging determinations of distances to specialised high orbit satellites equipped with retroreflectors. The satellite laser ranging techniques are well suited for vertical determinations, but require extended observing series to achieve the necessary precision because each satellite must be tracked individually. Only a fraction of this observing time is needed for GPS observations because several satellites are visible above the observer's local horizon simultaneously. With several satellites to refer to during an observation the reference system is well defined and high precision results become possible.

On northern latitudes, especially in the Arctic, the weather patterns are generally not in favour of using optical methods. A complementary technique to satellite geodesy is that of radio interferometry, which has the added advantage of defining its own reference system. When implemented in the microwave part (1–10 GHz) of the electromagnetic spectrum, it is well suited for accurate determination of distances between observatories in a reference system defined by astronomical radio sources in the universe. It is the only space geodetic technique that maintains high precision even for distances of several thousands of kilometres. Satellite techniques are best suited for relatively short distances between each satellite receiver and the uncertainties increase rapidly for longer distances.

The radio interferometry technique, commonly referred to as Very Long Baseline Interferometry (VLBI), uses steerable parabolic reflectors to point at astronomical radio sources and can observe all parts of the sky from zenith to the horizon. VLBI is thus better capable of high precision vertical results than satellite systems with fixed antennas which can only provide data of sufficient quality when the satellites are more than 20 degrees above the horizon.

In addition to the potential for high precision results, space geodetic techniques are distinguished from conventional geodesy by its global approach. This has opened a new dimension in the mapping of our planet and allows studies of tectonic plates and their movements as well as crustal deformation studies on a regional scale. In the Arctic and the North Sea region this includes post-glacial rebound effects as well as volcanic and earthquake related activity. The motion of about 20 tectonic plates which make up the Earth's lithosphere has been predicted from geological and geophysical data which are averages over millions of years. On this time scale the

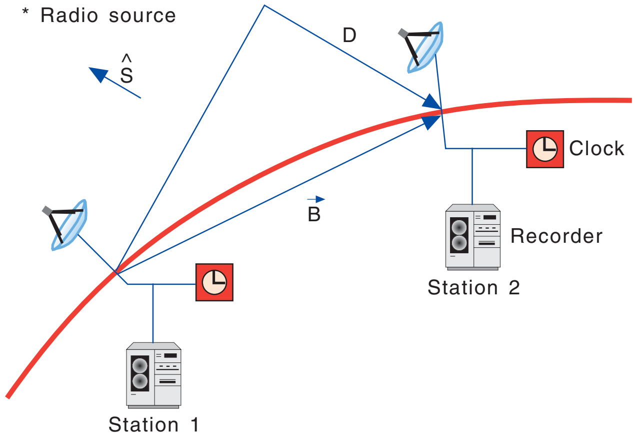

Figure 1 The geometry of a two-telescope interferometer

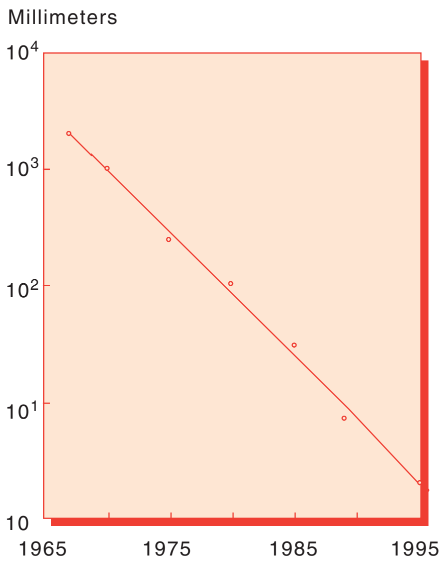

Figure 2 The historical improvement of the accuracy of VLBI results during the last 25 years

plate motion appears to be smooth and steady. It is known, however, if the present-day motion is steady or episodic. Understanding plate dynamics, deformations, earthquakes, and volcanic activity depends critically on our ability to describe and understand plate motions *today*. Space geodetic techniques have made this possible.

The basics of VLBI

The geodetic application of the VLBI technique became possible when the aperture synthesis technique in radio astronomy was developed to make group delay measurements of the relative signal arrival time. Group delay observations enable high precision measurements to be made without the difficulties of the more precise but ambiguous phase delay used in conventional interferometry.

In geodetic VLBI, random noise signals from compact extragalactic objects (usually quasars) are received by two or more radio telescopes which may be thousands of kilometres apart. The signals are amplified and down converted under the control of a hydrogen maser frequency standard to a lower frequency band. The translated signals are digitized, time-tagged, and recorded on wide bandwidth magnetic tapes. The tapes recorded at the different stations are shipped to a processing centre. The processor is a cross-correlator under computer control which delays and multiplies the signals from the tapes recorded at a pair of radio telescopes. The primary piece of observational information in geodetic VLBI is the group delay, which is the difference in arrival time of the signal at the radio telescopes. In practice, the group delay is obtained from measurements of the phase delay at different observing frequencies.

This set-up is described geometrically in Figure 1 for the simplest case of two telescopes. The primary component of the measured group delay is the geometrical delay of the interferometer, namely

$$\tau_{geom} = (B \cdot S)/c$$

where B is the baseline vector connecting the two radio telescopes, S is a unit vector in the direction of the observed radio source, and c is the velocity of light. In Figure 1, $D = \tau c$. Mathematically it is sufficient to carry out ten observations of three sources to determine the source positions and the three baseline components of a single baseline VLBI interferometer. In reality, as many as ten telescopes may measure twenty to thirty sources around the sky in 24-hour experiments, in order to obtain high accuracy. The Mark III data acquisition system used in geodetic VLBI collects data through six 2 MHz frequency band passes in the S-band (2.2 – 2.3 GHz) and eight 2 MHz frequency band passes in the X-band (8.2 – 8.6 GHz). These fourteen widely spaced video bands yield a synthesized bandwidth wide enough to determine the group delay accurately, by fitting a straight line to the observed phase versus frequency. The slope of this line is the observed group delay. Other observables are the interferometer phase delay and its time derivative, the delay rate. The group delay is related to the geometrical delay by

$$\tau_{group} = \tau_{geom} + \Delta\tau$$

where $\Delta\tau$ represents atmospheric and instrumental differential delays. The major dispersive part of $\Delta\tau$ is the differential excess group delay caused by the ionosphere. The additional time needed, relative to the transit time in vacuum, for a signal passing through the ionosphere, is given (to first order) by

$$\tau_{group} = const.\ n_e/\nu^2$$

where ν is the plasma frequency, and n_e is the column density of free electrons. If the electron density could be determined independently, the excess group delay of the ionosphere could be computed directly. Unfortunately, direct line-of-sight measurements of n_e are not routinely available. However, the dispersive character of the ionosphere allows a determination of the excess group delay if observations are carried out at two spaced frequencies, namely

$$\Delta\tau_{group}^{ion} = (\tau_x - \tau_s)\frac{\nu_s^2}{\nu_x^2 - \nu_s^2}$$

where τ_x and τ_s are the observed group delays, and ν_x and ν_s are the effective frequencies at X- and S-band, respectively.

The technical development of VLBI equipment and observing strategies have improved the accuracy of the results tremendously since the first experiments involving trans-Atlantic distances some 25 years ago. This is illustrated in Figure 2, which indicates that the millimetre level may be reached within very few years.

The Ny-Ålesund Geodetic Observatory

The Geodetic Institute of the Norwegian Mapping Authority is establishing a major research facility in Ny Ålesund, Spitzbergen. A permanent geodetic observatory has been equipped for satellite and space geodesy. Satellite receiver systems provide data for high precision geodetic analysis. These are the GPS and GLONASS systems that involve observations of multiple satellites simultaneously, and PRARE, a ranging system planned for the Meteor-3 and ERS-2 satellites will be installed later.

The VLBI facility at Ny-Ålesund represents a major investment and will play a key role in the scientific activities of the observatory. Figure 3 shows the 20 m diameter fully steerable parabolic VLBI antenna during installation at Ny-Ålesund in early August 1994. Its altazimuth mounting allows pointing to any direction in the sky with an rms accuracy of 0.002 degrees (7 arcsecs) under calm conditions and 0.011 degrees (40 arcsecs) at a wind speed of 15 m/s. It slews with a speed of 2 degrees/sec in both azimuth and elevation and can accelerate up to 1 degree/sec/sec. A large concrete foundation has been blasted into local bedrock and secured by steel rods. It has been well insulated to preserve the surrounding permafrost. The foundation is a cube with sides of 7 metres. The steel antenna structure with its aluminium reflector panels weighs almost 130 tons. The task of this instrument required rather stringent product specifications to ensure that it will not move away from its initial position by more than 1 mm rms in the horizontal direction and 2 mm rms in the vertical direction. This will be monitored regularly by conventional geodetic techniques, using a local reference network at the site.

Photo: Norwegian Mapping Authority

Figure 3 The 20 m diameter VLBI radio telescope at Ny-Ålesund during installation in September 1993

Photo: Norwegian Mapping Authority

Figure 4 The VLBI control building and other installations at the Ny-Ålesund research facility

In addition to dual frequency operation and large bandwidth as described above, antennas dedicated to geodetic VLBI should have a large end efficient reflector area since the observed quasar signals are extremely weak (typically 0.1 to 10 Jansky, or 10^{-27} to 10^{-25} $W/m^2/Hz$. The reflector surface must be of high quality as antenna deformations by gravity forces, wind and snow/ice loads would degrade the accuracy of the observed group delay. The Ny-Ålesund telescope has an accuracy of 0.61 mm rms.

The dual frequency S/X-band receiver is mounted in the prime focus. It is cryogenically cooled by liquid Helium and is operated under computer control (as is the antenna pointing and tracking) from the VLBI control room in an adjacent building (see Figure 4). A Mark III data acquisition system is used to receive and record the data from the telescope. A block diagram is shown in Figure 5. The two intermediate-frequency (IF) outputs of the S/X-band receiver are routed through fourteen separately controllable frequency converters to produce separate video signals from the upper and lower sidebands adjacent to the total local-oscillator frequencies corresponding to the settings of each of these converters. Each video signal is digitized by hard limiting it and sampling the sign at the Nyquist rate. A magnetic tape recorder records the digital signals together with a time code on 28 parallel tracks. The data acquisition recording rate is 224 Mbit/s.

The receiver delay is calibrated by injecting short pulses of approximately 30 picoseconds duration into the front end at a rate of 1 pulse/microsecond. These pulses generate low-intensity signals spaced 1 MHz apart which, when mixed to video, are made to appear as 10 kHz tones in the upper sideband passbands by offsetting the local oscillators. Extraction of the phases of these tones in the data processing serves to calibrate the phase delay of each individual 2 MHz wide passband. The electrical length of the cable which feeds the calibrator is monitored by measuring the phase of sideband signals at 5 MHz ± 5 kHz which are returned back from a reflection modulator in the unit near the feed. This method of receiver delay calibration provides for

Photo: Norwegian Mapping Authority

Figure 5 The VLBI control room during the testing phase in August 1994

the correction of small drifts in the front end electronics at the focus of the telescope and in the video converters in the control room, as well as for correction of changes in the IF cable length.

A hydrogen maser frequency standard (Figure 6) in a temperature controlled room in the basement of the control building provides the frequency reference signal for the local oscillators, data sampling, receiver delay calibration, and time-of-day clock.

The entire data acquisition process runs under computer control, except for the changing of data tapes. Complicated observing schedules specifying the location of each individual object and the time to observe it are loaded into the observatory computer at the beginning of each 24-hour observing session. Module settings, system temperature measurement, and the results of other calibration procedures carried out during an observation are all automatically recorded.

VLBI networks

The VLBI technique involves the simultaneous use of several radio telescopes, often located on different continents. The distribution of land and oceans on our planet and the extreme temperatures near the poles have led to a better East-West distribution of observatories than is the case in the North-South direction. The Ny-Ålesund VLBI facility thus has a unique position near the North Pole and will be able to observe and collaborate with any other observatory on the Northern hemisphere (Figure 7). For the European network alone the inclusion of Ny-Ålesund doubles the North-South baseline. The lack of nearby, large populated areas and the strict government monitoring of human activities on the Spitzbergen Island ensures a very quiet microwave environment. This will be well exploited for research purposes. The strategic scientific position of this facility should bargain for a long term existence at Ny-Ålesund.

Scientific topics

The collocation of several types of space-geodetic instruments at Ny-Ålesund will allow comparisons of the various techniques and help identify any systematic errors or individual peculiarities. The VLBI technique operates within an inertial reference frame and can thus guarantee long term stability of the results. This is extremely important since several phenomena may have to be monitored for one or two decades before a trend emerges. When spatially resolved geodetic observations are carried out with the permanent, national GPS network (SATREF), it is important that complementary VLBI observations also be made to ensure a tie to its long term stability. The Ny-Ålesund geodetic observatory possesses all the elements to serve as a fundamental geodetic reference station.

Geodynamics and space geodesy were preoccupied in the 1980s with testing the theory of plate tectonics. In particular, they tried to determine if contemporary plate motions are the same as those inferred from the million-year geological records; they studied the interactions between the plates and their boundaries; and they improved our understanding of the rotating Earth and its interaction with the interior, atmosphere and oceans. These topics required the development of cm and sub-cm level measurement accuracies. Despite many successes, several problems are far from being solved. In plate tectonics, small (1–2 mm/year) differences now emerge between observations and historical models. Comparable motions have been detected within the plates. We must determine if these reflect real differences between short- and long-term motions, whether there are errors in the geochronological time scale, if there are flexures within the plates, if there are inadequacies in the reference frames, or if there are other sources of time variable motions. In earth rotation studies we have now observed long enough to separate 9.3 and 18.6 years luni-solar effects from long-term changes in the shape of the Earth. We are approaching the sensitivity necessary to measure dynamical changes due to ocean and continental ice loading.

Further research topics that now appear to be within the measurement grasp of the 1990s are lithosphere deformations associated with post-glacial rebound (a few mm/year at the most), and sea level changes, which may be a climatic change indicator if caused by global warming leading to increased amounts of water in the oceans, or a response to land deformation. Land-based geodetic measurements are needed to separate these two effects, which are only a few mm/year. Measurements of elastic deformation of the Earth's crust in regions of high glaciation may serve as a scale by which the total ice mass can be weighed.

Virtually all climate models project a poleward intensification of global warming in the Northern Hemisphere in response to an enhanced greenhouse effect. The climate of the polar regions and their snow and ice cover are highly sensitive to fluctuations in atmosphere-ocean conditions on monthly to decadal time scales. The snow-ice-albedo feedback effect amplifies small perturbations of the global climate system, as shown

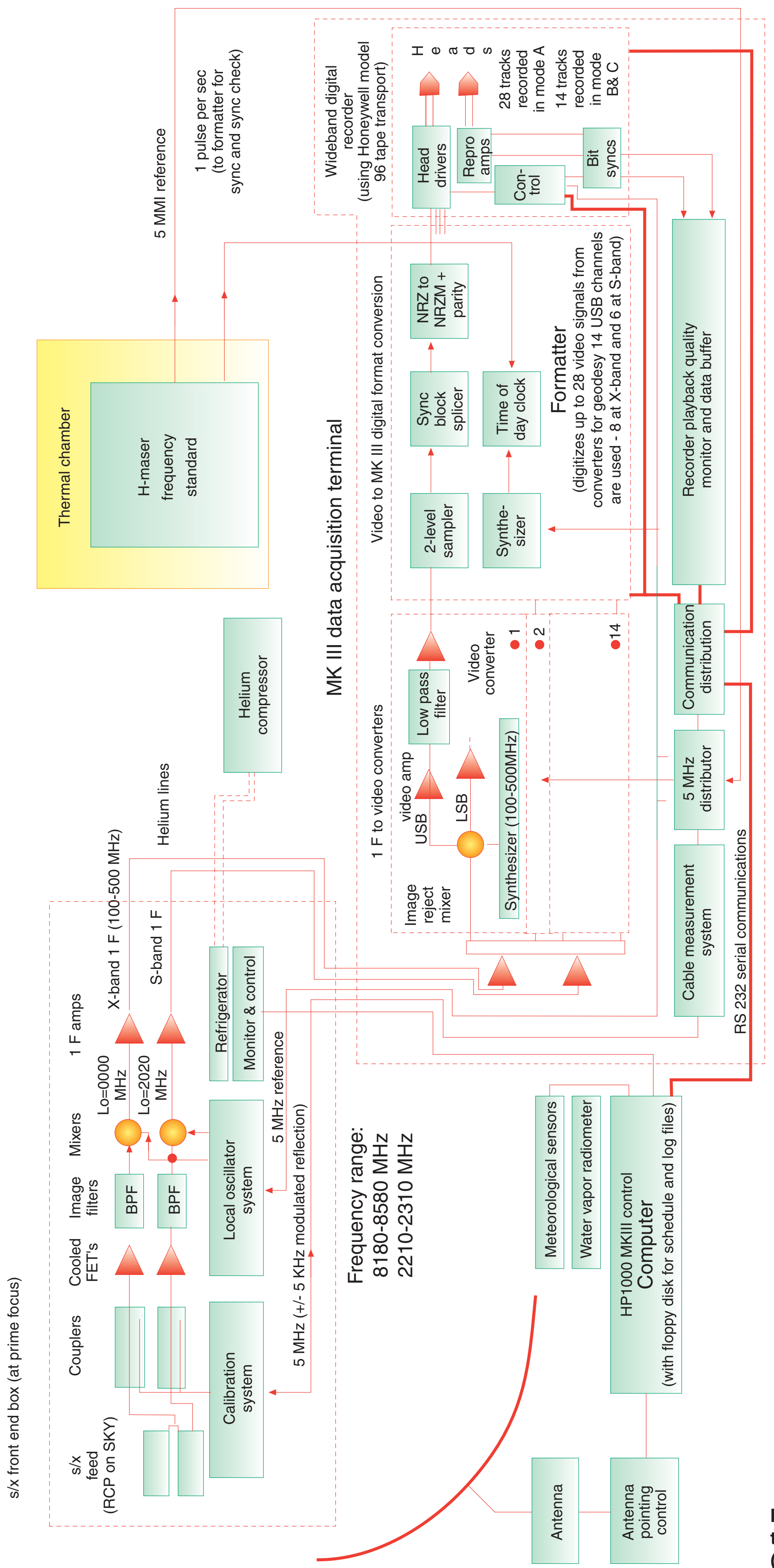

Figure 6 Block diagram of the Mark III data acquisition system
(From Clark et al., 1985 IEEE trns. GE-23, 438)

both by numerical climate models and by the evidence of past glacial cycles. A climate warming would undoubtedly increase melt rates in glaciers and ice sheets. It might also reduce the area of permafrost resulting in a release of large amounts of methane into the atmosphere. The model predictions for sea level rise are very uncertain, however, and at present it is not clear whether the mass of ice in the Greenland and Antarctic ice sheets is increasing or decreasing. Given the importance of sea level changes, this is an unacceptably large degree of uncertainty. An improved understanding of the polar regions will thus lead to more reliable predictions of climate and sea level rise.

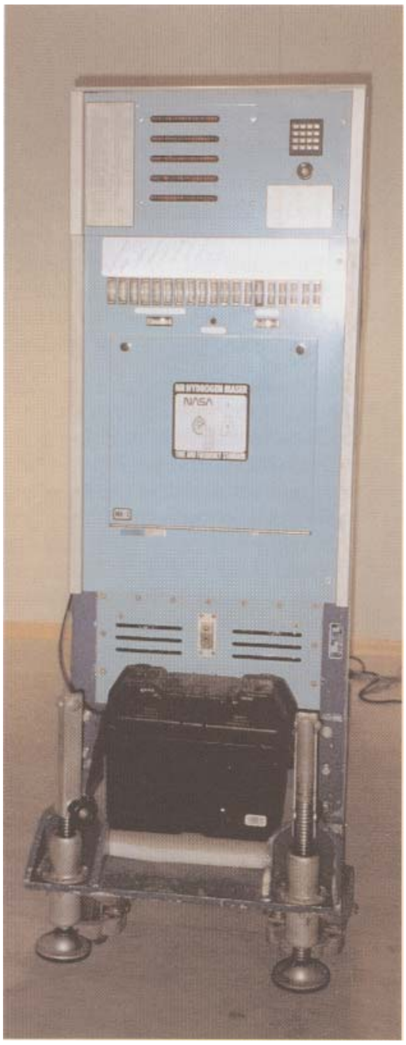

Photo: Norwegian Mapping Authority

Figure 7 Hydrogen maser frequency standard (atomic clock) used to provide reference signals to the data acquisition electronics

Geological records reveal that absolute sea level has varied considerably in the past from its present-day position. During the Ice-age Epoch (i.e. 1.6 million to 10,000 years ago), the sea level rose and fell repeatedly in response to the cyclical waxing and waning of large ice sheets on the continents of the Northern Hemisphere. Sustained intervals of a warmer climate were always associated with a rise in sea level, as the volume of glacier ice was reduced and the oceans underwent thermal expansion. The converse was true during the colder climate intervals. During the last interglacial interval (about 120,000 years ago), the sea level was about 6 metres higher than today and the Greenland ice sheet was significantly reduced in area and volume. At the end of the most recent glacial interval (about 21,000 years ago) the sea level was about 125 metres lower than at present. Over the past 6,000 years, the sea level has been within 1 metre of the present level. It has been estimated that during the past century it has risen by 0.1 – 0.2 metres.

The role of VLBI in monitoring Climate and Global Change relates to the ability of this technique to accurately determine baseline vectors between radio telescopes around the world at the time of observation. The changes in the solid earth, oceans, atmosphere system that are collectively referred to as Climate and Global Change essentially involve movements of masses that result in deformations of the Earth and changes in the vectors observed with VLBI. Melting of glaciers and polar ice caps and the redistribution of the mass over the oceans causes shifts in the location of the pole, changes in the length of the day (Earth rotation), and crustal deformations that affect the components of VLBI interstation vectors. These changes can all be detected by a series of VLBI measurements.

Figure 8 The unique polar location of the Ny-Ålesund VLBI facility makes it a hub in the Northern Hemisphere network of observatories

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Air pollution monitoring in the Arctic

BY GEIR O BRAATHEN AND ELIN DAHLIN

Introduction

The Norwegian Institute for Air Research (NILU) is an independent research institute founded in 1969. NILU deals with problems related to air pollution on all scales and has long experience in various co-ordination tasks in international research and monitoring activities. Over the last years NILU has been continuously upgrading its telecommunication network for long distance control of measurements. One area of particular interest is the Arctic region, dealing with activity both at Svalbard and on the Kola Peninsula in Russia. This article presents a few monitoring areas where daily telecommunication is necessary for NILU to get monitoring results on line. Daily communication with the measuring sites is also important to ensure that the measuring instruments are performing correctly and giving consistent data. Direct telecommunication can also be used to calibrate and adjust such instruments.

Photo: T Krognes, NILU

The Arctic Atmospheric Research Station on the Zeppelin Mountain, near Ny-Ålesund at Svalbard

The Research Station at Svalbard

If we go back 20 years in time, the Arctic was still regarded as pristine and largely undisturbed by human activities. However, the phenomenon of Arctic haze (1), was shown by Rahn in 1980 to have its origin in the emission of air pollutants in Eurasia. (2) (3) Measurements were started by NILU at Ny-Ålesund in 1976 and on Bjørnøya in 1977, and showed that the concentrations of both sulphur dioxide and sulphate particles in air were relatively high in winter, and low in summer. More comprehensive studies (4) showed this to be due both to increased transport of air masses from Eurasia during the winter– spring period, and too little oxidation and deposition of pollutants under Arctic winter-time conditions. Similar observations were made for many other pollutants, and have also been corroborated by extensive American studies. It was concluded that a permanent research station at Spitsbergen could provide much needed data on a number of environmental questions related to atmospheric trace gases.

Planning of a clean-air site began in 1987 (5). The following three requirements were of particular importance:

- The site should not be influenced by local pollution;
- The site should be accessible on a daily basis;
- The site should be intended for measurements over many years.

The best compromise was found to be a site close to the summit of the Zeppelin Mountain, which is approx. 2 km south of the Ny-Ålesund settlement at Svalbard. The construction work was carried out during the summers 1988 and 1989, and the station was put into operation in September 1989. The station can be accessed by aeroplane or helicopter from Longyearbyen to Ny-Ålesund and then via cable car to the station. The station is operated by the Norwegian Polar Research Institute in collaboration with NILU. Most of the instruments are connected to automatic data loggers which are called by telephone and modem from NILU for automatic transfer of data. Among the most important data NILU receives on-line every day from this station are the ozone and the radioactivity measurements together with general air pollution and meteorological data.

Tropospheric ozone

The background concentration of tropospheric ozone in the Northern Hemisphere has increased by approx. a factor of two over the last 100 years, and this increase is mainly due to increased emissions of nitrogen oxides ($NO + NO_2$) and volatile hydrocarbons. On the regional scale this leads to episodic high concentrations of ozone which is harmful both to vegetation and to human health. However, there is also an interaction between photochemical ozone formation on the regional scale and on the global scale. Observations of ozone and its precursors on remote locations such as Ny-Ålesund are particularly important in order to investigate these interactions.

During the dark winter period, high concentrations of even relatively reactive hydrocarbons are observed in the Arctic, due to the absence of sunlight and low photochemical activity in the source areas. The observed ozone concentrations in the Arctic during this period are either formed at lower latitudes, or from stratospheric folding events. This changes during the Arctic sunrise period in March, resulting in lower hydrocarbon concentrations and somewhat increased ozone concentrations in episodes with transport of polluted air masses.

Interactions with natural phenomena are also observed, in that periods with very low ozone concentrations may occur in April–May. These are thought to result from reactions with methyl bromide which is emitted from marine algae. During summer, concentrations of ozone, and particularly its precursors, are gener-

Photo: G O Braathen, NILU

Ozone sonde launch at Ny-Ålesund, carried out by the German Koldewey Station. Data from these experiments are transferred to NILU's stratospheric ozone database

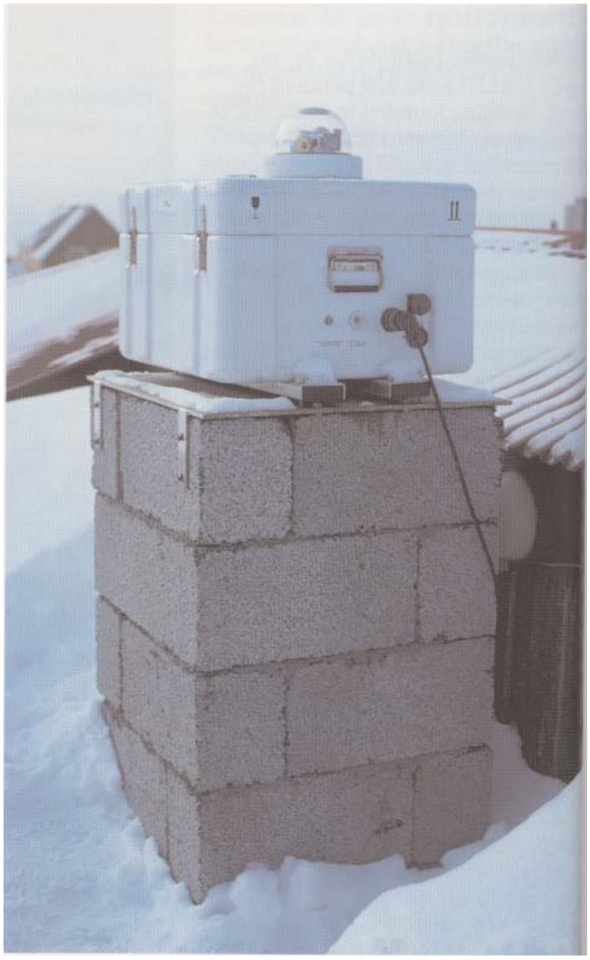

Photo: G O Braathen, NILU

UV-visible spectrometer for measuring stratospheric NO_2 and ozone. Data are transferred to NILU daily

ally low. The only exception is ethane and propane, both of which seem to originate from marine algae.

NILU has performed measurements of surface ozone at Ny-Ålesund since October 1988. In September 1989 the instrument was moved to the new station at the Zeppelin Mountain, and the results of the measurements are registered at NILU through the on-line data loggers every day. These measurements contribute to NILU's research on the tropospheric ozone problem, which is carried out as a part of the European Eurotrac project TOR (Tropospheric Ozone Research). The aim of this research is to determine the quantitative role of the Arctic in the hemispheric ozone budget. In addition to ozone, other important compounds, such as hydrocarbons and carbon monoxide, are also measured. Photochemical modelling combined with meteorological information, such as air parcel trajectories, is an important tool in the work to gain increased understanding of the ozone problem in Europe.

Stratospheric ozone

Whereas increased amounts of ozone in the troposphere is unwanted, we do not want any reductions of ozone in the stratosphere since it shields us from the harmful ultraviolet radiation (UV-B) from the sun. However, it has become a well known fact that stratospheric ozone has seen a decline both in the Antarctic (the ozone hole) and in the Arctic. The ozone decline in the North is far less dramatic than in the South, but it is still a matter of great concern. The last two years have seen record low amounts of total ozone both in the Antarctic and at middle and high latitudes in the Northern Hemisphere. There is no doubt in the scientific community that the Antarctic ozone hole is caused by active chlorine and bromine released from the chlorofluorocarbons and the halons. On the other hand, it is less clear what the reasons are for the observed decline in Northern Hemispheric ozone. During the last two years there is increasing evidence that chlorine and bromine chemistry is, at least partly, responsible for the ozone deficit in the North.

The ozone decline in the Arctic can be explained by the same mechanisms responsible for the ozone loss in the Antarctic, although the extent, duration and "depth" of the ozone loss in the Arctic is much less severe.

NILU performs stratospheric measurements at Ny-Ålesund and on Bjørnøya. At Ny-Ålesund a UV-visible spectrometer measures total columns of ozone and nitrogen dioxide (NO_2). This instrument is part of a larger network of similar instruments deployed at many stations in Europe. Data from this instrument are collected via modem every day. Ny-Ålesund has also been chosen as one of the primary sites of the Network for the Detection of Stratospheric Change (NDSC), which is a global network with international (American, European and Japanese) participation.

At Bjørnøya NILU has carried out ozone sonde launches in collaboration with the Norwegian Meteorological Institute (DNMI) since October 1988. Average ozone profiles from Bjørnøya show that the ozone concentration was considerably lower in 1992 than in the years 1989–1991. The downward trend continued in 1993.

Radioactivity data

At the request of the Ministry of Environment in 1986 NILU has established a network for monitoring of radioactivity. The network consists of 22 stations in Norway, including one at Svalbard and one station in Verhnetulomski at the Kola Peninsula in Russia. The nuclear instrument "package" consists of an electronic unit, a power unit and a detector (ionization chamber). The instruments are connected to a NILU data logger. The radioactivity level is measured continuously. The data centre at NILU automatically polls data from all measuring sites every 2 hours. Certain criteria are set to avoid false alarms. NILU personnel will be alerted by a pager connected to the national cellular telephone system when these limits are exceeded. The pager will inform about the nature of the alarm in clear text. All radioactivity data are transferred to NILU's external data base and can be read world-wide by researchers who have access to this database.

International co-operation

NILU has acquired experience in data collection and dissemination through several national and international projects. From the period November 1991 – April 1992, NILU hosted a data and operational centre for the European Arctic Stratospheric Ozone Experiment (EASOE). Experimental data from 60 research groups, meteorological data from the European Centre for Medium range Weather Forecast (ECMWF) and satellite data from NASA were collected in real time and made available to all the participants, on-line during the campaign, and on CD-ROM after the campaign. The data centre is also used for the Second European Stratospheric Arctic and Middle latitude Experiment (SESAME), which is a follow-up of EASOE and will end in 1995.

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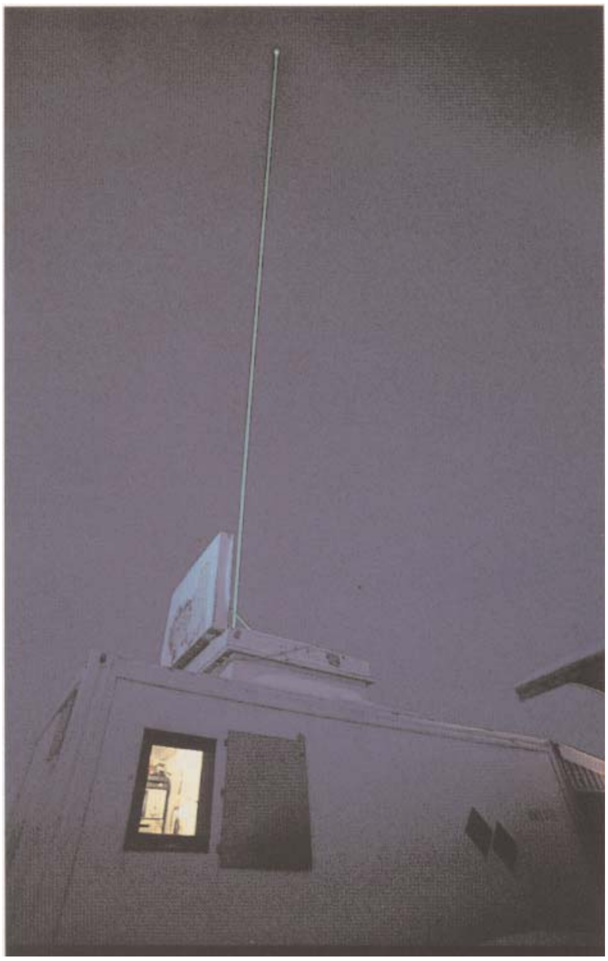

Photo: G O Braathen, NILU

Lidar measurements carried out by the German Koldewey Station. These measurements give vertical profile information on particles and ozone from 10–40 km in the stratosphere

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Operation and maintenance of telecommunication networks and services in Arctic conditions

BY KLAUS GRIMSTAD

Introduction

My experience from operation and maintenance of telecommunication networks and services in Arctic conditions was obtained during my stay at Svalbard as Technical Manager of the Norwegian Telecom, Svalbard Division, from 1988 to 1991.

Intuitively, everybody realizes that so close to the North Pole general aspects and conditions will be different from the Norwegian mainland. Climate, temperature, geology, and structure of society are made up of extremes which also may be found on the mainland. However, when all these individual extremes are brought together to a total, they give unusual conditions and limitations for the maintenance of the telecommunications network.

By accepting these limitations, and by considering the given conditions through daily routines, one can compensate for the limitations given by nature. By adding extra reliability to the network, it my sometimes even be easier to operate telecommunication networks under Arctic conditions.

Svalbard and Norwegian Telecom (NT)

Svalbard was formally established as a local division of Norwegian Telecom in 1981, when Norwegian Telecom acquired the local network built and owned by Store Norske Spitsbergen Kullkompani AS (SNSK) at Longyearbyen to serve the mining activity. Norwegian Telecom had until then been running the coastal radio, the air safety service and short-wave telephony to and from the archipelago. Furthermore, Norwegian Telecom was responsible for the internal short-wave telephony between inhabited places on the islands, except for the Russian population at Barentsburg and Pyramiden.

At the take-over of the local cable network at Longyearbyen, the local network was automized and the subscribers connected to the mainland via satellite (Nordsat A). Telephone and television transmission was extended to Longyearbyen, Ny-Ålesund and Svea during 1989–1990. This process was a part of the political efforts related to the Norwegian government's take-over of SNSK AS. The intention was to normalize the society by offering the same telecommunication facilities as on the mainland. This development was mainly achieved with analogue technology. NT's expenses at Svalbard were until 1992 related to the common Svalbard budget. Investments were given priority according to other requirements, such as housing, schools, hospital, sports installations, etc. Norwegian Telecom contributed with surplus material and great benevolence to cover up extra needs. In fact, the major cost of the network development was financed by the telecom budget. In addition to this, relevant operational activities were covered by Norwegian Broadcasting Corporation (NRK) (TV/radio) and the Civil Aviation Administration for the air safety service.

Technical installations and telecommunication services

During my work at Svalbard the technology was subject to rather extensive changes. The network status was:

Telephone service

- Approximately 40 analogue trunk lines between Oslo AKE and Longyearbyen ARM 503 group exchange via satellite. On the mainland there was an earthbound transmission from Oslo to Eik in Rogaland, then via Intelsat (Norsat A) to Isfjord Radio at Kapp Linne at the estuary of the Isfjorden, then via 2 x 900 channel radio link to Vestpynten at Longyearbyen airport, and finally to the telecom building at Longyearbyen on a mixed carrier frequency (CF) system via cable and 120 ch radio link.
- 1,000 lines ARK 521 local exchange and approximately 20 private exchanges (PABXes) of which SNSK AS's PABX network carried about 300 local lines including local switching arrangements in the coal mines.
- 24 ch CF from Longyearbyen to Ny-Ålesund via Kongsvegpasset relay station (powered from windmill and diesel generator). At Ny-Ålesund the connections were terminated in the PABX owned by the Kings Bay Company. Radio and television signals from Longyearbyen were relayed on the same transmission route.
- 24 ch CF from Vestpynten to Bykollen above Barentsburg, and from there via Russian owned cable to Russian subscribers.

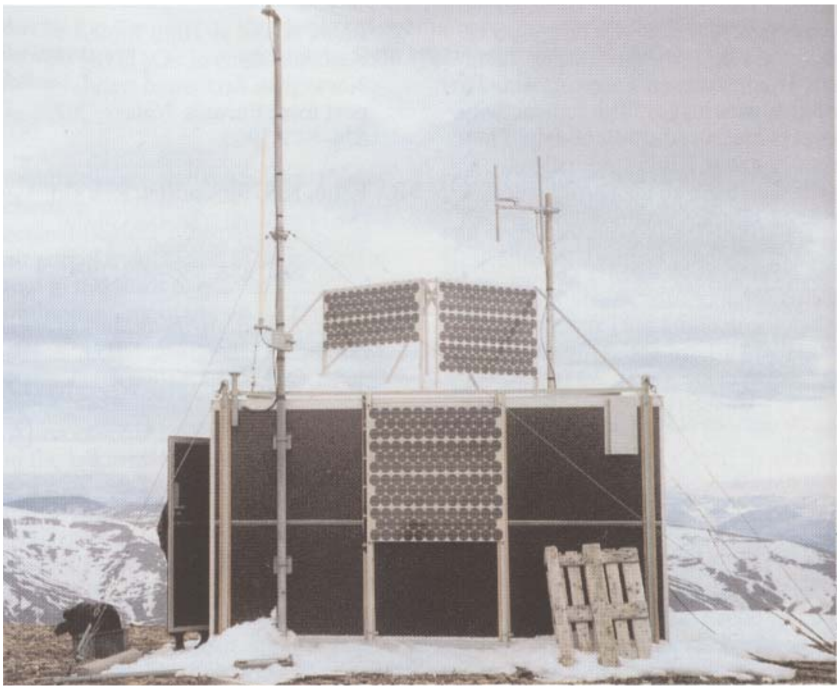

Photo: Klaus Grimstad

Figure 1 Radio relay point for closed VHF network for Store Norske Spitsbergen Kulkompani at Rundfjellet. Power is supplied by batteries lasting about one year in addition to solar panels

- 4–5 telephone connections from Longyearbyen via Isfjord Radio and Kapp Martin to the mining community of Svea in the Van Mien fiord. The distance between Isfjord Radio and Kapp Martin was supported by 10 ch PCM/ RL and 12 ch CF/RL. From Kapp Martin to Svea the connection was established via 4 Storno 1-channel radio links operating in parallel.

The coastal radio service (HF/VHF)

- Operator's desk and control boards for the coastal radio service are located in the flight control tower at Svalbard airport at Longyearbyen. HF transmitters at Isfjord Radio are remote controlled by the operators at Longyearbyen.
- VHF transmitters at Kapp Martin, Isfjord Radio and Longyearbyen.

Air service

- Garex operation and control desks in the tower at Svalbard airport
- ILS landing system at Svalbard airport
- Transmitters for air radio communication at Longyearbyen, Ny-Ålesund and Svea.

Television distribution (NRK)

- The satellite earth station at Isfjord Radio receives radio and television programmes which are transferred via 900 ch radio link to Svalbard airport, and via a chain of converters to Longyearbyen and Ny-Ålesund. There is a private satellite receiver for TV at Svea.

Radio distribution (NRK)

- FM receiver at Isfjord Radio via satellite (TV/RO) transmitted to a distributing FM transmitter at Longyearbyen and Ny-Ålesund via telephone type connection. Satellite based FM receiver at Svea
- AM transmitter at Longyearbyen operated from the local telecommunications network.

Data network service

- Fixed connections from Longyearbyen to Isfjord and via Norsat A (data link) to Eik and then to the X.25 node in Stavanger.

Telex service

- Fixed transmission lines to the telex exchange in Oslo.

In addition to the equipment supporting the different telecommunication services, the maintenance includes all aspects of housing and power supplies at Isfjord, Kapp Martin, Kongsvegpasset and the telecom building at Longyearbyen. In addition, the supervision and maintenance of antenna constructions, quay, cranes, ships, and snow scooters for transportation to and from the installations at Isfjord and Kapp Martin.

The service organization

Isfjord Radio

- Station manager and two telecommunication engineers responsible for operation and maintenance of the satellite earth station, radio transmitters and transmission equipment
- One mechanic responsible for running three diesel generators, windmill and generator at Kapp Martin, sewage and sanitation, tractor, supply boat and the quay construction
- One cook for cooking, cleaning, and general household jobs.

Svalbard airport, air safety

- Two telecommunication engineers supervised by the Civil Aviation Administration.

Longyearbyen

- One skilled lineman for cable work and installations
- One switching technician for operation of group and local exchange, PABXes and various equipment owned by the subscribers. The employee also takes care of buildings, rectifiers, and batteries
- Two telecommunication engineers on operative transmission systems, radio links, satellite receivers, FM/ AM/TV transmitters and data equipment from the suppliers IBM and Norsk Data, including PCs
- One Technical Manager responsible for planning, maintenance and investment projects as well as the daily supervision of all technical activities.

In total, Svalbard telecom area has a staff of 24 people, of which 11 are organized under the technical manager. The total maintenance budget for Svalbard area was approx. NOK 12 mill. per year in the early nineties.

Working cycles and priorities

Due to large climatic variations throughout the year it is necessary to have a special activity cycle in the Arctic areas. The transport of supplies, replacement of crew, outdoor maintenance work, inspection of antenna mast constructions, windmill constructions and buildings are mainly performed during the summer and autumn season.

If extensive outdoor work has to be done, these jobs must be given priority in the summertime. All indoor activities ought to be done in winter/ spring, which lasts from mid-October to the end of April. It is temperature, wind, rain, snowfall and daylight conditions that strongly influence the summer, autumn, winter and spring activities, and make it necessary to adapt the level of activity to the seasons.

Transport conditions vary a great deal with the seasons. When the fiords freeze and the winter snow covers the valleys, it is possible to travel by snow scooter throughout Svalbard. But due to the Arctic night conditions the scooter season does not start until January/February when daylight returns.

Helicopters and aeroplanes are used for local transport throughout the year. In the summer the fiords become free of ice, and transport by ship is convenient.

Freights to and from Svalbard are carried out by aeroplanes or ships from May to October, and aeroplanes only from October to May. The winter and spring seasons are used for planning and ordering of necessary remedies. This could be anything from washing powder and food supplies to oil supplies for Isfjord Radio. Spare parts and necessary maintenance equipment for all kinds of installations are ordered. Purchase of services from the mainland is also prepared to accomplish larger maintenance jobs during the summer and autumn months.


Photo: Klaus Grimstad

Figure 2 Enclosed oil rig at the Reindal pass


Photo: Klaus Grimstad

Figure 3 Close-up of the Norsk Hydro oil rig

Most of the goods and services for Isfjord Radio must be planned and accomplished this way. The maintenance efforts at Longyearbyen have a different character, because most of the goods and services can be bought from SNSK AS or other local contractors. Light goods may be shipped by post or air freight when delivery is urgent.

In the summer and autumn months there are a lot of outdoor activities. This is also the time for vacation and for changing of the staff. Summer assistants are hired, normally for a period of from 5–6 weeks up to 3 months. This period is very hectic for the Technical manager. He has to work "night and day" to keep activities going. However, as the light conditions are excellent with 24 hours daylight, and the nature itself gives few limitations, it feels quite OK to do one's best at this busy time of the year.

Late autumn and early winter comes as an anti-climax as for practical job activities. It is the time for finalizing jobs, budget preparation and long-term planning and projecting.

In collaboration with the Sysselmann (the District Governor of Svalbard) we can obtain free transport of goods with the District Governor's ship "Polarsyssel" or a military Hercules. The winter supplies and costly and heavy goods like cars and accumulators are often sent by ship or plane at the end of the summer season.

December to February are the worst months as for working conditions. If system failures occur, and the problems are outside the nearby area of Longyearbyen and Isfjord Radio, it may often be necessary to wait for weeks until the weather conditions allow transport by helicopter.

There may be a lot of idleness if the operating service is stable, and suitable indoor work has not been prepared. In the wintertime the staff have an overcapacity, and there is a need for extra activities to keep up the spirit. It is particularly important to keep the staff busy at the lonely place of Isfjord Radio. In the wintertime, travelling is difficult, and there may be weeks between each helicopter visit at Isfjord Radio.

At Longyearbyen, too, the winter period is spent on indoor activities. But by the end of January it is usually safe to make shorter trips by snow scooter on the glacier or to nearby cabins and communities like Svea. In this period we prepare for the great scooter season which lasts from March to the end of May. In May and June we again start to prepare for the boating season.

It is hard to describe a total maintenance cycle at Svalbard in just a few paragraphs – it has to be experienced.

A year with low maintenance efforts and an effective operating network could give a season of low productivity. To keep the activity at a reasonably high level, one has to employ the staff in investment projects and maintenance work continuously. If performed, it will give an optimum economic impact both for contractors and telecom workers.

When I arrived at Svalbard, the working conditions had for several years been marked by the fact that no investments should be made and maintenance expenses should be kept at a minimum. Therefore, the network had become rather old, which had resulted in frequent operational break-downs, expecially during the winter months. There was also a lack of traffic and a lack of capacity. It therefore felt necessary to start building a financial argumentation in order to start an upgrading of the telecommunication network. After energetic efforts, not least by the Director of Region North, the Area Manager of Svalbard and the Sysselmann, a political and departmental acceptance was achieved to transfer all telecommunication activities at Svalbard from the Svalbard budget to the budget of Norwegian Telecom. As a result, it was possible in the following years to accomplish an increased programme of investments, which gave a very high activity rate, performing a modern digital telephone network.

Combined maintenance and technical construction

The radio link route (900 ch analogue) from Vestpynten to Longyearbyen via a passive reflector at Revnesset, was completed. A radio link station was established at Bjørndalen to secure the communication route from Longyearbyen to Isfjord Radio. This was done because of the risk of an accident at Longyearbyen airport causing damage to Vestpynten RL station. A new 34 Mb/s digital radio link route was built between Isfjord Radio and Longyearbyen via Bjørndalen. 10 km of optical fibre cable connect Longyearbyen to the link stations at Vestpynten and Bjørndalen.

The cross-bar exchange ARM/ARK at Longyearbyen was replaced by a digital System 12 exchange. The cross-bar exchange was dismounted and given to the Russians. This ARM/ARK exchange has now been installed in the Murmansk area serving about 800 subscribers in the Russian telephone network. As the Russians took the responsibility of packing and transporting the exchange from Longyearbyen, Svalbard telecom area saved freight costs and work to get rid of several tons of surplus telecommunication equipment.

The digitization of the network caused a total rebuilding and moving of all technical equipment in the telecom building at Longyearbyen. Laying a new semi-conducting floor was necessary. Most of this work was done by own resources during periods of low outdoor activities. Much money has been saved by doing maintenance and investment work in low activity periods. For example, laying fibre cables in a 0.5 m deep trench was done at less than half the mainland prices because the contractor was free to do the work in his low season period. The telecommunication building could also be painted at half the mainland price. Great cost reductions can be obtained by getting offers from the contractors based on the condition that the work can be done when it is convenient for the contractor.

The digitization at Longyearbyen also involved changing of equipment at Ny-Ålesund and Svea. Because there was no digital transmission system to those places, RSUs could not be used. The solution was to use the analogue line concentrator ELD 96 and the existing analogue connections. Luckily, there was some ELD 96 equipment released on the mainland, and by extra service from the coastguard, who transported the equipment, the solution was free of costs.

As a consequence of the digitization we were able to offer SNSK AS Centrex service as a replacement for their PABX. In this way we ensured that SNSK AS's telephone traffic, both locally and to/from the continent, remained in the public network.

The telephone capacity was increased from 1,000 to 1,536 local lines. At the minimum there were only 60 free lines at Longyearbyen, and heavy traffic congestion to the mainland. New echo suppression equipment was installed. The quality of the conversations was then considerably improved. Because of the digitization, the people of Longyearbyen were also offered a new conference TV studio. An ISDN video telephone was also connected in order to demonstrate this service to mainland customers with pictures from the mighty nature of Svalbard.

Thus, working at Svalbard in a period of high investment activity brought practical and technical experience far beyond my expectations. The role of Technical Manager actually became very demanding with regard to co-ordination, inspection and creativity to carry out the tasks mostly with our own resources and at minimal expenses. The simplest way to describe it is: It was FUN. I believe that also my colleagues thought so, even if we had a complete change of staff in the middle of our busiest period. A transmission engineer and myself were the only people who continued from the season 1990 to 1991. There was also a change of Area Manager and Administrative Manager in that year.

Attention to customers and maintenance

Maintenance at Svalbard does not just mean fault corrections and maintenance work, it also means daily support to large and small customers. At Svalbard, too,

Photo: Klaus Grimstad

Figure 4 Visiting Barentsburg.
At the Russian kindergarten the telephone was a popular implement. This presentation shows the Russian equivalent to "White bear and Goldilocks" – "White bear and the telephone". Russians in the Arctic regions appreciate good telecommunications

the customers demand good service and quick delivery at the lowest possible price. In the summer of 1990 a delegation from Norsk Hydro AS arrives and asks about telephone and data services for an oil drilling project 50–60 kilometres way into the wilderness, with Svea as the nearest inhabited community. After some investigations Hydro found that it would be too expensive to establish a telephone connection to Svea. No deal was made, because it was still uncertain whether or not the drilling project would be realized. But on October 1, a message from Hydro is received. They will start drilling in the pass at the end of the Reindalen valley on January 1. Drilling has to be completed by April 1, 1991. Hydro merely demanded that Norwegian Telecom, as the only operator at Svalbard, should develop the necessary infrastructure to the drilling location on January 1, no matter what the expenses might be. What do you do in a situation like this? Should we take on the challenge to establish three RL jumps complete with housing and power supply in the middle of the wilderness of Svalbard in the coldest and darkest season, at three months notice with limited possibilities for transport and under extreme working conditions? How should we accomplish this job at an acceptable price with profit, and at minimal risk for the customer and to our own business? Would we be able to give the customer a guarantee that the telecommunication lines would be established in due time? All this at the same time as our biggest customer at Longyearbyen was going to get their entire telephone arrangement transferred to the Centrex service. To accomplish two such big jobs only with our local resources could seem difficult even to the greatest optimist.

However, we were not totally unprepared. The conditions for a radio link route to Reindalspasset had been surveyed and some planning was done at our own risk following the initial meeting with Hydro. We could therefore say yes as soon as the order appeared. A contract was signed on the condition that the customer approved our technical solution, was responsible for transportation and all transport expenses of all the necessary telecommunication equipment and labourers, kept necessary equipment and manning to establish housings and power supplies, and was responsible for inspections and fuel supply during the drilling period. Hydro should also bring all the equipment out of the area after completion of drilling.

The project was completed with a delay of three days and at a total cost for the customer of NOK 0.5 mill, even if Mother Nature and her Master were preparing for the hardest winter in several years. We succeeded, even if we sometimes balanced at the edge of what was acceptable as regards strain to the staff.

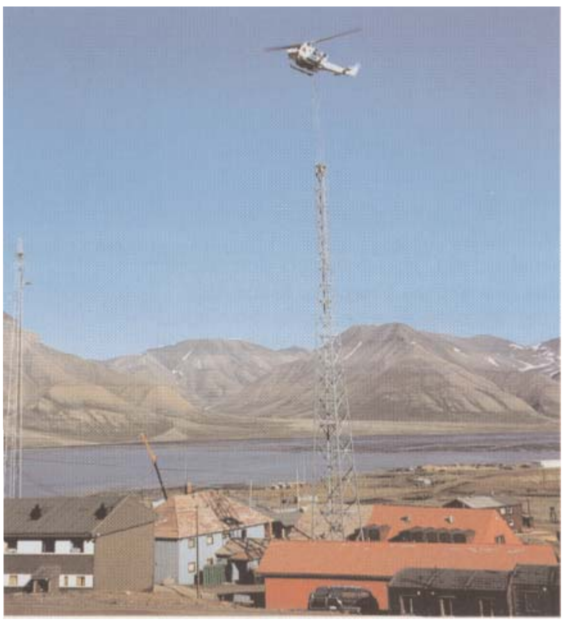

Photo: Klaus Grimstad

Figure 5 Top section of the new mast is put into place with the help of a helicopter

I wish to give my colleagues great credit for taking the challenge to carry out this job to everybody's satisfaction, without having any experience from the wintertime at Svalbard. Being pushed to the limits of what regulations can accept must be understandable, because telecommunication services also mean security for others. In this case it concerned the safety of 30–50 oil workers as well, who had very poor communication facilities to the outside world during most of December of that year.

In the same period of the year we managed a successful reconnection to Norway's greatest and northernmost Centrex service at that time, also mainly with the use of our own resources. However, other customers sometimes had to step aside, which was necessary under such conditions. Luckily the renewal of the network left us with almost no maintenance problems in this period.

At Svalbard, Norwegian Telecom has its special customers, too. In 1988 the ice front between East and West started to melt, when Gorbatchev introduced "Glasnost and Perestrojka". The milder climate was quickly noticed at Svalbard both in the form of closer contact with the Russian miners and of the Russians wanting Norwegian dialling tone at both Barentsburg and Pyramiden. At Barentsburg it was quite easy to establish telephone connections to the Norwegian network. The Russian mining community at Pyramiden is fairly inaccessible, so to manage the job without investment resources and without any cost for the Russians also became an art. Stretching the resources to get a maximum out of every penny became a great challenge for the Technical Manager. Also Pyramiden got its long awaited dialling tone by a single radio link, although operating below the normal quality of service. A lot of benevolence from the Sysselmann and his helicopter crew and some surplus Storno equipment from the mainland ensured a solution without any expenses.

At an early stage of my service at Svalbard, I experienced that the Russians at Svalbard are well educated, have technical knowledge and high competence within telephony. However, they are short of equipment. A bit of luck and some knowledge of radio technology saved my professional pride and the Norwegian teletechnical reputation. At the first project meeting with the Russians we presented identical route calculations to establish a connection between Pyramiden and Vestpynten. With a combination of route calculations performed by radio professionals at Lødingen, Norway, and good judgement on my part, we agreed upon the solution.

Supervising the operation of one single telephone subscription in a settlement belonging to another country via an unstable radio connection is a challenge, especially when the telephone is locked up in an office, and there is a natural language barrier to be kept in mind. To mend the problems we wisely introduced a routine whereby the Russians at Pyramiden would make a call every morning to the transmission technician at Longyearbyen and have one metering pulse credited each day from Norwegian Telecom. The arrangement was effected and the following incident took place every morning at 9 o'clock: "Brr ... Pyramiden ... click". This shows how simple it can be done, we did not even need to say "Good morning" in Russian. A similar solution with surplus Storno equipment was established to support the hunter Harald Soleim at Cape Wijk with a standard telephone service at an acceptable price.

Operating disturbances

One summer there was a snow and stone landslide down Vannledningsdalen at Longyearbyen which took away the road, the bridge, electricity, pipelines for hot water and sewers and two 300 pair telephone cables. After one hectic day the cables were repaired.

Several times the generator at Kongsvegpasset stopped. Kongsvegpasset is a relay station which is very inaccessible. A windmill breakdown at Kapp Martin also occurred. An accumulator cell stopped working and quay cranes collapsed. Most of the time there was something to attend to. Helicopter transport caused much of the maintenance expenses. Due to difficult weather and lighting conditions, the flights, especially to Kongsvegpasset, often turned out to be unsuccessful. Sometimes we had to wait several days for the weather to clear up. When the customers became impatient, the helicopter took off and had to return without success at a cost of NOK 30,000. Such episodes gave us a bitter experience, made us more careful, and also developed our interest in Arctic meteorology.

Because of the climate, extreme demands are made on transport security, both in the air, at sea and not least, by snow scooter transport. For safety reasons, at least two persons were normally involved in carrying out demanding maintenance jobs. The transmission technician often brought along an installer or a switching technician, while the other transmission technician took care of business at the base. Under such working conditions demands are made on efficient co-operation and exchange of professional knowledge. To establish co-ordination between different groups of occupation is necessary. At times, the Technical Manager had to work together with the entire staff.

Maintenance of the rather large station at Isfjord Radio is very challenging. From the very first day I chose to let the Station Manager take “command” for practical reasons, because it is difficult to interfere with the daily routines at a place 60 km away. This turned out very well, because the Station Manager gave me daily reports on the situation, needs and requests. We were responsible for co-ordinating transport to the station. Personal conflicts could occur at this kind of remote stations, especially in late winter at the time when the Arctic night is coming to an end. Most problems of this kind were solved by telephone as a result of teamwork and open dialogue. But at Longyearbyen, too, human conflicts could sometimes “pop up”. Arctic night stress is a common phenomenon. Fortunately, we avoided great conflicts. Both my family and myself experienced three very special and pleasant years at Svalbard, which none of us would have been without.

I could have told many joyful episodes from both job situation and private life; covering everything from rising masts at Longyearbyen in record time with the help of a 50 metre mobile crane and helicopter assistance, to meeting with polar bears and views of the fantastic Arctic nature. Also having contact with the Russians and a constant stream of tourists, journalists, researchers and the changing population of Longyearbyen, made the days eventful all the time.

I want to pay a special tribute to the “permanent” inhabitants of Svalbard, who welcomed us in a fantastic way and shared Svalbard with us. I never experienced a negative response when I was in need of help from the local community we served. I will also take the opportunity to thank all the telecom employees on the Norwegian mainland who sportingly helped us with both materials, knowledge and experience when our limited resources were not enough. Without this support it would be difficult to operate the telecom network at Svalbard.

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From 1988 to 1991 he was engaged as Technical Manager at Svalbard Telecom Area.

Telecommunications' importance for safety at Svalbard

BY VIGGO BJ KRISTIANSEN

Photo: AS Lufttransport

Super Puma helicopter

Photo: AS Lufttransport

Dornier plane

The relatively short history of Svalbard contains many tragic and dramatic chapters. Nobody knows exactly how many people who have sacrificed their lives in this climatically inhospitable area. Natural forces, the enormous distances and deficiency diseases like scurvy, have been the most important reasons for human tragedies. In spite of the fact that the area has been known, right from the discovery by Willem Barents in 1596, as demanding, barren and dangerous, people with different backgrounds and qualifications have challenged Svalbard. The search for adventure and the wish to conquer have in many cases overshadowed fear and respect for the conditions in the Arctic.

The Dutch, Danish-Norwegian and English whalers had their golden era at Svalbard in the early 17th century. These whalers would often feel what being in the Arctic could bring in the way of toil and tragedies. With the vessels and implements of that time we must assume that shipwreck and other accidents often happened.

The first organized activity was the hunt for whales. The hunt was only done in the "ice free" period, i.e. the summer season. Staying the winter at Svalbard only became relevant when the Russians developed an interest for hunting land animals like polar bear, fox and reindeer, in addition to seal and walrus. The Russians kept up their hunting activity at Svalbard more or less consecutively for a hundred years, from around 1730 to 1830. History says nothing of how concerned the Russians were with their own safety when spending the winters at Svalbard; at least, there is not much to indicate that safety matters were organized in any way.

However, in 1867 some people used the point of safety for hunters as an argument in their own plans. That was when a few families in Tromsø, 25 people in all, applied to the King for government funding of a ship and various equipment for a move to Svalbard. They wanted to settle at Svalbard, and one of their arguments was that they could be of help to hunters in case of shipwreck or other accidents. The application was, however, turned down by the authorities on the following grounds, among others: "It is not known how long such a colony can manage under such tough conditions of nature." This was probably the very beginning of the concept of safety at Svalbard.

I have included this introduction in order to illuminate the attitude of that time to the concept of safety. In relation to safety requirements of the present time, we can only express admiration and respect for the people who at that time set out on such adventurous undertakings. Should anybody attempt the same today, without complying with safety regulations and without using available safety equipment, we would call it hazardous and unwise.

An arrangement for safety and preparedness must be organized and adjusted to the specific conditions characterizing the area. Not only do we have to consider the enormous distances, which make the time factor so important, or natural and meteorological conditions putting restrictions on any rescue operation. It is just as important to adjust to possible rescue operations as a consequence of the high degree of mobility in the area. The permanent number of inhabitants total a mere 3,000 – 4,000, most of them living at Longyearbyen, Barentsburg and Pyramiden. In addition, there are at times a considerable number of fishing vessels in the area, and in the summer quite a few cruise liners with a total of many thousand passengers and crew on board. Tourist traffic to Svalbard has increased tremendously over the last few years, and many of the tourists set out on long hiking trips on their own or in organized groups. It is a positive development that more and more people use emergency direction finders and GPS when travelling in the area.

When Norwegian Telecom established a radio station at Svalbard in 1911, the foundation was laid for a considerable improvement of safety for the people in the area. Radio communication between Svalbard and the mainland brought a greater degree of safety both for people stationed at Svalbard, and for shipping in the Svalbard region and on the sea routes between Svalbard and the mainland.

In accordance with paragraph 9 of the Svalbard Treaty, no military activities are allowed at Svalbard. A safety concept for Svalbard must therefore be based on the civilian infrastructure already at the archipelago. An arrangement for safety and preparedness of a quality that will meet all existing and future needs is dependent on good co-operation between various authorities.

A local rescue management team is organized under the supervision of the Sysselmann (District Governor). It consists of people from relevant professions: police, fire service, transport, doctor, aviation, telecommunications, etc. In the case of major operations, the main responsibility is with the Main Rescue Centre in Bodø. All the local participants offer their skills when the need arises or when the Sysselmann finds it necessary.

The most important tool for the Sysselmann in the case of any rescue operation outside of Longyearbyen, is undoubtedly the helicopters and aeroplanes in the area at any time. This stock has now been considerably strengthened by the fact that the Sysselmann has a helicopter of the Super Puma AS 332L type at his disposal. This machine is equipped with the very best in electronic instruments, including equipment for rotor de-icing, and has all the necessary equipment for rescue operations both at sea and on land. The helicopter, which is stationed at Longyearbyen, has a range enabling it to cover the whole of the relevant area, reaching from 74 to 81 degrees north latitude and from 10 to 35 east longitude. This area corresponds to the area defined in the Svalbard Treaty as the Svalbard Archipelago. As mentioned, the helicopter is at the Sysselmann's disposal, but is operated by pilots from the company Lufttransport.

Lufttransport also operates commercial flights using other helicopters and a plane of the Dornier type. This plane seats 18 passengers and can fly Longyearbyen – Tromsø non-stop in 2.5 to 3 hours. The plane is also employed by the Coast Guard on inspection duty in the Svalbard region. If considered necessary, all of Lufttransport's aircraft at Svalbard may be used in possible rescue operations.

The Russians also have helicopters stationed at Svalbard. Their base is at Kapp Heer near Barentsburg, and if necessary, they too can be used in possible rescue operations.

Communication to/from helicopters and planes is handled by Svalbard Radio which operates integrated with the AFIS service from the tower at Svalbard Airport. The combination service of coastal radio / AFIS has proved to be very efficient at Svalbard.

At Longyearbyen there is a modern and efficient fire service. The fire call service is based on calls being made by telephone, which requires the local telephone system to be available and reliable.

The same may be said of the medical service which is established in a new and modern hospital at Longyearbyen. Even for this activity it is essential that the telecommunications are operable, not just locally at Svalbard, but also with the mainland. In some cases the local medical staff has needed to consult specialists on the mainland. This may only be done by way of telecommunications. I would also like to mention that Norwegian Telecom has established a video conference studio at Longyearbyen. By use of this a doctor at Svalbard could achieve greater effect from his consultations with specialists on the mainland.

The biggest rescue operation carried out at Svalbard was in June 1989 when the cruise liner *Maxim Gorkij* was nearly shipwrecked near the ice west of Svalbard. The situation for the 950 people on board was dramatic as the ship collided with massive ice more than two metres thick and had its hull ripped open in several places. The largest gash was six metres long. The ship took in water and the passengers were ordered into lifeboats, which were then lowered.

Svalbard Radio picked up the emergency call from the ship at 0030 and the rescue operation was immediately carried into effect. Both Norwegian and Russian helicopters took part in the operation. In addition helicopters and an Orion plane from the mainland were involved, as well as the Coast Guard *Senja* and the Sysselmann's ship, the *Polarsyssel.*

Svalbard Radio played an important part in the communication both with the helicopters and with the ships taking part in the operation. When the operation was called off after 18 hours, the local rescue team, under the leadership of the Sysselmann, could sum up that all passengers had been rescued from the sinking ship and that no loss of life had occurred in this dramatic play acted out on a scene with a backdrop of ice and Arctic Sea.

Thanks to telecommunications the whole world could follow the development of the drama by the minute. Capacity on the satellite connection with the mainland was congested as soon as the accident became known, but a well disciplined local population, who were requested not to use the connection with the mainland, did their best in order that the rescue management team and the news media could carry out their traffic without complications.

Nobody can guarantee absolute safety in any conceivable situation, but our aim will always be to try to improve the conditions for our own activities, so that the total level of safety increases. Safety can always be better, actually it is only the available amount of funding which sets the limits.

Photo: NTB

Odd Blomdal, the Sysselmann (District Governor) of Svalbard

Telecommunications at Svalbard must be said to be on par with what you find on the mainland. The only service at present lacking is a mobile telephone coverage. Most of the people visiting for the first time express their astonishment at finding such a well developed range of telecommunication services.

Development and updating of the telecommunication network and the telecommunication installations have been going on for a long time, but a new era for this activity may be said to have started when Svalbard obtained satellite communication with the mainland. The aspect of safety has been taken care of by the fact that alternative transmission paths have been established, the buildings of the radio relay stations have been updated, and multi-generator solutions have been sought out in order to secure continuous power supplies.

Norwegian Telecom at Svalbard has been, and will still be, a great contributor to establishing safety and security for the people living at or visiting Svalbard or the Svalbard region.

Viggo Bj. Kristiansen is Area Manager of Norwegian Telecom's Svalbard Telecom area.

Experiences from Arctic telecommunications

BY GUNNAR CHRISTIANSEN

On the 80th anniversary of the first telecommunication connection between Svalbard (Spitsbergen) and the mainland, much attention was paid to the importance of telecommunications for developing and underlining the Norwegian claim of controlling the archipelago. In the same year – 1991 – we celebrated Store Norske Spitsbergen Kulkompani's (SNSK) 75th anniversary. The coal mining in the Advent Bay can trace its foundations back a further 15 years, but then as an American property and interest. It is significant for the Norwegian interests in the archipelago that the first Norwegian telecommunication station was localized to a Norwegian whaling station at Grønfjorden. It was not until 1930 that the station was moved to Longyearbyen; reasons given for the move were of a financial kind. Economy is often used as a buffer, but that could hardly be consistent with marketing and further developing a station so far away from the main population. In recent years we have seen that technology has required locating the satellite connection at Kapp Linne, at Isfjord Radio. The editor of this publication has asked me for some popular considerations on the importance of telecommunications connections in an Arctic society. It is natural to claim that telecommunications means or brings a sense of unity.

With the experience of over 30 years and the opportunity to observe the development of telecommunications at Svalbard, this assertion remains fundamental. From being a community in the last part of the 1950s with an unstable and unrecognized telephone connection, to the possibilities of today with global satellite connection from one's own living room, the Arctic community has changed characteristics within several areas. One of the veterans indicated that being able to contact his family from his own home was the very best enterprise. This was a revolution in which we took great pleasure in from the 1980s onwards; being able to make a call at our own leisure and in full privacy.

The manual period brought close contacts with both Svalbard Radio and the mainland contact, Harstad Radio. There was a lot of creativity needed on both sides of the ocean. Many conversations needed help from one of the stations, and it was not unusual for the operators to be on the line taking care of necessary interpretation.

I have always been surprised by the great significance of the weather for our communication. Few conversations were completed without the weather situation having been summed up. Through this clarification one was also briefed on the general situation at both ends of the line, and could perhaps pick up possible discords; this as an excuse for a brief and technically difficult telephone conversation being centred around the weather conditions.

One must not forget that the conversations were not really of a private character, they mainly took place in one of Norwegian Telecom's early developed phone boxes. The chief steward had an appointment with Svalbard Radio about collecting the call charge. The charge was given by the operator on duty at Svalbard Radio after the end of the conversation; often approximately reduced in relation to the technical quality of the conversation. The conversations could of course also be made from the Norwegian Telecom building or from some of the offices. The coal company had constructed and owned the local network, and the internal telephones primarily covered the mines and the operational divisions. There were very few telephones open for external traffic.

The early telecommunications set-up, with the open connection, could be quite interesting. All conversations could be heard over the radio, and everyone could listen in, until a frequency distorter was finally installed. Stories are still being told of Managing Director Brodkorb's conversations with the management of the Svea coal mine when the decision was taken in 1949 to cease the mining activities there. A forerunner of democratic resolving processes?

The telegraph was the safest connection and was in constant use until more telecommunication lines were established through the broadband system in the late sixties. The individual could then use telegrams, up to sixty words, at NOK 2.50, later increased to NOK 3.20 in the late fifties/ early sixties. That equalled the salary for half an hour's work. Speaking for myself, I did not have the pleasure of a telegram at Christmas or any other days. In my family telegrams are very serious, and are only used for sad occasions.

The company used telegrams for a number of work projects. There were separate series to the offices in Bergen and Harstad. The series were concerned with purchasing, personnel movements, shipping calls with loading directions, accounts, disbursements, and so forth. The telgrams would contain many abbreviations and standard formulations. A certain etiquett was to be maintained; all telegrams which did not have a number for ordering material or supplies, consistently started with the word "Please", showing some respect for the receiver.

Photo: Birger Areklett - NN/Samfoto

Advent Bay

There was a special interest in the telegrams for the Personnel Manager. Most of the employees were contract workers or people who did not plan on staying too long at the archipelago. Then, like now, the changes in personnel and plans had a common interest.

Svalbard Radio was operated by people alternating between mainland Norway and Svalbard. Many were employed at Rogaland Radio. In the early days they were alotted a bedsitter with a separate mess room, but later they would have flats big enough to house their families as well. They were a group of their own with a close contact with the coal company's employees, and they planned and arranged social events in the autumn, at Christmas, and in spring.

The station had a prominent place in the community with overnight accommodation for personnel from Isfjord Radio. These visits sometimes made good use of all the hours of the night, and could be heard in the vicinity. One Saturday night in summer, myself and a friend had been wandering about the mining community. The manager's family at the Telecom building was very hospitable, and we thought it would be nice to stop by. It so happened that the General Director of Norwegian Telecom, Mr Leif Larsen, was visiting that weekend. We were very well greeted, but understood that the general manager afterwards had commented that "the boys from Isfjord really lived up to their reputation".

I should add that at Isfjord, as at the other outposts, polar bear hunting brough a considerable increase in the income some years. Hunting with dogs was of course also rewarding in the daily life of the individual.

Personal contact with the personnel at the Telegraph was considerably better in the days of manual operation than it is today. People from the Telegraph would do daily errand rounds to the great mess room via the offices for delivering and collecting telegrams, as well as collecting charges for calls. The job might be done by the manager or the manager's wife. The route was done either on foot or on bicycle. It was pretty easy to check the customer's credit worthiness as it was the manager himself who made the errand round, but it also gave great opportunity for communicating with your customers which was well made use of.

Svalbard Radio had separate premises for a local radio which was a source of both pleasure and irritation. On the close of the national programme transmission, the operator would play regular request concerts in connection with birthdays and anniversaries, which went down well. My wife still claims that I asked him to play "I love you because" for one of her birthdays, it was probably Nat King Cole who conducted that version. The contact with the station personnel was good, and thanks to their effort it became possible to carry out plane landings on the tundra in the Advent Bay. The planes were informed on the weather and track conditions; quite a pilot service executed with a ship's radio from a workman's hut on the tundra!

The conditions under some of the ambulance trips were quite demanding on the crew both in the air and on the ground. Practice from the "normal" mail-flights brought the necessary experience. Another example of how good will can be put to good use, was something we experienced when the Svea mine was started up again in 1971. An unstable ship's radio connection had to be improved. The previous manager, then at Norwegian Telecom's main administration, found out that Svea Radio never had been shut down when the mining activities ceased in 1949. It was therefore easy to get material at short notice for the reopening of the station; an example of the willingness and understanding for experienced solutions which brought safe operation facilities in the Arctic winter.

One of today's topics is the safety of the travelling individual in summer as well as in winter. A mobile telephone on the snow scooter or in the boat, possibly combined with a pager and gps-navigation, are examples of equipment one may choose in order to keep future travelling on a safe level.

We anticipate this development with excitement. However, the personal contact between people should still be emphasized.

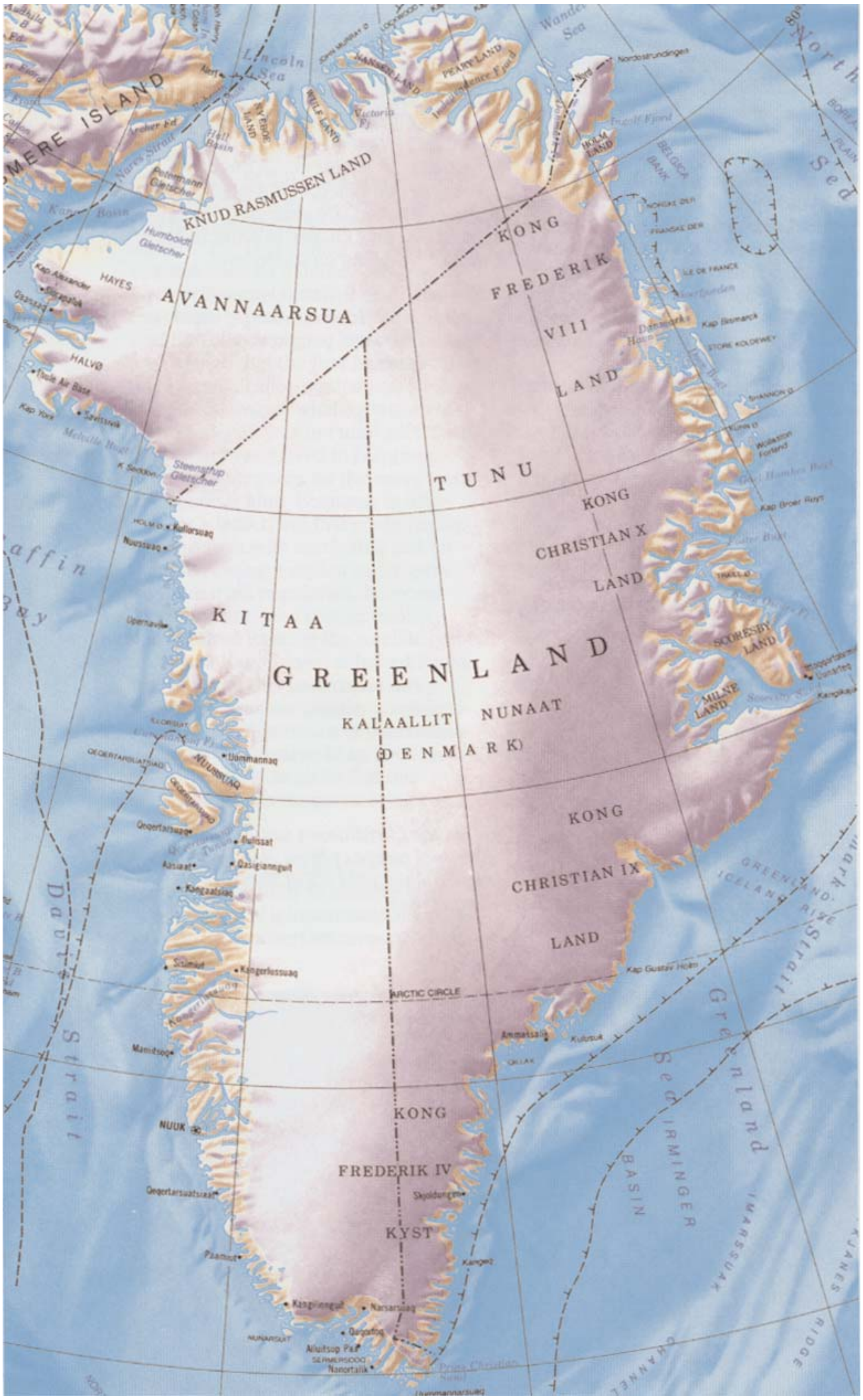
Gunnar Christiansen was Manager of the coal company Store Norske Spitsbergen Kulkompani AS at Svalbard for many years.

Photo: Ole Åsheim/Samfoto

Advent Bay

Telecommunications in Greenland – challenges and solutions

BY PER DANKER



Map: Canada Map Office, Energy, Mines and Resources Canada, Ottawa

Greenland

Greenland is a country with only 55,000 inhabitants spread over an area as large as the United Kingdom, Holland, Belgium, France, Germany, Austria, Switzerland, Italy, Spain and Portugal together. To provide telecommunication services in an economical and rational manner to a country like this is the challenge Greenland Telecom has to face.

About Greenland

Greenland is situated in the North Atlantic between North America and Europe and closer to the North Pole than any other country.

2,175,600 square kilometres make Greenland the largest island in the world. The ice-free territory covers an area of 341,700 km^2 – that is the size of the British Isles or eight times as large as Denmark. From North to South, Greenland extends some 2,670 km.

Mountains up to more than 3,000 metres high tower over large fiord 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 isolated settlements on the West and East coast. The capital city of Nuuk, with 13,000 inhabitants, lies on the South-West coast, where over 80 per cent of the population live.

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 typical for 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.

Greenland Telecom

The Greenland Home Rule Government has its own telecommunication company, Greenland Telecom (TELE Attaveqaatit), which administers the monopoly for telecommunication in the country on behalf of the Home Rule. The Danish PTT, TeleDenmark, is only the gateway for international telecommunications out of Greenland.

On the technical side Greenland Telecom is responsible for the telecommunication systems all over Greenland. Besides handling automatic telephone and telex subscriber services, Greenland Telecom offers a large number of supplementary services like mobile telephone, facsimile, data transmission, a public packet switched X.25 data network, etc.

Further, Greenland Telecom is responsible for transmitting and broadcasting radio and television programmes for Greenland Radio. 100 per cent of the population is able to receive the radio programmes and approx. 80 per cent the TV programmes.

Greenland Telecom is also running stations for aeronautical and coastal radio services with remote controlled hilltop transmitters and receivers covering the trafficked coastline of Greenland and an "In-Flight Phone" station offering telephony and data transmission to the international network for flight passengers passing Greenland.

For ICAO meteorological services including upper-air radio probes and synoptic observations are performed.

Greenland Telecom has its head office in Nuuk and employs a staff of approx. 400 in Greenland. The engineering and installation department, TELE Greenland International, is situated in Copenhagen with the status of a subsidiary company. With a staff of approx. 50 persons TELE Greenland International is still responsible for the planning and construction tasks in Greenland, but since 1992 the company is also exporting telecommunications products such as know-how and contractor jobs in other parts of the world.

The total revenue of Greenland Telecom in 1992 was 445 mill. Danish kroner.

Photo: Søren Madsen/Samfoto

Figure 1 Narssaq, Greenland

Photo: Søren Madsen/Samfoto

Figure 2 The fishing port at Narssaq, Greenland

The past in short

Public telecommunication was first introduced in Greenland in 1925 as the Danish government established radio stations in four towns (colonies) and founded Greenland Telecom.

The amount of radio stations grew by and by so every town got a station, but up to 1973 the domestic telecommunications network in Greenland and the international connection to Denmark consisted of this weak and unstable system of short-wave and long-wave radio.

The only means of communication with this system was by telegram, which for many years were transmitted by Morse telegraphy. From the early 1960s, however, life was made somewhat easier thanks to installation of protected telex systems.

A major step towards binding Greenland together as a single, coherent society was taken in 1972, when Greenland Telecom

Photo: Søren Madsen/Samfoto

Figure 3 Qaanaaq, Greenland

took the diction 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 1,500 kilometres, with 25 unmanned mountain top repeaters.

When the radio link system was established, four outlying 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, and in 1983 the domestic INUKSAT system was completed with six stations in Greenland and one in Denmark.

During the late 1960s and early 70s Greenland Telecom equipped the towns and major settlements with analogue cross-bar telephone exchanges. The establishment of the radio link and satellite system linked the subscribers together in a common telephone network and gave them access to the rest of the world.

Because of the extraordinary and varying demands Greenland makes on its infrastructure technology, Greenland Telecom has often had to be on the cutting edge of technological development. On many occasions standard solutions have either lacked essential final details or been totally inadequate. Greenland Telecom has had to work closely together with manufacturers to provide the last essential requirements or develop systems from scratch.

The investment policy

The expansion and running of telecommunications in Greenland had depended on grants from the Danish government from the beginning in 1925 until the end of the 1970s. But with the establishment of a modern Greenlandic telephone and telenetwork, Greenland Telecom obtained the income basis for business running of a telecommunications company in Greenland.

Thus, it was a self-financing company with a positive liquidity that Greenland Home Rule Authorities took over on January 1, 1987, and they have since, on January 1, 1990, made it into an independent, public company.

The financing of the modern telenetwork has been effected through the Danish Government by way of development loans from the European Investment Bank, but Greenland Telecom has been able to repay at a steady pace.

The constructive development for Telecom Greenland has continued since, so speaking about Greenland's own telecommunications company carries some weight.

It must be admitted that the price paid for getting a modern, self-contained telecom service has almost given the highest prices for teleservices in the world, even if it is a common aim for Greenland Telecom 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 common 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.

This task has almost 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 former deep isolation. At the same time, telecommunications have shaped the foundation of Greenland's development into a community with services and standards of living at the same level as that of other countries in the Western world.

As we all know, nothing is perfect forever and least of all telecommunications systems. Therefore, Greenland Telecom is constantly working with expanding and developing the Greenlandic telenetwork in the best possible harmony with the wishes and possibilities of the society.

Presently, Greenland Telecom is in the middle of a digitization project, renewing systems components and updating the technology to meet the requirements of a modern society.

Per Danker, B.Sc., has worked with Communication Systems in Greenland as Technical Manager for Greenland Telecom, Nuuk Division from 1966 to 1983. Vice General Manager in Greenland Telecom until 1992, when he was appointed Market Director in TELE Greenland International.

The INUKSAT system and its alternatives – a description of satellite communications in Greenland

BY PETER MALMBERG

Until 1978 all communications from Greenland to the outside world was carried out via short-wave radio and the so-called ICECAN cable. The capacity of these systems was limited to a few circuits which, during the 1970s, turned out to be completely insufficient due to the rapid development of the Greenlandic society.

Looking at the location and geography of Greenland it is easily understood that a communications system between Greenlandic towns and from Greenland to the outside world shall be built up by radio-based transmission systems. The capacity requirements in Greenland necessitate the use of radio relay systems in densely populated areas, while satellite communications is the only realistic possibility in the remote areas and for connections out of Greenland.

The radio relay system is described in another article. Here the development and use of satellite communications in Greenland is discussed.

Satellite systems

Only very few satellite systems give 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. However, when the satellite systems in Greenland were developed in the late 1970s this was regarded to be the only realistic possibility for a complete domestic system.

The EUTELSAT system was not initially designed for covering Greenland. But the EUTELSAT II generation of satellites became, upon request from the Signatory of Denmark, 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 an alternative, but until now it has 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 American military bases there. Today, one of these satellites is used by Greenland Telecom.

A general problem with geostationary satellite communication in Greenland is the low elevation angles, especially in the Northern areas. The Northernmost town in Greenland is located 1,200 km north of the Arctic circle. This also implies restrictions on the usable satellite position.

INUKSAT

In 1978 Greenland Telecom 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.

This solution turned out to be only temporary for various reasons:

- It did not meet the communication needs in the towns in Eastern and Northern Greenland
- The capacity was too low, so manual service was necessary with long waiting time during the busy hours
- It was difficult to expand the system as the circuits ran through Swedish territory with high transit charges per circuit.

To overcome these problems Greenland Telecom decided to lease transponder capacity in the INTELSAT system with the purpose of building up a domestic Greenlandic satellite system, including a connection to a station in Denmark.

The stations

Starting in 1990 with three Greenlandic stations operating at a 9 MHz segment of a Global Beam transponder the system has expanded to contain seven stations in Greenland, one in Denmark and one at an off-shore oil rig in the Danish sector of the North Sea, operating at a complete (36 MHz) transponder. Furthermore, stations in Canada and Iceland are connected to the system for services for the International Civil Air Organization (ICAO).

The stations shown in Table 1 are today included in the system.

The elevation angles apply to operation at the INTELSAT position 325.5° East, which has been used since 1988. As can be seen the station in Qaanaaq (Thule) has a very low elevation. This means that it has been necessary to operate this station with extremely high margins.

Furthermore, the station was completely out of service from 1989–92, when the satellite at 325.5° was inclining. Due to terrestrial obstacles the station could only

Table 1

Name	Latitude	Longitude	Elevation angle
Nuuk	64.19 N	51.74 W	16.24°
Aasiaat	68.71 N	52.86 W	11.66°
Upernavik	72.79 N	56.16 W	7.35°
Illoqqortoormiut	70.46 N	21.96 W	10.50°
Qaanaaq	77.51 N	69.23 W	1.59°
Ammassalik	65.60 N	37.69 W	16.02°
Kangerlussuaq	67.01 N	50.48 W	13.66°
Blåvand (DK)	55.57 N	8.10 E	16.26°
Tyra (oil rig)	55.72 N	4.80 E	17.57°
Skyggnir (ISL)	-----		17° *
D.Laurentides (CAN)	-----		31° *

* approximately

Photo: Telecom Greenland

Figure 1 The INUKSAT station in Aasiaat

Photo: Telecom Greenland

Figure 2 The EUTELSAT station in Qaqortoq

see the satellite for 13 hours a day during most of this period. As the down-time was following satellite sidereal time, it was not possible to plan a regular service under these circumstances, so it was decided to take the station out of service. After the successful reboost of INTELSAT 603 this satellite was located at 325.5° and a few months later normal operation could start at the Qaanaaq station.

Equipment

The main purpose of the INUKSAT system (INUKSAT is taken from the Eskimo word "inuit", which means human being) is to establish voice communication between Greenlandic towns and between Greenland and the rest of the world. Two important decisions had to be done during 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 unrealistic to build antennas larger than Standard B type. All the antennas at the Greenlandic stations are therefore 11 metres.

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

Modulation: The transmission network in Greenland was analogue when INUKSAT was specified. As a consequence it was decided to select an analogue satellite transmission system. Except for the link between Nuuk and Blåvand in Denmark the traffic structure is typically thin-route, 20 circuits or less between various stations. A suitable system to fulfil this is companded FM SCPC, similar to the system used in the INTELSAT VISTA systems.

As the world is getting still more digital, this also applies to Greenland. A plan has been worked out to make the satellite system completely digital at the end of 1995. The station at Kangerlussuaq

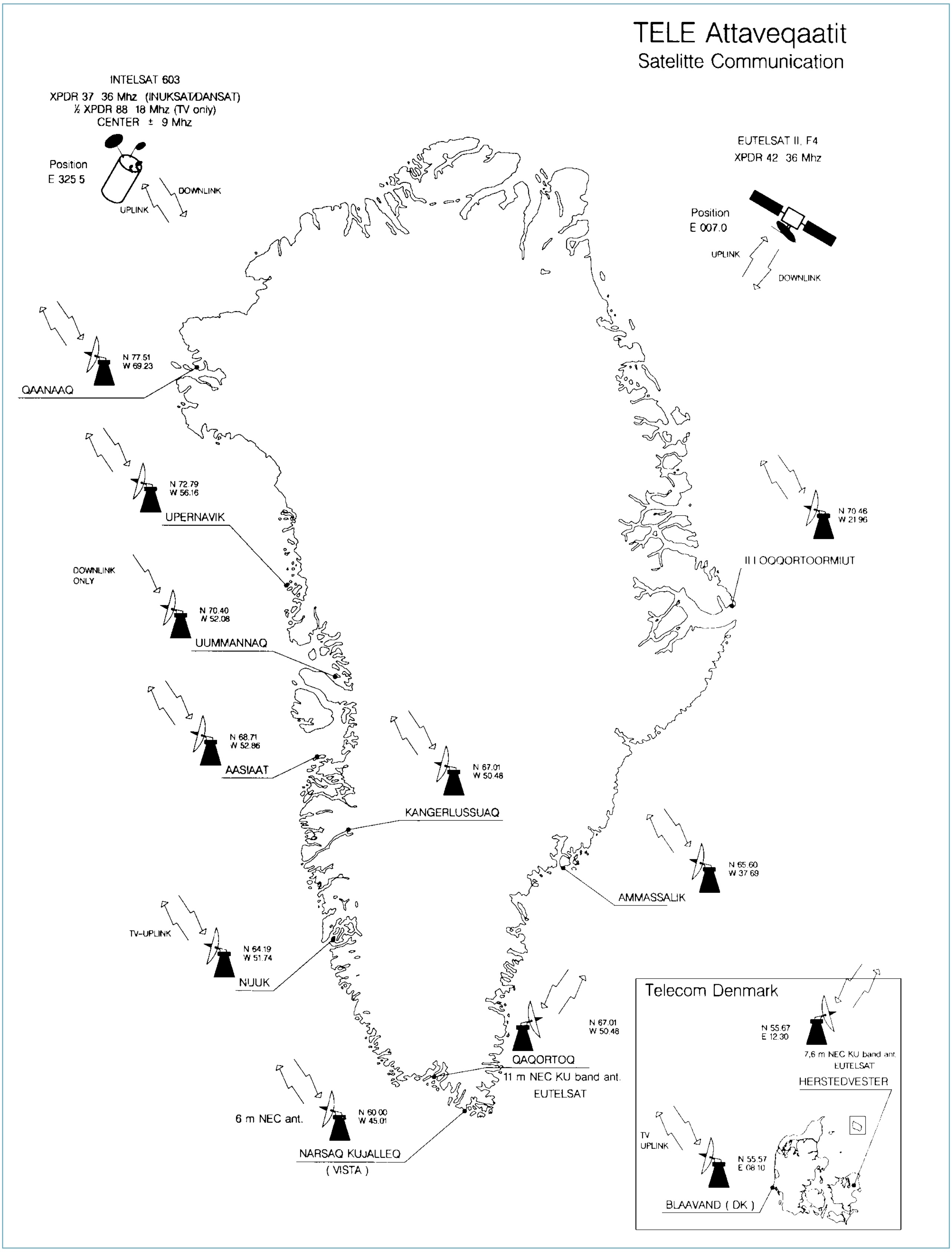


Figure 3 Satellite stations in Greenland and Denmark

(completed 1992) was built as a digital station, and the link between Nuuk and Blåvand has been digitized this year.

The number of circuits between Nuuk and Blåvand (90) made it possible to implement this link as one 2 Mbit with DCME. For the thin-route traffic to the other Greenlandic stations it has been decided to operate 16 kbit low rate encoding (LRE). For voice circuits this gives four times better usage of the satellite than normal IDB/IBS standard, without affecting the quality for the end-user.

Television

During the 1970s distribution of television in Greenland developed locally in many Greenlandic towns on a co-operative 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, there were still two problems to be solved:

- Programme transfer from the outside world to Greenland
- Transmission of KNR programmes to the towns on the east coast and in the north.

INUKSAT was initially not designed for TV. The costs of leasing an INTELSAT transponder on a permanent basis in 1980 for TV distribution only were too high for the Greenlandic society. So, the two problems described above were solved by tapes, flown from Denmark and redistributed by plane to the remote towns in Greenland.

For some special events other solutions were worked out. On the 5th of June 1985 a soccer game between Denmark and the USSR was transmitted directly from Denmark via France to Greenland on a temporary leased transponder in INTELSAT. The following year a TV up-link was established at the Blåvand station. Transmissions were only done occasionally.

The problem with analogue TV is 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°.

Upon request from KNR Greenland Telecom leased 18 MHz transponder capacity in INTELSAT 603. 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 applying the 11 metre antennas.

Instead, Greenland Telecom bought a newly developed digital TV system from CLI, California. This system compresses one TV and two audio channels to a digital signal at 6.6 Mbits. In this way it is possible to transfer two of these carriers within 18 MHz Global Beam capacity.

The 1st of November 1992 two digital TV channels were put into operation via the satellite. One of these were used for transfer of programmes from the national Danish broadcaster, Danmark's Radio, from Denmark to Greenland, and the other was used for transfer of KNR's programmes internally in Greenland. After a few months' initialization the service became fully operational.

Alternative systems

As mentioned earlier, other satellite systems are used in Greenland, although INUKSAT is by far the most important. It can be mentioned that Greenland Telecom in 1986 established an INTELSAT VISTA station at Narsaq Kujalleq in Southern Greenland for ICAO circuits to Canada.

EUTELSAT

In 1991 Greenland Telecom established a satellite station in Qaqortoq in southern Greenland for operation on a EUTELSAT II satellite. This station is connected to a station in Copenhagen via a transponder in EUTELSAT II, F4, located at 7°E. The capacity of this link is 2 Mbit with DCME.

This station is the only satellite station in Ku-band (14/12.5 GHz) operated by Greenland Telecom. Although the elevation angle in Qaqortoq is only 8.5° and the station is located at the -10 dB contour of the coverage of the satellite, this link has proved to be of remarkably good quality. It gives an alternative route to INTELSAT between Greenland and Denmark.

GE SATCOM

During the problems with the inclination of the satellites at 325.5° it was necessary to establish an alternative route to the Thule district. A national American satellite system, GE SATCOM, gives a reasonably good coverage of North-Western Greenland. A 2 Mbit link was set up between two stations at the American military bases in Pituffik (Thule) and Kangerlussuaq (Søndrestrøm).

When the US Air Force left Kangerlussuaq in 1992 Greenland Telecom took over operation of the GE SATCOM station there. Today, there are circuits to Pituffik and the United States via a GE satellite located at 288°E.

Future plans

With the digital TV distribution system completed and a digitization programme for the communication system on its way, combined with a reasonably good redundancy on the most important routes, it can be stated that the satellite communication system in Greenland today is fully comparable with the most modern system in any country. What will the future plans be?

One of the major tasks of Greenland Telecom during the rest of the century will be to establish communication to Greenlandic settlements, of which many today have very limited communication facilities. In many cases the best way to do this will be via satellite. Around 15 settlements have been identified where satellite communications might turn out to be the best solution. The key words for a station in a settlement are simplicity and low price.

Greenland Telecom is now working out an optimum concept for settlement stations. These stations will follow the same line as has been the situation for satellite earth stations in general all over the world during the past 15 years, smaller, simpler and cheaper. So the stations which we shall see in the Greenlandic settlements within the next few years will probably occur at many other places in the world.

Peter Malmberg, M.Sc., has been Manager of the Transmission Section at TELE Greenland International since 1992. He has worked with Satellite Communication Systems for European Space Agency, TELECOM Denmark and Greenland Telecom.

The challenge of building a digital radio relay system in Greenland

BY ANDERS KLOSE FREDERIKSEN

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 have to be specially designed and highly reliable.

Existing system

The existing analogue radio relay system in Greenland was established in the period 1973 to 1977. It covered the towns along the west coast from Ilulissat (Jacobshavn) to Narsaq Kujalleq (Frederiksdal), which is the area where most of the 55,000 people in Greenland live.

Digitizing most services in Greenland the analogue radio relay system had to be replaced by a digital system. The general requirement for higher capacity and the age of the analogue equipment made the change necessary as well. Also the shelters for equipment and lodging on the sites had to be replaced. 15–20 years in the Greenlandic climate started to show.

New digital system

The replacement of the analogue radio relay system was started in 1991 and will be finished in 1997. The replacement will take place in 5 or 6 phases. For each phase the construction of buildings, towers and power plants is made the year before installation and line-up testing of the radio-, supervisory- and mux equipment.

The frequency bands used for the system are 7725–8275 MHz and 7425–7725 MHz. A medium capacity 34 Mbit/s radio system using an N+1 configuration was chosen. The bitrate was kept as low as 34 Mbit/s in order to prevent the use of higher order modulation schemes. Using 34 Mbit/s and 4 PSK, most hops can be made without the use of space diversity, even though part of the hop is over water. The new radio relay system for Greenland is shown in Figure 1.

Infrastructure

The repeater stations in Greenland are located in very remote areas. The outdoor temperature is estimated to vary from -40

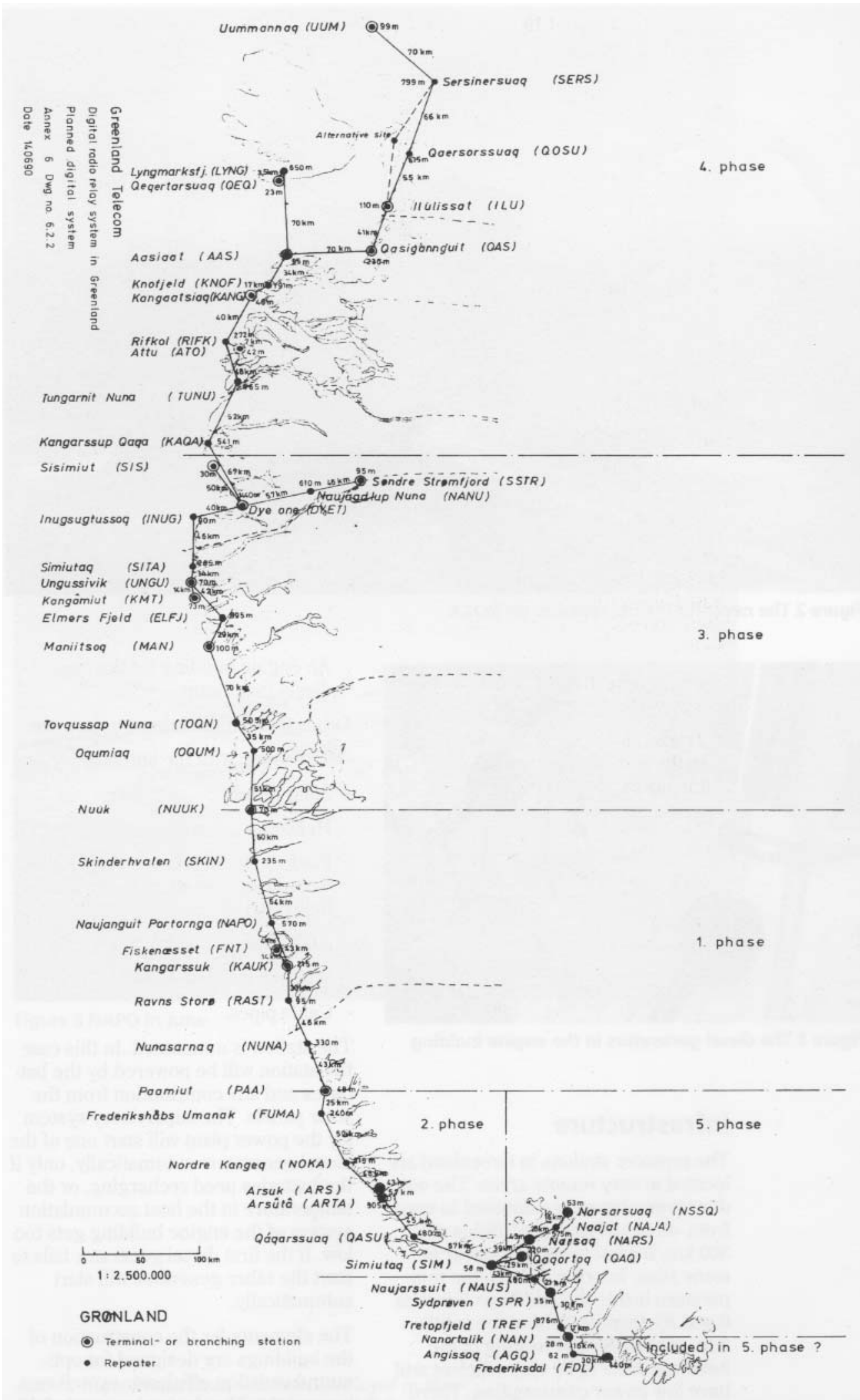


Figure 1 The new digital radio relay system for Greenland. The phases 1 and 2 have been completed, and was put into service in January 1994. Buildings and towers for phase 3 to UNGO were made in 1993

Photo: Greenland Telecom

Figure 2 The new and the old repeater on NOKA

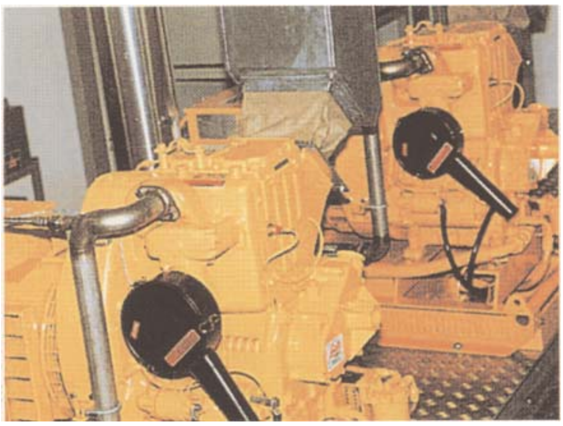


Photo: Greenland Telecom

Figure 3 The diesel generators in the engine building

to +20 degrees Celsius and 300 km/h wind gusts may occur in 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 and have low power consumption. There are two buildings on each site:

- A repeater building for the radio relay equipment, batteries and lodging
- An engine building for the two diesel generators.

Other parts of the infrastructure are:

- The tower with the antennas
- Solar panels
- Helistop
- Platform for set down of fuel tanks, when these are slung to the site by helicopter
- 4,000 liter fuel tanks
- Wooden walkways
- Cable pipes.

The station is unmanned. In this case the station will be 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 other 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 polyurethan insulation layer.

To prevent any over-heating 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 lodging is only heated when there is a maintenance crew on the station and the diesel generators have been started manually. In the unlikely event of both diesel generators failing, it is possible to heat the room for the maintenance crew using a petrol stove when needed.

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 till 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.

The design of the power plant with one or more redundant systems makes a total failure of the power plant very unlikely.

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 the DRO supervisory system, a supervisory system developed by Jutland Telecom (TELE Denmark). All important test points can be monitored and all main functions, such as diesel start, can be controlled via the system. The remote stations will be polled from control terminals placed in the three supervisory centres in Greenland: Aasiaat, Nuuk and Qaqortoq. Until now the centres in Nuuk and Qaqortoq have been installed.

The centres in Aasiaat, Nuuk and Qaqortoq will be monitoring the supervisory system of the radio- and mux equipment as well. When the system is fully installed, Nuuk will be the main centre with a 24 hours a day staff, and the possibility to monitor and control the other regions, too.

The supervisory system of the radio and mux equipment is divided into 8 polling sections, where each end of the polling section has the capability of becoming the master. In the regional centres in Aasiaat, Nuuk and Qaqortoq the host computers are placed. The two ends of a polling section will always be connected to two different host computers. The three host computers are connected using an X.25 network with the option of rerouting via satellite (EUTELSAT and INUKSAT), if the total fallout of a station should occur.

Like the design of the power plant the supervisory systems have been designed with redundant systems for maximum reliability.

Conclusion

Building a digital radio relay system in Greenland has only been possible with a special design of buildings and power plants.

The solution chosen is expected to withstand the Greenlandic climate for the next 15–20 years with a minimum of maintenance.

Photo: Greenland Telecom

Figure 4 NUNA. The solar panels are mounted on the wall of the engine building facing south

Photo: Greenland Telecom

Figure 5 NAPO in June

Anders Klose Frederiksen has been employed in the Transmission Department of Greenland Telecom since 1991. Since 1993 he has been Assistant Project Manager for the installation of the digital radio relay system in Greenland.

Development of telecommunications in the county of Murmansk

BY E N MESJTSJERJAKOV

Photo: Svein Erik Dahl/Samfoto

Murmansk

The programme for upgrading telecommunications in the Murmansk region calls for partnership, funds, technical support and training. The co-operation with the Norwegian Telecom is appreciated as a contribution to realizing the plans.

Introduction

Over the last few years co-operation between Norway and the county of Murmansk has developed in all spheres of the economy, and it is a pleasure for me to acknowledge that conditions for this co-operation have been made by joint efforts from telecommunication personnel from Norway and the Kola region. The development of modern telecommunications systems between our two regions has led to a considerable increase in co-operation between politicians, business people, researchers and other individuals, which is important in order to achieve mutual understanding and friendship.

The links in the chain of friendship, based on mutual understanding and respect, will be a contribution to the great cause of peace, which all good men on Earth strive for, and will see to the development of cultural and economic connections between countries and peoples. Our experiences from working with colleagues from Norwegian Telecom are convincing illustrations of the above assertion, for the implementation of our projects within telecommunications has been made possible by human connections based on friendship and mutual understanding.

In connection with the above, I would like to take this opportunity to express a heart-felt thank you to our colleagues from Norwegian Telecom: Svein M Pedersen, Atle Andersen, Halvard Austlid, Kurt Markussen, and many other highly qualified experts, with whom we have had a long and fruitful co-operation. We have enjoyed sharing both work and social life, because these are people with culture and orderliness.

Completing my introduction, I would also like to thank the editor of this publication for giving me the opportunity to use this space. I see this as another chance to tell the readers of this periodical of our business, problems, and worries, something which in my view may help strengthen our co-operation.

Our company

The main occupation of the state owned company for communications and informatics, Rossvjazinform, is the development and operation of telecommunication plants in the county of Murmansk. The company comprises 11 telecommunication areas, the Murmansk city telephone network and own production, consisting of long distance exchange and telegraph exchange. Until recently, the television centre and post offices in the county were also sub-divisions of our company. These sub-divisions have now become separate structures, which is a step towards the reorganization into a limited company.

In total, there are 3,200 telecom experts working in the county, operating a telephone network of some 180,000 subscribers, a telegraph network, channels for intra-zone communication and cable radio network. Gross income for 1993 is stipulated at 5–6 billion Roubles (rate of exchange 11.9.93: NOK 100 = 145 Roubles).

Unfortunately, it is impossible to make precise estimates on our income, because of the processes of inflation which the Russian economy is exposed to. It leads to a constant need to re-assess the prices for our services and usually increase them. We trust that the readers of this periodical are familiar with the economic reforms taking place in our country, and the self-contradictory processes connected to them. Our company is not run in a vacuum and is obviously influenced by the negative and positive changes in the economy. On the one hand, we fully understand that the establishment and functioning of market economy is impossible without supplying the market subjects, including commercial structures, with modern communication systems reacting quickly to changes in the market. This means that modern digitized telecommunication networks must be established at an increasing rate. These networks should offer not just telephone services, but also data communication, electronic mail services, mobile telephone, video conferences, and so forth. But, enormous investments are needed for this.

On the other hand, the possibilities for increasing investments in the company are very limited, as inflation is galloping and volume of production is decreasing (in 1992 telegraph traffic decreased by 60% and trunk traffic by 18% compared to 1991). The chances of a sudden increase in prices of telecommunication services are limited by the customers' inability to pay. Credit resources are given by the banks at 220% and have simply become too expensive.

This paradox has spurred us to seek new ways of attracting investments into the telecommunication development. In 1993 the limited company Sevtelekom was established. It is now in operation and the owners are, besides ourselves, Murmansk Shipping Company, all fleets belonging to the fishing co-operation Sevryba, sea and fishing ports, Arktikpromstrojbank, and many other companies who have convertible currency at their disposal.

The development of a superimposed digital network in the county started as early as 1993 with the help of united currency funds from the shareholders. The aim of this company's activity is to establish a digital telecommunication zone within the county, which is integrated to the national and international network. As the newly established network is developed, (morally and physically) antiquated switching systems and transmission systems will be taken out of operation, and an increasing number of subscriber will have access to the new communication services. Besides, the newly established network will form the basis for developing multi-programme television in the county, including cable television.

At first, the trunk traffic for most of the subscribers will be routed via a semi-digital automatic long distance exchange of the "Kvarts" type. On completing the digital zone, the question of using the digital exchange S-12 for these purposes will be discussed. This exchange now operates in the dedicated international network belonging to the joint Norwegian-Russian limited company Kolatelekom.

In general, our plans for developing telecommunication services in the county of Murmansk are as described. At the same time we openly admit that the financial possibilities for realizing these plans clearly are inadequate, even with a large company like Sevtelekom. This is why we are persistently continuing our search for investors. Aided by the county administration, we are working with the question of funding based on long-term credits from suppliers. Frankly speaking, we are also counting on a substantial help from the newly established Barents Region Council. Because more efficient economic co-operation is not just dependent on good roads, but certainly also on modern telecommunications systems.

In connection with the approved concept of digitizing the network, it will also be necessary to solve the problem of personnel training. In the near future, five of our experts are going to South Korea on a two months training scheme with the company Samsung. Another ten experts are going to the company AT&T's training centre to study a digital exchange of the 5ESS type. We are also very grateful for the help we have received from colleagues at Norwegian Telecom – about 20 of our experts have visited some of Norwegian Telecom's sub-divisions for short-term training. Other alternatives for speeding up training of our personnel are being discussed.

A question then arises: "If development and reorganization of the network is to be carried out by Sevtelekom and Kolatelekom, what will be left for the telecom administration of Murmansk's (GPSI) sub-divisions to do?"

During the initial period of the divisional digital telecommunications, the main tasks for Rossvjazinform's sub-divisions will be:

- Maintaining existing communication equipment on the highest operational quality level
- Rehabilitating and extending capacity in existing lines
- Technical operation of new switching systems, lines and transmission systems in accordance with agreements with Sevtelekom and Kolatelekom
- Development of new service types, including a network of business centres offering international telephone and telefax communication, electronic mail services and information services.

Even now, one of GPSI's sub-divisions can inform customers of demands at the raw material exchange in Russia, of all acts passed by parliament and of all changes made in the acts of parliament (the programme "Consultant plus").

With regard to the ever closer connections between Russia and Norway, I think that Norwegian Telecom could offer these services to their customers by subscribing to our information network. At least I think a market survey ought to be carried out.

Finally, I would like to send friendly greetings to the readers of this periodical from all telecommunications personnel in the county of Murmansk, wishing them good results in their work as well as in their private lives, and express a hope for further development of our co-operation.

E N Mesjtsjerjakov is Head of GPSI "Rossvjazinform" for the county of Murmansk.

Photo: Ole Åsheim/Samfoto

Murmansk

Norwegian Telecom's efforts in North-West Russia – development of a dedicated network in Murmansk

BY ATLE ANDERSEN

In November 1989 the telecommunication authorities of North-West Russia and Norway signed a document stating an official agreement of co-operation for developing telecommunications in that part of Russia. This article describes what has been done so far, and the experiences from the project.

1 Milestones in the co-operation

As a first concrete result of the co-operation with North-East Russia, a 34 Mbit/s radio relay system (NERA) was installed in 1990 as a border connection between Norway and Russia. On the Norwegian side the radio relay system is terminated at Lyngberget radio link at Kirkenes, and the communication is routed on to Vadsø via existing systems. On the Russian side, the radio relay system is terminated at Zapolyarny, and the communication routed on to Murmansk via an 8 Mbit/s insert system on an existing Russian analogue radio relay system.

The border connection was opened in December 1990 for manual traffic. In 1991 it became possible to remote connect pay-phones and subscribers in Murmansk to the S12 exchange at Vadsø.

In 1992 the expansion of the dedicated network in Murmansk started. A new S12 exchange was installed in the city, and a new 34 Mbit/s radio relay system was established from the border into Murmansk itself.

The limited company Kolatelekom, which is owned by Norwegian Telecom and the telecom administration of Murmansk (GPSI), was founded in January 1993. Since July 1, 1993, the company has been responsible for operating the dedicated network in Murmansk. The main objective for 1993 was to get people to subscribe to the network.

2 Description of the Russian tele-network

The civilian Russian tele network is made up of old electro-mechanical exchanges and KV exchanges of Eastern European manufacture. The communication network between the cities and the counties consists of analogue multiplex systems by cable with a capacity of up to 300 channels. The radio links, which are installed along main alignments through the counties, are largely used for the transfer of radio and TV programmes.

In the city networks are used physical cable connections between the exchanges, so the multiplex systems are hardly used in this part of the network. Digital transmission systems in the network were not taken into use until 1990.

The network has small dimensions, so there are major restrictions on trunk traffic, both nationally and internationally. For instance, there can be a blockage of up to 50–60% on the traffic from Murmansk to Moscow. There are also considerable quality problems in the network. In effect, telex has been the only service to work fairly satisfactorily for international communication.

In theory, international trunk traffic may be dialled to and from Murmansk, but in real life this does not work. (The Russian number plan consists of a 3-digit area code and a 7-digit subscriber's code.) The network in Murmansk uses a 5-digit subscription number, but during 1993 it will be expanded to a 6-digit number plan. As per 1993, 70,000 –80,000 subscriber lines were installed in the city of Murmansk (approx. 450,000 inhabitants), and approx. 50,000 are on the waiting lists.

In step with the increasing internationalization in Russia, consumer demands have grown for more modern and efficient tele-services. It therefore seemed natural to put effort into the expansion of the dedicated network in Murmansk, with international access via the border connection in the north and the Norwegian tele network, in the same way as dedicated networks have existed for several years in Moscow and St. Petersburg, having international gateways to other countries via satellite.

3 Description of the dedicated network in Murmansk

3.1 Radio relay system Murmansk – Zapolyarny (– Lyngberget)

The radio relay system installed on this distance in 1992/1993, consists of 3 stretches, NERA NL 141, 34 Mbit/s in the 7.5 GHz band with standardized CCIR frequency plan (Figure 1). The Russian network makes use of other frequency plans, and besides, other radio communication systems and radar systems are used in this area.

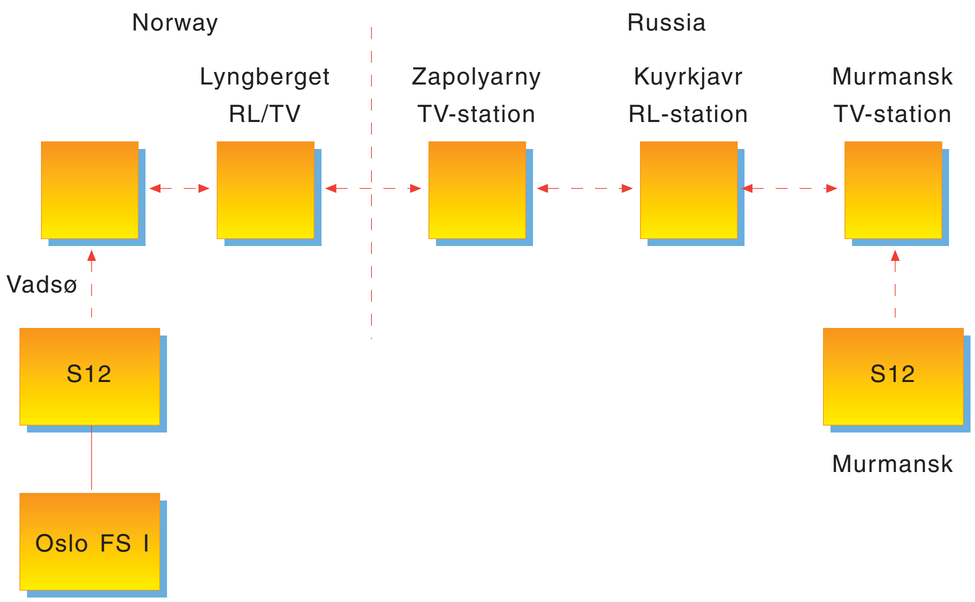


Figure 1 Transmission routes of the dedicated telephone network in Murmansk

After a close assessment we chose not to use the existing Russian masts between Zapolyarny and Murmansk. For this alignment to be satisfactory regarding margins and quality requirements, we would have had to extend the existing masts, which we considered too time consuming and technically complicated. Instead, we chose a new alignment for the radio relay system including the erection of a new station, Kuyrkjavr. Mast and necessary equipment were supplied from Norway. The station was established and was ready to operate early 1993.

The radio relay system was used for traffic in May 1993, and is now running without any problems.

3.2 The System 12 exchange and the network in Murmansk

The S12 exchange (3,500 numbers) was delivered in September '92 and was installed by Alcatel Norway. Following normal procedures of testing and reciever control, the station started operating on December 4, 1992.

The exchange was delivered in accordance with usual Norwegian specifications as a subscriber exchange with software package N3, and is connected to Vadsø group/remote exchange. The exchange is placed in the same building as the Russian transit exchange in the city, and a separate subscriber cable is laid to the Russian subscriber exchange covering the inner city (where customer potential was greatest from the outset).

We had originally assumed that the Russian cable network in the city was to be used to the full for connecting subscribers to the S12 exchange. In practice, this has turned out to be rather troublesome, partly because the subscriber network is equipped with a 0.3 mm cable (transmission limitations), and partly because the connection cables between the points in the exchange are pressurized (difficult to join regenerators) and besides are badly suited for installation of digital transmission systems. There are also certain capacity problems in the existing subscriber network.

During 1993, therefore, a fibre cable system will be installed through the city (appr. 15 km), which will unite all the 8 subscriber exchanges and the transit exchange/S12. This will enable the establishment of RSUs and other electronic solutions for improving the subscriber admission, and thereby the profitability of the project.

The S12 exchange is connected to Vadsø group/remote exchange, and the Norwegian number plan is used as a temporary solution for subscribers in Murmansk. Tariff corresponding to the Nordic rate applies to traffic from Norway to this number series. Traffic from third country to Murmansk is rated as traffic to Norway.

The licence which Kolatelekom has acquired from the Russian Ministry for Communications in Moscow for the dedicated network in Murmansk, requires the use of a Russian number plan. A particular Russian area code has been assigned for this. Using a Norwegian number plan implies that Norwegian Telecom must enter into agreements with third countries on the routing of traffic via Norway (instead of via Moscow/St. Petersburg). Some other dedicated networks in Russia today operate with special routing of traffic on a 3-digit Russian area code (e.g. traffic to COMBELLGA's network in Moscow, is routed via Bruxelles and a satellite link to Moscow).

The interest of third countries to analyze the new 5-digit Russian area code to a relatively small network in Murmansk is

DEN RUSSISKE FØDERASJONS
KOMMUNIKASJONSMINISTERIUM

LISENS # 452

for realisering av kommunikasjonsaktivitet på Den russiske føderasjons territorium

Utstedt til *Aksjeselskap av lukket type* ***"Kolatelekom"***

med hjemmel i Lov "Om bedrifter og næringsvirksomhet" (paragraf 21), Dekret fra Den russiske føderasjons President av 31.07.92 # 810 (paragraf 12 i Midlertidig forordning om kommunikasjon i Den russiske føderasjon) og Forordning om Den russiske føderasjons Kommunikasjonsministerium.

Opplysninger om lisensinnehaver

Postadresse: 183038 Murmansk, pr. Lenina 82A

Bankkonto: konto nr. 1467541 i AIK PSB "Arktikpromstrojbank" MFO 221298

Telefon: 7 24 45 Telex: 126989 Telefaks: -

Aktivitetstype: Internasjonale telefonkommunikasjonstjenester i dedikert nett.

Område: Murmansk fylke

Lisensens gyldighetstid til 01.06.2004

Start på tjenestetilbud (ikke etter) 01.06.1994

Figure 2 Copy of the licence document (Norwegian version) issued by the Ministry of Telecommunications to the corporation "Kolatelekom" assumed to be limited. On the basis of this condition and other plans of modernizing the Murmansk network (see section 5), work is now being done to find other solutions for routing international traffic via Norway to Kolatelekom's network in Murmansk.

In order to comply with the requirements in the licence, co-traffic between the S12 exchange and the Russian network in Murmansk has not been established.

All terminal based operation of the dedicated network in Murmansk is carried out from Vadsø. COCOM-exemption is given for the use of signalling system No.7 on the link between Vadsø and Murmansk. This opens the possibility for efficient managing of administrative and technical support systems in connection with the established network. All invoicing is today being done as if the subscribers were Norwegian.

4 Temporary solutions to other cities in North-West Russia

Murmansk has had a certain historical tradition of trading with the West, especially because of fisheries and other sea related transport activity. After Glasnost and Perestroika, other cities further south on the Kola Peninsula, including Arkhangelsk, have also been opened for Western business and trade with foreign countries. The situation in the telecommunication network in these towns is generally the same as in Murmansk, and there is therefore a certain demand for modern telecom services with the possibility for efficient international communication.

Norwegian Telecom/Kolatelekom have not built their own network outside the city of Murmansk, and the demand therefore has to be met by leasing lines in the Russian network. One major problem with this is the fact that the Russian carrier systems only operate with an in-band signalling channel (2,100 or 2,600 Hz). This causes problems in installing card payphones (the transfer of counting impulses) and partly also for telefax (the signalling filters are so wide that they e.g. may pick up signals from the telefax, resulting in an unwanted disconnection or other interruptions in the transmission). It has therefore been necessary to install a special junction line relay set and partly use a separate channel for transmitting the signalling.

4.1 Installation in Arkhangelsk

Norwegian Telecom/Kolatelekom lease an analogue 12-group from Murmansk to Arkhangelsk and have installed second-hand 12-channel equipment from Norway to solve the problems with the signalling. An analogue line concentrator ELD-96 has been installed in Arkhangelsk (second-hand equipment from Norway) which is connected to the S12 exchange in Murmansk. This solution works well, and the quality of the Arkhangelsk line is satisfactory.

4.2 Installation in Apatity/ Kirovsk

(The cities are situated on the Kola peninsula, some 200 km south of Murmansk.)

Norwegian Telecom/Kolatelekom have installed a small PABX (ORION with 64 gates, delivered by Norwegian Telecom / TBK), with a two-step direct dialling. This solution works well for outgoing traffic. For incoming traffic we have experienced that companies in some countries, e.g. Germany and Italy, still have decadic PABXes and sets, thus they cannot activate the two-step direct dialling in ORION, which is pitch-operated. The same applies to traffic from mobile subscribers to ORION subscribers, and some fax subscribers are not able to send to a two-step direct dialling. The solution using ORION PABX and a two-step direct dialling is therefore not functionally satisfactory. ORION is connected to S12 via three analogue channels with specially constructed junction line relay set.

In addition to this, there are a lot of single subscribers outside of Murmansk on Russian lines. For instance, NILU (Norwegian Institute for Air Research) in co-operation with the environmental department of the county of Murmansk, have established a monitoring station for radio activity appr. 50 km south-west of Murmansk. This monitoring station is connected to S12 as a "regular subscriber", and enables the Norwegian authorities to continuously monitor the radio activity in the area.

5 Perspectives for further efforts in North-Western Russia

During 1992 Norwegian Telecom and the telecommunication operators in North-West Russia carried out major clarification work on wider expansion and modernization of the tele-network in this region. Among other things, they considered starting digitization by installing a large amount of exchange equipment over a period of 5 years. The clarification work also contained plans for installing a 140 Mbit/s radio relay system between Murmansk and Arkhangelsk. Since this clarification work began the development is perhaps more towards assessing the use of fibre cables in parts of this stretch. In addition, the possibility of using Western or Russian satellites for communication between Murmansk and Arkhangelsk is also evaluated. (The satellite alternative is now evaluated as a replacement for the leased analogue lines on this distance, partly because the lease price for these lines is very high.)

The expansion on a scale mentioned above can be started in 1994 at the *earliest*. A lot of questions concerning company structures, principles for co-operation, and financing etc., have to be solved before the expansion can begin. The time for start-up will also depend on the development in demands for modern international tele-services.

In 1993 the telecom administration in Murmansk (GPSI) have, on their own accord, entered into a contract with AT&T on the delivery and installation of digital exchange equipment (appr. 25,000 lines 5ESS), for expansion of an overloaded digital local network in Murmansk. This is mainly done to alleviate the enormous waiting queues and the quality problems in the Russian network.

During the autumn of 1993 the fundamental possibilities and technical solutions for co-traffic between the 5ESS network and the S12 network are evaluated. As a basis, the 5ESS network will be connected to an analogue transit exchange in Murmansk, so that national and international remote traffic is routed via the analogue network to Moscow and St. Petersburg, with the limitations this entails. The 5ESS network will be included in the regular Russian number plan for Murmansk.

A probable development in the question of co-traffic will be for the 5ESS network to use S12 as a transit for international traffic, and in principle there will be an opening for full co-traffic between the two networks. The S12 exchange will after a while take over the role as a national and international transit exchange in Murmansk. In order to meet the the requirement of a Russian number plan for S12 (ref. section 3.2), solutions are now being assessed to utilize free number series within the existing number plan for Murmansk. However, these co-traffic solutions, together with the perspectives for development of the network, are dependent on approval from the Russian Ministry for Communications in Moscow.

During 1993 the S12 exchange in Murmansk will be transferred from Vadsø to the new Norwegian foreign exchange in Oslo.

6 Experiences from co-operation in the North

The co-operation with Murmansk and the telecom operators in North-West Russia has posed some challenges different from what we are used to in our own telecom world:

- The Russian tele-network is installed in accordance with specifications different from the Norwegian ones. It has been necessary partly to make adjustments, and partly to carry out the installations with Norwegian supply of equipment and parts (e.g. power supply, because the Russians use 60 V DC in their network).
- There is a lack of equipment and material.

However, in the implementation of installations indoors as well as outdoors there has been a very good co-operation between Russian and Norwegian personnel, and it has probably been inspiring for both parties to show that things may be achieved by joint effort.

Atle Andersen is a Senior Engineer working for Norwegian Telecom's Region North at Lødingen.

Norwegian Telecom's involvement in the Barents region

BY SVEIN MARTIN PEDERSEN

The Barents region of northern Russia is close to the northern part of Norway. Telecommunications in this part of Norway has a high technological standard and offers large traffic capacities. According to old trading traditions, it seems logical to co-operate and make use of Norwegian know-how and transit capacity when reconstructing a high performance digital telephone network in the Barents area.

The Barents region

The Barents region is on the agenda. This geographical area, which contains the most northern counties of Finland, Sweden and Norway, as well as the Russian counties of Murmansk and Arkhangelsk, has frequently been in the focus of the media this last year. The regional Barents Council has been founded, and co-operation across the borders has started. What is taking place in the region is met with great expectations. The authorities now signal a willingness to put effort into it; the time has come to clear overgrown trading routes.

Photo: Norwegian Telecom

Figure 1 The symbolic cutting of the silk ribbon marking the opening of Norwegian Telecom's digital exchange in Murmansk, was undertaken by the late Foreign Minister Johan Jørgen Holst together with the Mayor of the County of Murmansk, Evgeni Komarov

The trade between the areas in the north has long historic traditions. The contact between Northern Norway and the areas around the White Sea goes back several hundred years. What we know as the Pomor trade developed until 1917, when the revolution put an end to all trade.

After more than 70 years of a more or less dormant state, new trading connections are not established overnight. However, there seems to be no doubt that the Barents region is an area with great potential: We would like to mention the fishing resources, oil and gas deposits, large forests, mining industry, etc. Economic development, growth and new jobs are already being talked about. The challenges are queuing up!

Norwegian Telecom has decided to face the challenges.

Telecommunications tie the Barents region together

Traditionally, Norwegian Telecom has had an offensive attitude when it comes to expansion of the telecommunications in the northern regions. And, especially in the sparsely populated areas, good telecommunications is an important matter.

Trade and industry and public administration are particularly dependent on efficient telecommunication services. Through the years, Norwegian Telecom has stressed the importance of services being equally distributed throughout the country.

Even so, political authorities have stated that the rate for long distance traffic is to be particularly low in Northern Norway. Today, it is twice the price of the local call rate, while trunk calls in other regions are four times the price of the local rate.

The expansion of the network in Northern Norway has generally been along the lines of the telecommunications development in other parts of the country.

The telephone network was fully automatic by 1985. What we had then was a well developed network based on conventional technology. It was therefore difficult to decide whether to replace it with digital equipment in the second half of the eighties. However, we chose to follow the strategy drawn up for the rest of the country. Today, we have reached a level of digitization which is close to the average level in the country. In 1993 all main exchanges will be digitized.

Northern Norway is very long. It has been a challenge to expand the tele-network so that the reserves for the main connection between Northern and Southern Norway are sufficient. At present, we have in principle two main alignments from the border of Trøndelag to Vadsø, based on 140 Mbit/s radio relay system. One of the distances, Narvik – Tromsø, is run on fibre.

Fibre connections have also been established from the border of Trøndelag to Bodø. The distance Bodø – Narvik will be completed in 1994. When finished, there will be fibre connection from Trøndelag to Tromsø.

Norwegian Telecom Research established a subsidiary in Tromsø in 1988. In co-operation with the operating organization, the unit has had a special responsibility for testing out the possibilities for new telecommunication services, especially in sparsely populated areas. The test operation has included video meetings, distance education and telemedicine. Their present work is to develop applications for municipal administrations and corporate networks.

Region North of Norwegian Telecom has also, together with the fishing industry, looked into the possibility of special arrangements for the fisheries sector. This mainly concerns arrangements for the sale of fish products (the IT-Fish Project).

Norwegian Telecom's involvement in North-West Russia

The question of improving the telecommunications in North-West Russia was first brought up on county level in Finnmark/Kola/Arkhangelsk in 1989.

Norwegian Telecom has a strategy for international involvement. We felt a special responsibility for looking more closely into the needs for and the possibilities to establish telecommunications in these areas.

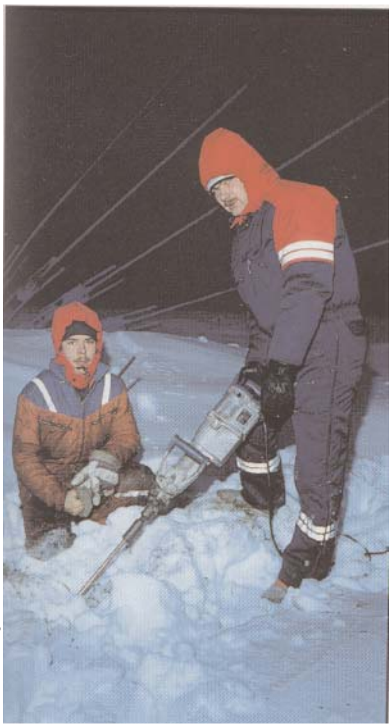


Photo: Norwegian Telecom

Figure 2 Earthing work in wintry Kola. Geir Mathisen, Kirkenes (sitting) and Knut Roald Hansen

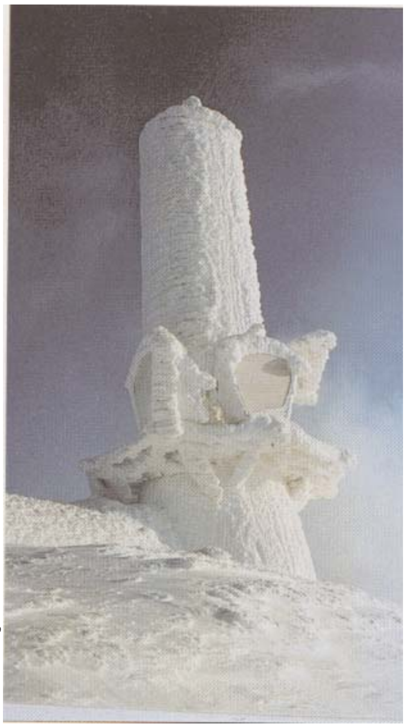


Photo: Norwegian Telecom

Figure 3 Cold Kola can have a totally different meaning than the one we usually think of, and see representations of in commercials. This is Chief of Installation, Ole Olaussen, at the radio mast at Kuyrkjavr, a mountain peak on the Kola peninsula

Photo: Norwegian Telecom

Figure 4 Radio link in snow

Contacts with the Russian telecom administration in Murmansk, Arkhangelsk and Karelia were soon established.

The new year of 1990 saw the establishment of a connection to Murmansk on a Norwegian radio relay system from Kirkenes and across the border, and from there on leased lines. The lines were first used for manual operation and a card based pay phone, but later on, the subscribers could be remote connected to Vadsø exchange.

Because of the increased demand for subscriptions like these in Murmansk, an S12 exchange (supplied by Alcatel Telecom Norway) was installed in the city in 1992, with a capacity of 3,500 subscriber lines. The exchange was started up in December 1992. Furthermore, a 34 Mbit/s radio relay system was installed on the distance Zapolyarny – Murmansk in order to obtain high quality digital systems with sufficient capacity between Murmansk and Vadsø. This radio relay system was ready for operation in May 1993.

NOK 20 million have been invested in the installations. The prerequisite has been that the investments and the development will give a business profit.

Intensive work is carried out in order to connect subscribers to the new exchange in Murmansk and thereby secure the income.

Furthermore, we now have the chance, via leased lines, for a limited connection of subscribers in Arkhangelsk and a service connection to Vologda, north of Moscow.

Further work

There seems to be a considerable market potential in North-West Russia, especially in the counties of Murmansk and Arkhangelsk.

Norwegian Telecom has considered possible alternatives for further development of the telecommunications in North-West Russia. The long term goal has been to further develop the dedicated network for the region on the basis of the investments in Murmansk. However, it has turned out that telecommunication authorities with regional responsibility for telecommunication traffic and the ministry in Moscow are having second thoughts about channelling international traffic from Russia via Norway. They primarily want to utilize the fibre cable which was recently opened between St. Petersburg and Denmark.

Work is being undertaken on a high level in the telecommunication authorities to clarify our further efforts. The connection of a future co-operation to a new set-up for developing telecommunications for the whole of Russia is considered. The so-called 50 x 50 programme was recently released by the Russian authorities and implies the building of 50 exchanges and a total of 50,000 kilometres of fibre optic cable for trunk connections.

Svein Martin Pedersen is Regional Director of Norwegian Telecom's Region North.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Phippsøya
Martensøya
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Lågøya
Storstein-
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Isdomen
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ERIK ERIKSENSTRETET
Svenskøya
Hopen

Svalbard

The first years and messages across

BY JAN HASSEL

Photo: Trym Ivar Bergsmo/Samfoto

North West Svalbard

Introduction

On November 23, 1991, Norwegian Telecom at Svalbard celebrated the 80th anniversary of telecommunication services at Svalbard (Spitsbergen).

It is a great technological leap from the first spark transmitter for telegraphy established at Finneset at Green Harbour in the autumn of 1911, to the digital System-12 exchange started up at Longyearbyen in October 1990.

Svalbard is an outpost. In 1911 Norwegian Telecom used high-tech of the day by installing a Telefunken spark transmitter with a 5 kW transmission effect for the benefit and pleasure of both national and international interests in the Svalbard region.

In 1990, Norwegian Telecom again used the very best technology available to meet the needs for communication in the Svalbard communities. We have reason to be proud and grateful to the Norwegian Telecom managers who had the clear-sightedness and energy to get through with these projects.

In this article I give some glimpses of the Norwegian telecommunication history as seen from Svalbard. Technical specialities and innovations are not the main theme in this article; I have sought to find the people and the story behind the development more than technique and expertise. Trying to see the routine of the everyday in a historic perspective is quite a challenge. The description of events and episodes experienced when creating Norwegian Telecom at Svalbard is mainly based on brief notes made by the people who were there from the start. I have also used my imagination to try to sense and describe reality as it was for the people who were in it.

The pioneering era has been described as a mixture of events in the world outside and of local everyday events.

The early history

In historic time Svalbard was not always accessible. Old Icelandic documents show that Svalbard was known to the Icelanders in the 12th century. But after that, Svalbard was obviously forgotten for several centuries, until the Dutchman Willem Barents rediscovered the archipelago in 1596 and named it Spitzbergen.

The long period of oblivion can be explained: Meteorologists tell us of a considerable deterioration in the climate of Northern Europe in the first half of this millennium. The sea ice obstructed shipping in the northern areas. When the climate improved the expanse of ice decreased. Meanwhile, shipbuilding techniques had improved tremendously and everything was set for a thrust northward. What Barents and others actually were looking for was the sea route through the North-East Passage to the treasures of the Far East.

A long time passed before interest in Svalbard became connected to coal and minerals as it is today. For more than 300 years Svalbard was "No man's land", although there were controversies between seafaring nations from time to time. The strategic significance for sea farers in the polar areas was obvious, but the inhospitable nature did not tempt anyone to settle there.

The possibilities offered by marine resources were easy to see. Whaling developed from a hunt for fragrant oils like ambergris, to a hunt for blubber and oil for use in housing and industry. Later on, catching colonies were organized in several places along the coast where whale, walrus and seal were the raw materials for an entire "oil industry".

Into the 17th and 18th centuries, Svalbard was the arena for whalers and other hunters from Holland, England and Russia. Norwegians turned up in number in the 19th century, hunting mainly whale, seal and polar bear. Then, at the turn of the century, coal was explored as a great energy source. This was the starting point of modern times, with coal mining as the driving force.

Now, towards the end of this century, the coal epoch is coming to an end, although there are great coal deposits in the mountains. Svalbard is still the focus of Norwegian and international attention. The government and the Storting (Parliament) keep an eye open for Svalbard's resources and the development of Svalbard's opportunities.

The prelude

In 1899 captain Søren Zachariassen of Tromsø shipped the first load of coal out of Svalbard. This is said to be the beginning of Svalbard's coal era. The Americans were early on the scene with their sense for Coal Business. John Munroe Longyear from Boston, USA, secured control of great areas along the Isfjorden. In 1905 he purchased the rights of property from a Norwegian company, and started extracting coal in the Advent Bay. In doing so he laid the foundation for the mining community which was later named Longyearbyen and became the capital of Svalbard.

His company, the Arctic Coal Company, badly needed a connection with the outside world, and would soon establish a radio telegraphy station at Longyearbyen. This was the direct reason for Spitsbergen Radio being established in 1911.

Mr Longyear was not the only one to see the possibilities. Both the Russians, the Dutch, and the English were early on the scene fighting for the "black gold". And they all burnt their fingers. Achieving an economical coal operation at Svalbard was, and is, a challenge. Nobody has succeeded yet! But the coal working continued, and is still going on. For the driving forces behind activities at Svalbard are more than hope of a financial profit.

Even early visitors like Willem Barents and his home country Holland were aware of Svalbard's strategic importance; first as an outpost for trade and transport, and later as a point of departure for discoveries and expeditions in the Arctic.

Norwegian interests at Svalbard were well established before the turn of the century. When the Americans showed their interest, they were regarded as a threat. The news came in 1910 that the Americans wanted to establish a telegraph station at Svalbard and a receiving station near Harstad in mainland Norway. The idea was that the Americans then would be able to use the Norwegian telegraph network for their own international traffic. Norwegian telecommunication people saw this as a threatening signal. How was Norway going to counter this situation in an area where she had strong economic interests, and thereby national interests?

Marconi's wireless telegraph was a reality by 1902, and in 1909 he got the Nobel price in physics for this invention. Although the technique was new and revolutionizing, there were experts in Norwegian Telecom who saw the possibilities this new invention offered. The engineers were ready to use the invention the very same year. A coastal network for wireless telegraphy was being planned. Incorporating Svalbard in this network was quite feasible.

Norwegian Telecom had in 1908 made a main plan for building radio stations along the coast of Norway. In the plan was also included a coastal station for the most northern parts of Norway. The station would serve shipping routes in the Arctic Ocean as far north as Svalbard and along the Norwegian coast eastwards to Vadsø and the coast of Murmansk, and southwards to the Lofoten and Vesterålen islands. But stations along Norway's southern and western coast had a higher priority than the ones in the north, as the shipping traffic in the busiest areas had to be covered first.

On the political front opinions were divided – politicians were perplexed. The Liberals set the tone in the Storting, and saving and carefulness marked the foreign policy following the end of the union with Sweden in 1905. The newspaper *Dagbladet,* a political organ for the Liberals, was clearly against it: Why spend money on a useless outpost like Svalbard?

But Norwegian Telecom had a different opinion. The Telegraph Director, Mr Heftye, stated that the telegraph service had such an importance for trade and industry, fishing, shipping and defence, that no private interests should be allowed into this market. Norwegian Telecom's expansion plan of 1908 for building telegraph stations along the coast, was changed to include Svalbard in the very first stage.

The main plan was changed, and in a well founded document the Storting was requested to grant money for a wireless telegraph station at Finneset at Green Harbour, a side fiord to the Isfjorden. The station at Svalbard had a budget of NOK 150,000 – 170,000. The receiving station was located to Ingøy on the coast of Finnmark, estimated to cost NOK 120,000.

By the Storting's resolution of May 3, 1911, things turned out the way Mr Heftye wished. The margin of expenditure for the whole project was set at NOK 300,000, which turned out to be enough.

While the politicians were discussing, Norwegian Telecom was getting prepared for a big and risky project: To establish a wireless telegraph station with an almost unknown technology in a few short summer months in the Arctic wilderness of Svalbard.

The management went for it! All necessary equipment was pre-ordered and was ready for loading on to the steamship *Fanny,* which was hired for the job. Shipping out the equipment started as soon as the Storting gave the green light for the project. On Saturday July 9, 1911, *Fanny* reached her destination and construction work was started on the following Monday. That was the beginning of a new telecommunication era, created by clear-sighted and pushing leaders.

Pioneering times

In June spring reaches Svalbard. The fiord ice breaks up and the snow disappears in the lowlands. By late June – early July it is already summer. The mountain saxifrage is ablaze in vivid purple among grey rocks and green patches of moss. The midnight sun is flowing over the rocky landscape. At Finneset there is a slight green between stone nests on the flat neck of land. Summer is reflected in the green glacier water in a sunny fiord. Green Harbour is indeed a good name.

Into the fiord sails a steamboat. It is *Fanny,* loaded to the rim with people and equipment for the new Telecom station at Finneset. Nature and people's hearts are filled with sunshine. There at last, after dramatic weeks in the sea: A fire on board, unpleasant weather, seasickness and boredom. It feels good to be on solid ground again. The landlubbers are happy, curious about all the new things around them, but also impatient to start working.

The Telecom people had earlier pointed out Finneset as the place for the new telegraph station. There are already Norwegians living here. The whaling station Nimrod, established 1905, is in full operation.

With hindsight, the location of the station may be questioned for radio technical reasons. But the technology was young, less than 10 years old, and nobody had much experience.

The project needed careful planning. The supply routes were long, and if anything was forgotten it could not be supplied until next summer.

The summer at Finneset turned out to be a rather hectic one. While the whaling station was busy and spewed smoke and nauseating stench from boiling blubber and stinking offal, the joiners, fitters and station personnel started an unusually hectic construction work. Normal time for a building this size on the mainland would be eight months – here the job was done in two. A great effort! At the busiest times there were 45 men at work digging, casting, building houses, installing antennas and technical equipment. The workers considered the construction a national concern, and their working spirit was high. Besides, it was in everybody's interest to get the work done before the ice returned, in order to get home before winter set in.

With the help of shift work and working days of up to 13 hours, things really kicked off. The pay was 75 øre per hour and workers had free meals. On September 20 the last workers headed back to Norway. At that time the station was almost ready for use.

Much credit for the sucess of the project went to the head of the construction work, senior engineer Hermod Petersen. He stayed at Svalbard the following winter in order to make sure the equipment worked as it should. Two telegraph operators, an electrician, an engineer and a steward also stayed that winter.

The equipment in the radio station was new, unknown and complicated. Installation and testing was a technical challenge. The engineers with special skills were of course key personnel, then as now. But the telegraph operator was also treated with respect – he mastered the secret language of dots and dashes, literally the key to the messages flying through the ether to the entire world.

Spitsbergen Radio was ready for broadcasting on September 23, 1911. The antennas were directed towards Ingøy Radio, which was under construction. There was a lot of listening and waiting for signals from Ingøy. The night between November 23 and 24, the connection was established. But the official opening was not until December 10. Then the station was open for public communication.

The celebration of the 80th anniversary of the radio connection was described like this in the local newspaper of Spitsbergen, *Svalbardposten*:

> The Morse key ticked in beat: "This is Spitsbergen Radio. We are transmitting on 1600 metres. Report my signals." Over and over again: "This is Spitsbergen radio. We are transmitting on ..."
>
> A stream of signals into the Arctic night. The antenna wire was reflected like a blue silver thread in the Northern light. Invisible messages flew over ice cold plains, swept across the Arctic Ocean and spread out over the entire coastal Norway. Di-di-di-da ... Spitsbergen Radio calling ...
>
> The message is picked up. The operator listens with his head bent. Tense, excited. The headset is crackling. "This is Ingøy Radio. You are loud and clear." The operator sits up with a smile on his face. The tension is released. His fingers are dancing on the Morse key, new messages are streaming across the ocean to the telegraph station at Green Harbour. Norwegian Telegraph has connected Arctic Svalbard to the rest of the world.

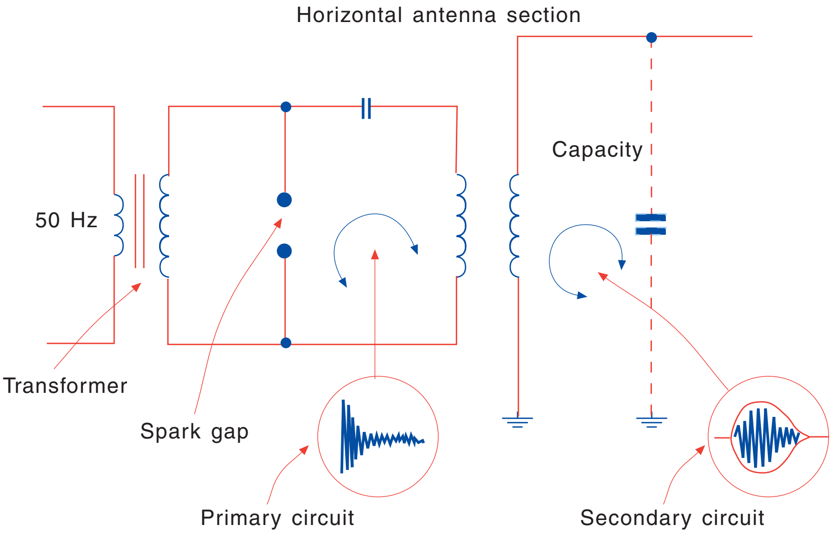


Figure 1 Spark transmitter tuned system with loosely coupled antenna

The telegraph station, the whaling station and the post office constituted a Norwegian miniature community at Finneset. Spitsbergen Radio indicated that the kingdom of Norway was represented at Svalbard – an important part in the process giving Norway sovereignty over Svalbard in 1920.

Sweden and the USA were strongly opposed to establishing the Norwegian radio station. Svalbard was an area of international interest, and Norway kept a low political profile in this matter. There was certainly no question of claiming any form of privileged rights for Norway in this "No-man's land". On the contrary, the telegraph station was presented as a service to everybody, and, if so decided, could be taken over by other nations. The only Norwegian condition would then be a refund of the building expenses.

The same strategy was used when Norway established a postal service at Svalbard at the beginning of this century. It was then claimed to be done on behalf of The International Postal Union, and no nation had any objections to this.

The needs and the clients were there from the very beginning. The winter of 1911/1912, 150 people spent the winter at Svalbard. 19 of these stayed at Green Harbour. People who stayed the winter – explorers, scientists, seafarers, hunters, businessmen, journalists, people connected with industry, the odd tourists and visitors – they all had great use for Spitsbergen Radio for several decades.

In the summer of 1912 Fridtjof Nansen visited the station. The first Sysselmann (District Governor), Johannes Bassøe, hired a room there when Norway established its official control of Svalbard in 1925. The Mine Superintendent also lived at the station for several years.

The station was shut down in 1930 and moved to Longyearbyen. For the pioneers who had been present from the start, things would never be the same. On comparing the conditions in later years, there is no doubt: Green Harbour was the best.

After the station was left, a certain supervision was carried out in the years to follow. During the second World War, all the constructions at Finneset were

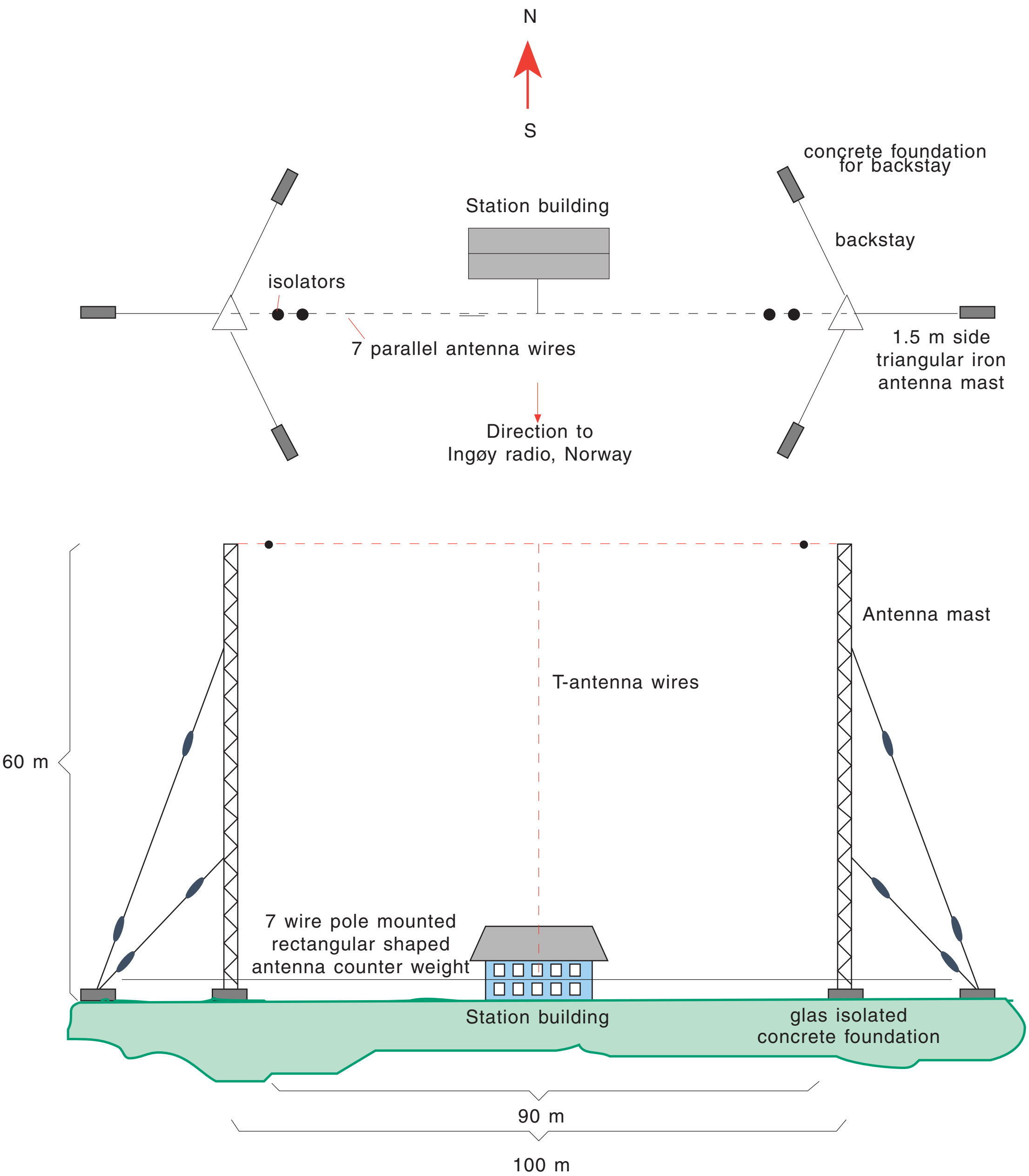


Figure 2 The antenna construction at Spitsbergen Radio, Green Harbour

destroyed by Allied forces. The history writers claim the Germans were to blame, but that is not quite correct.

The radio technique

What did a coast radio station look like in 1911, and how did it work? In our view it was a primitive technology, but with the knowledge of that time Marconi's invention was a masterpiece. Figure 1 shows a schematic description of the principle of the telegraph transmitter.

The working principle of early spark transmitters was the use of ionization phenomena between electrodes placed close together.

When the voltage between the condensator plates reach a given limit, discharging takes place due to the break-down effect of the ionization in the spark gap area. Wave trains of damped oscillations are repeatedly created in the primary circuit. With a loosely inductive coupling to the secondary curcuit which makes the antenna circuit, radio frequency pulses are transmitted. By the use of a Morse key controlled relay in the transformer circuit, short and long pulses with a modulating frequency of 1000 Hz are transmitted.

Due to the waveform, the spark transmitters created a lot of electronic noise. In the early days of electronics, this was a minor problem when there was no-one else to disturb. Tuned systems are more efficient and give more energy and less noise. So in due time, the spark transmitter was replaced by more modern transmitting equipment.

The first transmitter at Finneset was a spark transmitter of 5 kW supplied by the German company Telefunken through its

Photo: Norwegian Telecom Museum

The main street of Longyearbyen, July 25, 1911

representative in Kristiania (Oslo). In those days, that was a large transmitter. But the distance to the receiving station at Ingøy was 900 km, so powerful radio signals were necessary.

The station was powered by two diesel engines at 35 horse power each. The engines operated two shunt dynamoes at 16 kW which were recharging the storage batteries. There were also two sets of batteries, each with a capacity of 570 AH and a maximum discharge current of 180 A.

The accumulators operated the rotating converters providing the alternating current. The AC generators delivered 10 kW at 220 V; the frequency was 500 Hz. The alternating voltage was transformed up to 12,500 in the transmitter's transformer circuits.

The high frequency circuit is composed of a copper coil, a Leydner bottle-battery, and a spark course. A power current relay controlled by the telegraph key is connected in series with the transformer's primary winding. The relay will break with the primary winding in step with the Morse key. Then a pulsating alternating voltage of 12,500 V is induced in the secondary circuit. The Leydner battery, which works as a condenser, is recharged until discharge takes place with a breakthrough in the spark course. The circuit's resonance frequency determines the wavelength. Moderating high frequency electrical vibrations are thereby created in the resonance circuit. The signal is then fed to the antenna and transmitted as electromagnetic vibrations, i.e. long-wave radio signals.

The spark courses consist of 2 parallel copper discs, placed 0.2 mm apart. The discs have a silver coating in the centre. They are kept apart with the help of mica rings. There is room for up to 16 such spark courses.

Two sparks flash over in each alternating current period. As the alternating current's frequency is 500 Hz, there is a total of approx. 100 sparks per second. At the receiving station the signal will sound like a tone of about 100 Hz, and with a durability in pace with the Morse key at the transmitting station.

The antenna system is shown in Figure 3. It consisted of two 60 metre masts 100 metres apart. The masts were backstayed with 3 backstays each. Each backstay foundation consisted of approx. 60 tons of heavy rocks and concrete. The masts were mounted on concrete foundations, approx. 5 cubic metres big, and were insulated from earth with specially constructed glass insulators which could stand high mechanical pressure.

The antenna was a T-antenna made up of seven 90 metre long parallel bronze wires which were put into the masts with the help of a lift.

As electrical counterweight for the antenna was used bronze wires hung in regular telegraph poles at a height of approx. 5 metres. The counterweight consisted of two elements. Directly under the antenna the counterweight formed a rectangle 180 m long and 20 m wide. In addition there was a counterweight shaped as a semi-circle with a diameter of 80 m and with 40 m long beams directed at Ingøy.

The signals from Spitsbergen Radio reached far. The station covered practically the whole of the Arctic Ocean. Daily weather reports were sent to the Meteorological Office in Kristiania from day one. These reports meant a great deal for the quality of weather forecasts for the Norwegian Sea and mainland Norway.

The first winter

After the workers went back to the mainland at the end of September, things went quiet. The station staff had plenty to do with the finishing off. They also prepared themselves for the long Arctic nights to come – the last glimpse of daylight would disappear in the middle of November. From then on only absolutely necessary outdoor jobs were done. The staff listened to the European radio stations, but most important was listening for the first signals from Ingøy. As the Arctic night grew ever darker, the excitement and expectations grew as well: When will we get the signals from Ingøy?

False victory outbursts from the listener on duty were not met with grace. Several times the duty officer would try to bluff when he was bored. So when the signals from Ingøy finally reached the station, and there really was a reason to celebrate, no-one believed the man on duty.

The first manager of the station was Division Manager Hermod Petersen. He spent the winter there, both as manager and as technical expert. The other staff were two telegraph operators, an electrician, an engineer and the cook. One of the telegraph operators, Brønner, later returned as manager. Both Brønner and Petersen later wrote articles on the station and the early times there. On request and by appointment, Petersen wrote an

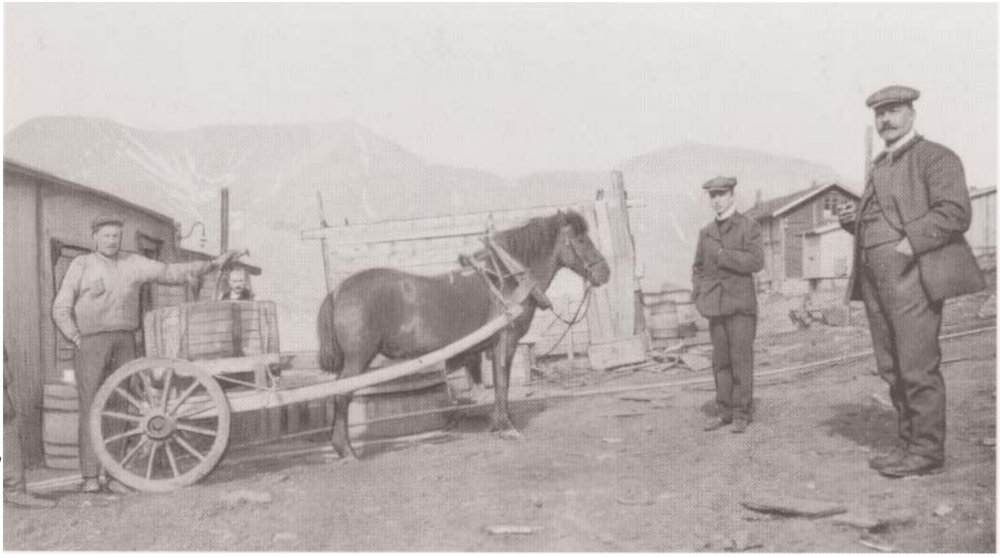
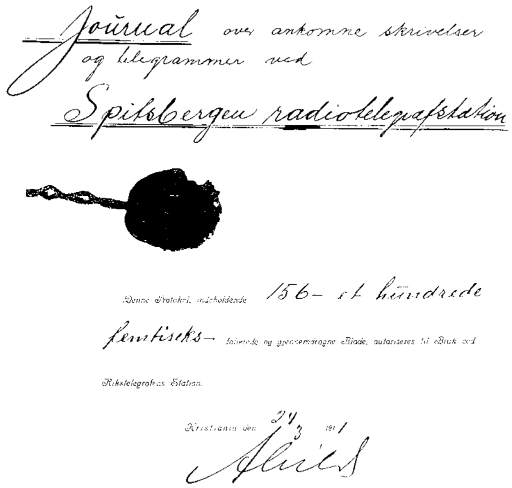


Photo: Norwegian Telecom Museum

The world's most northerly horse. Longyearbyen 1911

article about those early days at the station for the newspaper *Tidens Tegn* in 1911. Brønner wrote an outspoken article, published in the magazine *Norsk radio* in 1924, describing his general impressions from the first year at the station.

During my stay at Svalbard in 1992, I came across several radio diaries, journals and internal documents. The documents were found in the attic of Norwegian Telecom's building at Skjæringa. They had survived all the moving and tidying up through the years. One of the goodies I found, was the original of "Journal of incoming documents" to Spitsbergen Radio. In it were all incoming telegrams and letters – from the very beginning in November 1911 to the protocol ran out of pages on May 18, 1927. The entries in the journal are mainly


Journal over ankomne skrivelser og telegrammer ved Spitsbergen radiotelegrafstation

156 – et hundrede femtisex –

Kristiania den 24/3 1911

Figure 3 Facsimile of the first journal

level-headed descriptions of letters and telegrams the station received, but still reflect everyday events and dramatic headlines from accidents and incidents from Arctic history.

This first journal was exhibited at Svalbard Museum during the 75th anniversary on November 29, 1991. All the journals are now handed over to the Public Record Office in Tromsø.

All the official communication was logged in the journal with date, number, sender and a short case description. In the column for notes, telegraph operators often stated their personal opinion of certain cases. That was hardly in accordance with instructions and regulations, but undoubtedly with their own feelings.

Summary of the station's journal

1911

First note is dated November 24, 1911. It is the Telegraph Directorate, represented by the Traffic Office "Asking, wavelength as a coastal station, and geographical position." Maybe the contacts between technical and administrative personnel was not too good back in those days either?

The following day the next message is received. It is the newspaper *Tidens Tegn* who requests a detailed report. Spitsbergen Radio was popular reading from the first day. The station manager gave a detailed description of the situation. It is reproduced in Brønner's article in *Norsk Radio* from 1924.

The last day of November the Meteorological Office gives notice that the station can start transmitting "met" straight away. Weather observations and weather telegrams were one of the most important tasks from the very beginning. The weather in the Arctic is of great significance for the weather in the rest of Europe. Because of that, weather stations were early established at Bear Island, Hopen, and Jan Mayen.

Snooping in the Meteorological Office's archives has brought up a facsimile of the first weather observations which were carried out by Hermod Petersen and Olaf Henriksen. All Norwegians take great interest in the weather. New Years Eve saw a record -40 degrees Centigrade. Also, 5 days of temperatures above 0 and rain in the beginning of December have been noted.

Economic status for November was settled with one dispatched telegram paid for and 6 official telegrams. That brought 84 kr and 20 øre in the till, and that in spite of the fact that the station was not formally open for traffic until December 10. But in December the Christmas traffic took off. 93 paid telegrams brought in a fantastic 1,284 kr. It looked as if the project could turn out to be a gold mine, but then January was quiet – only 3 telegrams were dispatched and 42.80 kr entered.

After December 16th, the festive season reached the mainland administration – no messages were received for the rest of that year.

1912

1912 sees mainly official telegrams for a long time, but the outside world is gradually becoming aware of the station, and coal companies, ships and freighters all have messages. Most of the activity at Svalbard took place in the Longyearbyen area. Telegrams addressed there had to be carried by a dog team 40–50 km, which was the distance that separated Green Harbour and Advent Bay. This was no joyride in the Arctic night at low temperatures.

In the years to follow, there were lots of inquiries about missing expeditions. The first one was on January 5, 1912, when a Mr Hergesell from Strassburg is asking about "the condition of the Physics-geological expedition". A week later Mr Hergesell repeats his request. The coastal radio probably did not have any information of interest to him. In the middle of the cold Svalbard winter the whole expedition would have had to go in winter shelter, but this was perhaps difficult to understand in Strassburg. There is more information on this expedition later.

The days of February, March and throughout the spring, people were asking about telegraph rates, opening hours, supplies, bills, weather, ice, and the state of the ground. Once in a while memorable messages do however occur. On February 20 the administration in Oslo asks : "Did Spitsbergen tune in to Paris yesterday?"

In April the plans for new personnel are taking shape. The winter has probably been tough on the staff. Will assistant Henriksen take over the job as administrator? Will Brønner stick with his job? How about the engineer and the cook, will they stay another year?

In May and June it is time for new supplies. Applications for positions for next season are coming in, while others have relief and vacation on their minds. On June 13 the administration in Oslo says that "The manager may return whenever he finds it convenient". I guess he was not completely hooked on Svalbard. The same obviously applied to the cook and the engineer.

The Norwegian polar researchers "Staxrud and Hoel report departure from Tromsø June 26." On the same date, 78 years later, yours truly left for Longyearbyen. Staxrud and Hoel have made a lasting imprint on the history of polar research. Yours truly cannot say that he made a similar achievement, even though he was the first one to put up a Norwegian card telephone on Soviet land at Barentsburg.

In July, the Arctic Coal Company is registered as a lousy payer: "Regarding settlement Arcticoal, refuse telegrams without cash payment." Could this be a sign of bad times to come? It was probably with good reason that the company sold out to Store Norske Spitsbergen Kulkompani (SNSK) four years later.

The cook is an important man. Oscar Johansen from Trondheim is picked for the job this time. He receives a large number of telegrams about employment, departure Trondheim, arrival Bodø, departure Tromsø.

In August the Svalbard summer is coming to an end. A new telegraph operator has been employed – judging by the new handwriting in the journal. 65 incoming telegrams in August; a record so far. And the senders are not only the bosses in Oslo anymore.

Ludvig Varming sends a message concerning the radio station in Advent Bay. Varming was one of the crew who helped put up the station at Finneset in the summer of 1911. For several years he worked for ACC, SNSK and Norwegian Telecom; the last time as caretaker of the empty buildings after the station was moved to Longyearbyen in 1930. Ludvig Varming was the father of another Svalbard friend, Henrik Varming, today a man with enormous knowledge about Svalbard.

Then Mr Hergesell from Strassburg appears again. He turns out to be a professor and now announces the arrival of Dr Robitzsch. The same Robitzsch is to have his training at the station according to information from Telegraph Director Heftye.

Spitsbergen Radio had their own horse! It is a reasonable guess that horses were used (and later eaten?) during the construction work at the station. In July 1912 Construction Manager Hermod Petersen announces a horse for sale. In the middle of August it is decided that the horse is to be sent to Tromsø. But 8 days later a new message reaches the station: "The horse is to be shot." It was probably too expensive a boat ticket for the poor horse.

Dr Robitzsch wants to establish a radio station – that is why he is training with the station personnel, judging by a new telegram from Hergesell on September 1. The German expedition is catching people's interest. On September 25, Hergesell is again giving a message to his "doctor", this time it is about news coming to Robitzsch with the mail boat. Then there is silence until March 25, when a telegram from Monaco arrives saying "Hergesell asks for information about Wegner's expedition." Then there is no more. For the people who wonder what happened, only two years before the first World War, there is plenty to wind up.

1913

January 1, Spitsbergen Radio has the signature and call sign "Lfg" assigned, Ingøy the signature "Lei".

There are several German expeditions at Svalbard in the winter of 1912–1913, remarkably many. They get into trouble and a message for help is sent. Beginning of January the Ministry of Foreign Affairs send a telegram guaranteeing that they will cover all expenses for equipping a relief expedition. At the same time the Ministry of Foreign Affairs asks the station to give the names of the German expedition. The help has probably been sent out from the miners in Advent Bay. Every day new requests for help come in, and people are asking for information about the situation. The Ministry of Foreign Affairs are busy:

> "Request to inform the Germans about help at Kings Bay."
>
> "Ask to get connection with the Germans at Kings Bay."
>
> "Ask for Ritscher's state of health." He immediately responds with information about his expedition.
>
> "Where is Schröder Strauss and others?"
>
> "When will the relief expedition depart?"
>
> "Regarding possible help from Cross Bay."
>
> "Ask for information about different expeditions' goals and so on."
>
> "Information concerning rewards for help to Schröder Strauss."
>
> "Asking for various information on Schröder Strauss."

January 31 sees the last telegram sent from the Ministry of Foreign Affairs about the relief expedition. It concerns the whereabouts of the botanist and geologist of the Schröder Strauss expedition. From the radio journal we can only imagine the drama behind this whole scene. How it ended is not known to me.

Station Ebeltofthafen, which is obviously also German, asks on February 13 about Schröder's expedition, and on February 27 they send a message concerning the rescue of the expedition. The drama is over. But in March/ April we see an aftermath in the shape of rewards to the people who gave a helping hand. The administration in Oslo report that they will cover the expenses for the material which was lost during the expedition, as promised earlier.

But the case concerning the rewards had an epilogue. In June 1914 the first World War broke out. The Ministry of Foreign

Affair's interest in the German activity at Svalbard probably had a reason. On August 15, 1914 the Ministry sends a message saying "The Germans in Cross Bay and Ebeltofthafen must be picked up." Immediately after, the message comes: "The German government has postponed the reward for information on Schröder Strauss' destiny."

That was it! The money was probably more needed for war material than as payment to fearless rescue personnel. Maybe someone was left with a long nose and frozen toes, rather annoyed for not getting the reward they were promised?

The equipment and instruments of the Schröder Strauss expedition were shipped to Tromsø and handed over to the German consul there, according to the telegrams dispatched. Norwegians are kind when it comes to situations like these: We do not make free with other people's property.

1914

The start of the war has of course affected the internal messages. In October all routines are tightened, and fear is strong that foreign countries' warships may show up. Precautions are taken. But this war led to no troubles for Svalbard, it got a lot worse in the next war.

1915

Brønner returns as Station Manager, together with a new engineer, Olsen, and cook Mathiesen. Brønner had probably not forgotten his first winter, and the dream to re-experience Svalbard was probably strong in him. This is the way it has always been: most people who have stayed at Svalbard do return.

The war in Europe gradually causes problems in getting spare parts, but the station manages to keep the wheels turning all through the war. The station is told to keep reserve provisions for one year, but "only necessary food". Better safe than sorry, in case the supply routes to the mainland collapse. And, naturally, no extravagancies in cooking are accepted.

The well known hunter Hilmar Nøis spends the 1915–1916 winter at Svalbard. For some reason the Technical Division in Oslo ask for his address. If they mean his address at Svalbard, it is probably something like "The wilderness innermost in the Tempelfjord". And out there he will not receive bills nor other mail before half a year's time, when summer comes.

1916

Summertime is introduced in 1916. A confusion arises about what time to write on the telegrams.

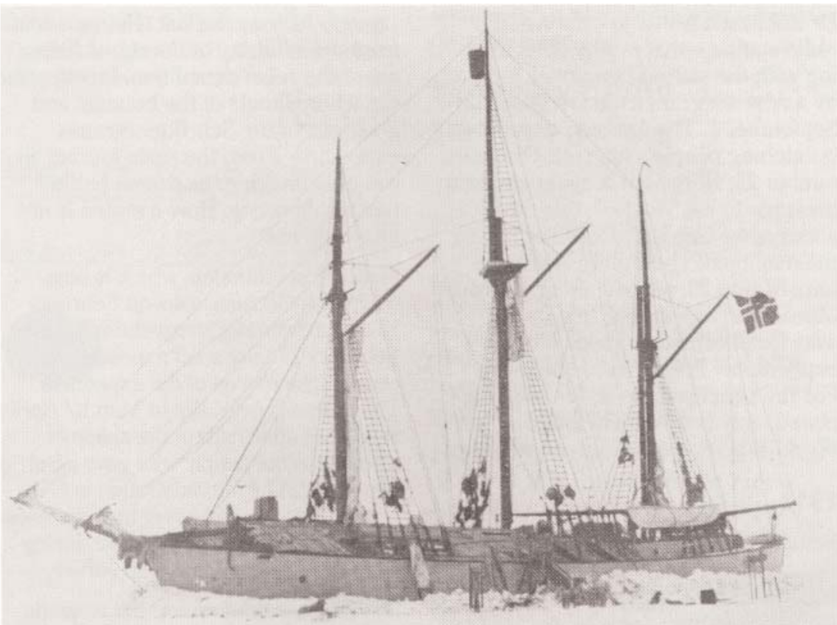


Photo: Norwegian Maritime Museum

Roald Amundsen's *Maud* in winter quarters

The Telegraph Directorate make an issue of the personnel's well-being. They report that "Photographs of the General Director and the Senior Engineer" will be sent to the station. They must have been thinking that the Svalbard staff would find comfort in gazing at the bosses when the Arctic storms howled in the black nights and homesickness was unbearable.

Late September/early October, the freighter *Moholmen* is wrecked in the Isfjorden. The crew manage to reach land at Russekeila, on the south side of the estuary of Isfjorden, a couple of kilometres east of Kapp Linne, where Isfjord Radio is situated today.

The *Moholmen* was obviously carrying freight for ACC, at least they were the first ones to ask about the ship's arrival in a telegram of October 2. The Telegraph Manager in Tromsø confirmed their departure in September. For the next weeks telegrams pass between Tromsø and Spitzbergen: "Where is the *Moholmen*?"

On October 21 the loss becomes known. Both Norwegian Telecom and the authorities take action. The winter is just around the corner, the Arctic nights have set in, and there is a real worry of having to stay the winter if the ice settles. Discussions are started on how much supplies can be given away to the shipwrecked. In Tromsø the icebreaker *Syd-Varanger* is hired to pick up the crew. The Ministry of Commerce asks "if life and health are in danger in case of a forced winter stay."

November 6, Tromsø telegraphs that "*Syd-Varanger* departs tomorrow". But it is too late. On November 18 the icebreaker returns without having reached its goal. The Telecom people at Finneset are told to help the crew to get to ACC in the Advent Bay. The Norwegians had just taken over the coal company there.

The crew were allowed to telegraph home at Christmas. On December 14 the Directorate informs that "Welfare telegrams may be exchanged between the crew of *Moholmen* and their wives at no extra charge." But there was too much slack and advantages were abused. On December 22 the Directorate tightened things up with the message that "The price cut does not apply to the captain's business telegrams and so forth." The benefits do not last long when good will is stretched too far. The Government is a strict master and demands sobriety of his subjects.

1917

Europe is ravaged by war and has entered the trenches. In neutral Norway people are short of food, but at least we are at peace. For the people of Svalbard, winter silence rules. There are few official telegrams and very little ship traffic. The days drag along. Winter turns to spring, and spring to summer. Again the midnight sun flows over Svalbard. The crew is replaced.

Supplies again have to be ordered. The experience of extra mouths to feed after the wrecking of the *Moholmen* causes orders of extra supplies, in case of "forced winter stays". This arrangement with extra supplies for people in need continued until the station closed down in 1930. Several people benefited from those extra supplies over the years.

Parts are ordered and replaced. The summer months are used for repairing the station after the tough winter, and preparing it for a new winter season.

1918

The pressure of the war in Europe is now well noticed. Small signals of things getting tougher in neutral Norway can be read in the messages. "Save on your oil. Do not let anyone borrow it!", speaks for itself. And what is worse for a Norwegian than scarcity of potatoes? In June a message comes from Svea: "Can now ship potatoes". The telegraph operator receives with a desperate sigh: "Bring them for God's sake!"

The Directorate also finds reason to tighten up business routines: "Sign for receipt only after commodity is received." There are also "Rules for firing the stove". Bureaucracy is alive in spite of the war.

The fact that the war is over on November 11, 1918 at 11 a.m. is as good as unnoticed. On the other hand, it is noticed that telegraph stations have been established at Kings Bay, Longyearbyen and Svea. We also see the start of what turned out to be the decade of polar expeditions in the Arctic. The race to the North Pole starts.

Roald Amundsen's expedition on the *Maud* started in the summer of 1918. The plan was to drift with the ice westwards towards the North Pole, and pass so close to the pole that they could reach it by foot. It turned out "not to be that simple". The *Maud* was stranded in the ice for several years. The expedition regularly attracted the international media interest in the 1920s. Spitsbergen Radio had a good radio connection with the ship, and was at times the most important intermediary of telegrams to and from the expedition. Around Christmas in 1918 press telegrams for the *Maud* are noted and in January 1919, Roald Amundsen's name is constantly being mentioned.

1919

Not only Amundsen and the *Maud* get attention in 1919: Attempts have been made at flying across the North Atlantic. In April, for instance, there is an instruction about "Weather telegrams in connection with the Atlantic Ocean flying". On July 31, there is a message to Amundsen about the location of depots.

The year 1919 is important to Svalbard and the people there even in other ways. The fact that the station manager at Green Harbour got his allowance from the Post Office to operate an office there was probably important to the man who had to do the job. But meanwhile, in Paris, intense negotiations were taking place about the destiny of Svalbard. The World Powers and winners of the first World War had a hot potato to handle.

During the war it had become clear that Svalbard was of major interest to many nations. Its geographical location and the access to rich coal deposits made many generals and statesmen wish they had the control of the archipelago. The World Powers came to the conclusion that Norway was the right nation to be responsible for the administration of Svalbard. The government's ambassador in Paris, Mr Wedel Jarlsberg, worked untiringly for this solution. The fact that Norwegian Telecom had a well established telegraph station at Svalbard was a good reference for Norway's neutrality as well as her international service.

In August/September a letter from the Telegraph Directorate is recorded about "taking over the supervision of the coal fields at Svalbard". It must have seemed a tall order for the poor telegraph operator, and was probably not meant that way. But the telegraph station was the only institution that represented official Norway at Svalbard, so who else should it be addressed to?

In October 1919, the matter of Svalbard is settled in favour of Norway. On October 10, Telegraph Director Heftye sends the following message to Spitsbergen Radio: "Send a tribute telegram to ambassador Wedel!" This is when the negotiations of placing Svalbard under Norwegian supremacy are completed,

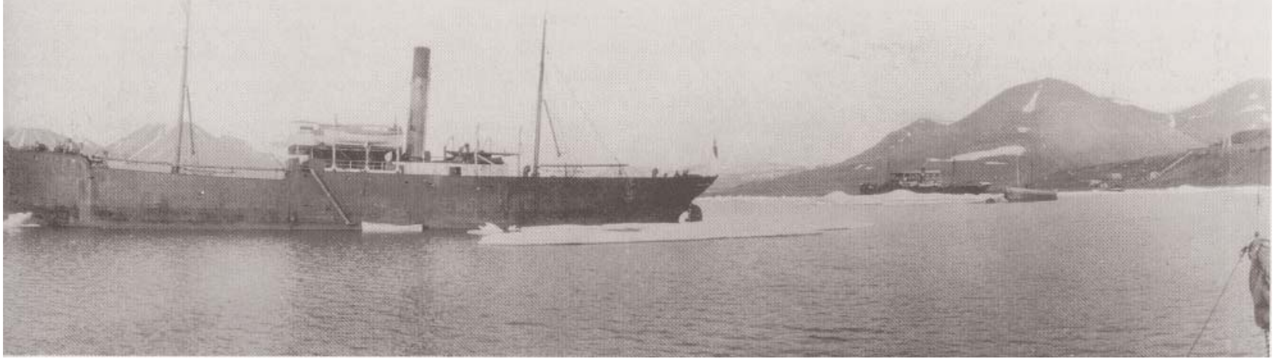
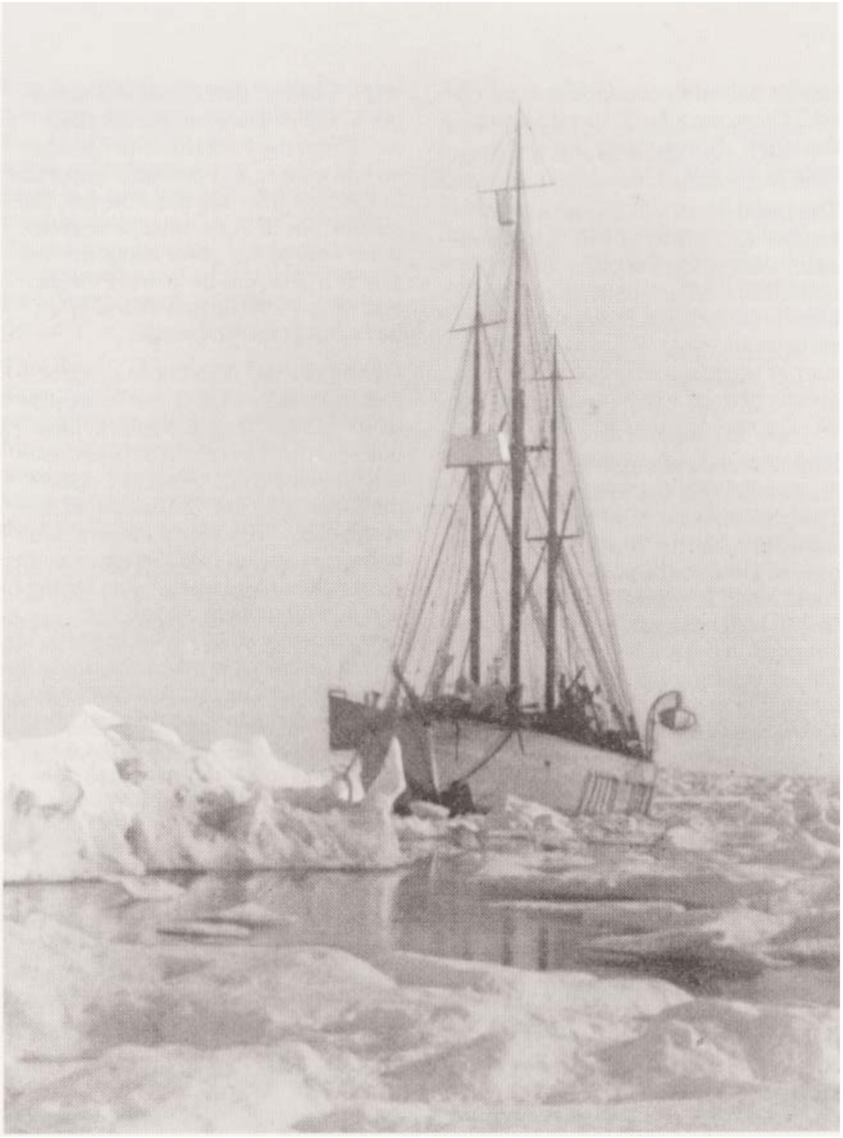


Photo: Norwegian Telecom Museum

Advent Bay, July 24, 1911

Photo: Norwegian Maritime Museum



***Maud* in the North-East Passage**

and who would be closer to send a congratulatory telegram than Svalbard itself?

The order was carried out: a proper telegram was written and sent. And it was duly noted by the receiver, who four days later returns: "Thank you for your self-sacrificing patriotic work." It could not have been better, and the people at the station most probably met the Arctic night with great delight that year.

The decade of the polar expeditions

1920

1920 saw the start of a new decade when polar expeditions were in the focus of the media. Roald Amundsen's ship *Maud* had sailed out in 1918 to try and drift along with the ice over the North Pole. The journey started out as, and ended up being, an expedition through the North-East Passage. Amundsen made two attempts in the years 1918–1925. The journey certainly was hard. The *Maud* was captured by the polar ice and was stranded for several years, which meant many winters in the Arctic Ocean. The ship had its own radio transmitter on board, and Spitsbergen Radio was the conversation partner during the whole expedition, when radio conditions would allow.

In addition to the expeditions with the *Maud,* Amundsen, Ellesworth, Byrd, Nobile, and other adventurers tried to reach the North Pole during this period. The American Peary claimed to have been there as early as April 5, 1909. The struggle for being next was hard, and the interest for the Arctic grew remarkably.

The world press followed the polar expeditions throughout the decade. The news reporters sensed problems and possible sensations. The radio station at Svalbard therefore became the centre of all this attention in the years to come, which was both a boon and a curse to the station staff. The foreign reporters who turned up were often hard to please, and complaints about the service did not go down well with the staff.

The year started with a message to the station saying that the broadcasting to Roald Amundsen should be on wavelength 2500 m. It was not easy to change the frequency for one single customer in a tick, but the management in Oslo accepted no objections. "The request of transmitting at 2500 m should be followed", was the message they got. It was a case of high priority, but clearly not too easy to effect. There were therefore quite a few correspondences on frequencies and reporting until a message on April 2 said: "Forwarding of telegrams to the *Maud* to cease". The *Maud* was then stuck at Aijon Island north-west of Tsjuktser Island on the other side of the North Pole.

1921

The traffic at the station had increased considerably over the last years. In the summer of 1921 there was a request for employing an extra engineer, as the batteries had to be recharged frequently because of the increase in telegram traffic.

The *Maud* was still stuck, but by no means forgotten. A thank you telegram from the *Maud* to King Haakon in July confirms that: "We thank you for your good wishes". After a year stuck in the ice, such attention must have been encouraging and comforting for the crew.

A glimpse of the tough days at the station is reflected in the message "The watch of the perished obviously has no interest". It might have been the station cook, because a couple of weeks later the wages office asks to whom the cook's salary should be paid out, and the answer is "To his wife".

A telegraph station has also been established at Jan Mayen, two years after Bear

Island got its station. It is the weather service of the Meteorological Office that has a need for observation stations. The station is also important for the safety of sea travelling in the North Atlantic.

Svalbard church at Longyearbyen was consecrated on Sunday, August 28. The first priest, Rev. Østensen, sends "Thanks for greetings on the church consecration".

The standard of living for the personnel improved a little every year. They get a coffee table, a gramophone, a piano, a washing machine, and a bath tub – even a Christmas tree, shipped on the last boat before the winter. Now the telegraph operator can afford a few irregular but amusing remarks. On the question from the supplier in Tromsø: "Did you receive 24 bottles of cognac and 10 bottles of spirits?", the operator remarks: "Yes, unfortunately". But when the same question is asked about "24 bottles of Martell", the comment is: "Yum-yum ...", and "This is a good place to live!". Alcohol was a source for pleasure and worry – then, as now.

What are we to think of the Christmas card from the main office that year reading "May Christmas be what it used to be."? It sounds intentionally profound. Was it just teasing, or an indication that affairs among the personnel was not as harmonious as they should be?

Among all the Christmas cards there is also a complaint from the Meteorological Office that "Not even 1/3 of weather observations from Lfg (Spitsbergen Radio) made it in time". Poor transmitting conditions or poor service?

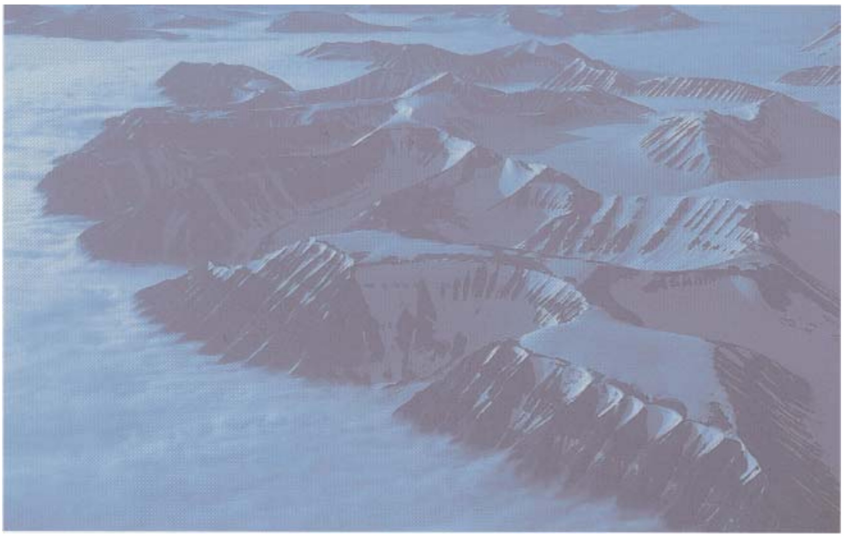


Photo: Kim Hart/Samfoto

Southern Spitsbergen, summer 1993

The main book-keeper is also stirring things up just before the festive season is about to start. It concerns a missing krone in the account. Just listen: "The sum of the listed amounts for telegram charges for September constitutes kr 8,147.00 instead of your record of kr 8,146.00. Further information requested." Yes, there probably was some trouble that winter. A telegram like this was hardly appreciated in the dark Arctic nights.

1922

In 1922 Amundsen started his second journey with the *Maud.* After having made it through the North-East Passage and the Bering Strait in 1921, the *Maud* sailed to Seattle for repairs and to be equipped for a new expedition. In the first days of July, the *Maud* set out again. This time Amundsen also brought an aeroplane with him. The new idea was to try to fly to the Pole. The starting point was to be Wainwright in Alaska.

In July "smoke-fires" are planned and organized in several places around Svalbard, probably to notify the wind direction and the landing spot should the flying machine show up. The world press were again alerted. Messages are coming in of deposits paid and warranties for payments for possible news telegrams. The *New York World* guarantees for up to 4,000 words, while the Norwegian newspaper *Handels & Sjøfartstidende* (the Trade and Shipping News) "want a telegram of unlimited length if sent immediately after landing. Please agree with someone at Kings Bay if landing there." There was money in hot news back in those days, too.

But the correspondents had to wait in vain. The plane never took off, because of persistent storms and bad weather in Alaska all through the summer of 1922. The plan to start from Wainwright failed.

Photo: Norwegian Telecom Museum

Green Harbour, July 23, 1911

On August 3, the whole thing is cancelled with this message: "Weather telegrams to Amundsen are to be ceased as of today."

The *Maud* is stuck in the ice and sends her telegrams of weather and wind conditions. In the autumn and winter there are good radio connections and lots of traffic, and at Christmas telegrams flow in and out.

In June 1922 there was an avalanche in Grumantbyen, a small mining community some 15 km from Green Harbour. The avalanche levelled the storehouse with the ground prompting following request from the company Grumant Coal: "Avalanche has taken our storehouse into the sea. Request the loan of a crate of milk and a sack of sugar." They were not exactly demanding, so there must have been some porridge to live on!

There were also geo-physical examinations at Svalbard in these years, and "Geofysen" was a frequent wireless conversation partner, especially on weather, wind and ice conditions.

1923

In 1923 there was also good radio connection with the *Maud,* and the interest in the expedition is great already at the start of the year. The Telegraph Directorate finds it necessary to regulate the traffic somewhat. Radio telegraph has become common, and there are several people who want to pass on their messages to the *Maud.*

Spring comes early this year. On April 16 it is announced that the first ship for Svalbard will sail on April 30. Not everybody is happy about this – the telegraph operator comments with a sigh: "Yes, the commotion starts early this year." A true Arctic-lover is happy when he does not have to see other people for a few years.

Amundsen makes another attempt to reach the North Pole by air. The people at Svalbard notice less of the hullabaloo this time, although the press interest is stable. The guarantees of the previous year are renewed, but radio traffic is gradually being transmitted via other stations.

Supplies and provisions always cause minor and major problems. Tromsø announces that "the Wine Monopoly does not stock red wine", and the station operator comments "Yes, that is almost scandalous." Amundsen and the *Maud* had their problems, but so did the telegraph operators.

The year 1923 went by without any other great events being noted, and the *Maud* was still stuck in the ice.

1924

1924 does not start too well for the station. In January a "Complaint from the Shipmasters' Union about the coastal radio service" is forwarded. It is possible that the consideration for customers and service had second priority, and that the technical equipment after a while became old fashioned and could not meet all the customers' needs. The wish to invest was not too great, and the economic climate was getting tougher on the mainland, too.

But new polar flights are being planned, and all willing companies at Svalbard promise to assist if needed. But they did not have to that year, as there was no flying. So there is only the *Maud* drifting about in the ice that catches the interest from time to time.

It is not always easy to live in harmony with each other and a distant Directorate in Oslo which knows very little of the everyday difficulties and the polar strain on the staff. Personal discords and staff matters often come up when people do not want to behave like "nice boys". We sense the controversies from the dispatched telegrams. The engineer, for instance, does not want to fit the engine in the new boat, despite repeated exhortations. Boat and boat-house were old news; it now peaks with a mutual ill will. The engineer probably thought : "No way did I come up here to build boats and mess about in the boat-house, freezing cold!"

Spitsbergen Radio had since its opening in 1911 also been in charge of the post office at Green Harbour. Although there had been discontent with the pay in relation to responsibility and work load, the position of post clerk had meant a good extra income for the manager. In 1924 this arrangement ceased.

1925

In February 1925, the Directorate sent a telegram saying "Post office to be moved from the radio station." Once again a suitable comment comes from the telegrapher: "The new sub-postmaster came, did nothing, and the post office disappeared." It was obviously unpopular to lose the close contact with the Post Office.

In the summer of 1925, Amundsen plans to fly from Ny-Ålesund with the American Ellesworth in two planes. On May 22, one of the planes has engine failure and has to make a forced landing. The other plane also lands, and one of the planes sinks, but the crew is rescued. It was quite a job getting the other plane in flying condition again and the runway cleared. On June 15, it manages to take off and lands at North-Svalbard. The entire crew is saved and transported by boat back to Ny-Ålesund.

The world press boils with sensation hunger, and the telegraph operators works in high gear.

The whole thing was actually quite a national point of honour: Norwegians ought to be the first to reach the North Pole. For it was never proven that the American Peary really had been there. In recent years, experts have concluded that Peary's claim to have reached the North Pole in 1909 is very doubtful.

Persons not concerned were again asked not to send messages during Amundsen's polar flying or in the area near the expedition's base at Kings Bay. The press awakes again, and the reporters once again have new authorisations and warranties for payment of their telegrams.

In May excitement is growing. The station is told to prepare the best possible conditions for telegram traffic about the flights. Another telegraph operator is sent to Svalbard as a summer reinforcement.

On May 25 comes a message saying "The station will be open day and night until Thursday morning." It seemed to be just before something big was to happen! Night-time service was unusual because of costs. Three days later the state of readiness is reduced with the message that opening hours will be until midnight June 3. Now Amundsen ought to show up soon? But at this time the whole expedition was stuck on an ice floe between Svalbard and the polar point.

So, this attempt also ended in failure. Norwegian Telecom would no longer cover the expenses for extra stand-by, but the station had longer opening hours for a while paid by *Luftseilasforeningen* (the

Air-Sailing Society) until Amundsen and Ellesworth turned up in the middle of June.

The foreign reporters were not pleased and complained about the service in a telegram dated July 4. *Luftseilasforeningen,* on the other hand, sent a telegram thanking the station for good service a week later and notified that a present was on its way. Roald Amundsen himself also sent his “Thank you for work well done” card on July 14, 1925. It is always a question of the eyes of the beholder. Journalists are often quick to complain when things do not go their way.

The year 1925 is important in the history of Svalbard. The resolution of 1920 saying that Norway has supremacy over Svalbard, is put into effect. On August 14 the Telegraph Director marks the occasion with a message for his employees at Spitsbergen Radio: “Greetings on Norway’s taking over Svalbard.” The telegraph operator has even here made a laconic comment to the telegram with his “OK”.

The September 19 message puts “Svalbard Radio” on the map: “LFG is from today named Svalbard Radio.” The old call-sign Lfg for Spitsbergen Radio is kept, even though the name is changed. This was a way of marking that Svalbard had become a part of the kingdom of Norway. Again, the telegraph operator commented “OK”.

Times changed for the people at Finneset. The position as Sysselmann (District Governor of Svalbard) had just been established and he would need a place to live. His lodging was a room at the telegraph station, arranged by the Telecom. There was very little space, so the one room had to serve as both office and bedroom for the authority.

Johannes Bassøe was the first Sysselmann at Svalbard. He announced his arrival at the end of September, and asked before his departure: “Is everything all right?” The crew was apprehensive about having Norwegian authorities so close, but it turned out to be no problem. Bassøe was adaptable, one of the most important qualities of anybody spending the winter at Svalbard.

These were lean times in the Telecom, and salaries and food budgets was a constant source of worry. It has been told that shipping suppliers along the coast of Norway had several different qualities of food. The lowest quality was said to have been: “Slightly damaged – may be used in the Arctic.”

The Smeerenburg Fiord in North West Spitsbergen is wild and beautiful

Norwegian Telecom at Svalbard got its share of this “Arctic quality”. The winter supplies for 1925/26 were not first class; the station complained about 20 tins of “damaged anchovies.” was dispatched. On return, a telegram came from the Telegraph Directorate asking: “Are the 20 tins of anchovies *completely* damaged?” In a later telegram, though, permission was given to order new anchovies for Christmas.

Roald Amundsen also got rid of old provisions in his depots. September 2, there is an entry saying “R.A.’s stock of margarine in the boathouse may be sold.” Rancid butter was a delicacy for both humans and polar bears at Svalbard.

1926

The year starts with a “Happy New Year!” from the Telegraph Director. Amundsen is possessed with the thought of reaching the North Pole, and has by no means given up. An air ship now seems to be the solution. Together with the Italian Nobile, the air ship *Norge* is built with the one goal: To fly to the Pole! The project is again a government concern, although others are financing the project. On February 13, there is a “Weather forecast to Amundsen”. The air ship *Norge* gets the call signal LBT, and “There will be no charge for traffic to the *Norge.*”

In the spring the ether really gets hot. Amundsen meets competition from the American Byrd, who also wants to fly to the Pole from Kings Bay. In mid-April reporters from the *New York Times* and other newspapers are again on the spot with their authorisations to telegraph home. One of them was “the complainer” of the previous year, and the telegraph operator again makes his personal notes in the journal.

On April 30 a new complaint comes from the *Times* reporter: “The Directorate forwards complaint about service of Lfg radio.” The telegraph operator is bitter in his remark: “William Bird arrived at Kings Bay last night. This was his first message from S/S Chantier.”

The Russians also enter the media race. The Telegraph Directorate reports that “The Russian telegraph agency TASS may send telegrams from Svalbard to Associated in N.Y.”.

On May 1 it is reported that “The *Norge* departs from Leningrad on the first day of nice weather after Sunday.” For us it seems a hazardous undertaking to travel with an air ship that is almost unsteerable, to one of the most inhospitable and windy areas of the world. But maybe it was no worse than the lonely skiing expeditions of today to the North Pole in order to make new records.

On May 5 *Norge* takes off. A whole world waits for news of the expedition. Svalbard Radio is in the spotlight again. Everybody wants direct information as soon as anything happens. “Please do mail us a short express telegram when connection with the *Norge*”, Aeroclubpress asks. But the Telegraph Directorate reiterates that no such traffic is permitted. Amundsen and his supporters claim monopoly of the news telegrams. That is a part of the deal to finance the project. The ship *Tromsøværingen,* hired by the newspaper *Aftenposten,* gets to send press telegrams at half price. This was a national undertaking, and we had to give ourselves *some* advantages.

Already in the morning of May 7, the *Norge* is at Ny-Ålesund. The journey for the North Pole starts from there on May 11. On May 12 the polar point is reached.

The *Norge* has some icing trouble, and on May 14 the air ship makes a forced landing at Teller in Alaska.

On May 12, our own radio department gets worried. “Do you still have contact with the *Norge,* express telegraph!” And then Aeroclubpress again try: “Express telegraph when your station last heard from the *Norge*.”

On May 15, the founder of the station, Hermod Petersen, acts: “Express telegraph the precise time when you last heard from the *Norge*.” They are obviously very worried. Where is Amundsen and his air ship *Norge*?

Byrd’s flying expedition has been left in the shadow of the latest incidents. The Sysselmann speaks in Commander Byrd’s interest when he asks if not “Commander Byrd can get more frequent transmission times with Svalbard Radio?”

On May 9, Byrd had flewn to the North Pole and back, departing from Ny-Ålesund. But later analyses have shown that it is doubtful whether he actually reached the Pole.

Later on in May things cool down, and everyday matters again become important at the station. Telegrams from TASS and the *New York Times* are replaced by messages like: “Fitting out a room in the whaling station can go ahead, an odd-job man may be hired – everything in the cheapest possible way!”

At the same time they try to cut down on expenses for provisions. The question “Can amount of dog biscuits be reduced?”, tells its own story. The world news is one thing, dog food another.

The new era is sensed in a message dated August 8 in Longyearbyen. A certain Mr W.U. Wederl, Spitsbergen Company “Invites all men to his cinema shows every Sunday at 8 p.m.” A bit of entertainment in the Arctic nights was great, but it is 60 km from Green Harbour to Longyearbyen, so they probably did not have too many visits from there.

1927

Routines and Arctic drama continue. It is reported that the Sysselmann wants to stay at the station this summer, too, and the manager is requested to take over the running of Ankershavn post office.

We leave the history of the first 16 years at Spitsbergen Radio when the first “Journal of incoming messages” is completed. We end the pioneer era at page 156 on May 18, 1927. New chapters in the telecommunication history of Svalbard can be found in other journals.

The inter-war period

Towards the end of the 1920s, focus was strongly on costs. There was little doubt that an all the year round operation of such a large radio station at such a deserted place as Finneset was expensive. The Telegraph Directorate therefore started to look for other alternatives. Technical experiments with transmission from both Kings Bay and Longyearbyen were carried out; the idea being to try to make use of the infrastructure that already existed around the mining industry in these places.

A move was planned already in 1928. There were plans to establish a shortwave connection between Longyearbyen and Fauske. Due to the unusually heavy traffic in the year of the great polar flights, 1928, one simply did not have time to prepare the move, and it was therefore put off. Technical tests had also shown that conditions for short-wave transmissions from Longyearbyen were rather poor. Among other things, electrical noise from the mining equipment was quite a nuisance. It was therefore decided to move the station and the general office to Ny-Ålesund on the Kongsfjord (Kings Bay), which is situated some 110 km north of Green Harbour.

In the summer of 1929, Telegraph Manager Bowitz-Ihlen took the transmitting equipment with him to Kings Bay. After all the activity and attention in connection with the polar expeditions in the twenties, this place seemed to be closer to the incidents and have better transmitting conditions than Longyearbyen. The operation at Green Harbour was carried out with a temporary long-wave transmitter after the main transmitter was moved.

But a major mining accident at Kings Bay suddenly put an end to all mining industry. Nearly the whole of the Kings Bay community was moved. Telecom’s people and equipment barely managed to get on the ship back to Green Harbour before the ice settled. So the crew spent another winter at Green Harbour.

In September 1930, Svalbard Radio was moved to Longyearbyen. Social conditions were now completely changed for the station crew; no more isolation and loneliness; no more listening to the same old gramaphone records for the umpteenth time. They could now fill their spare time with many kinds of cultural activities. They had access to a doctor, hospital, church and a priest. “People could foot it in the dance on Saturday nights and atone for their sins in the church on Sunday”, as a telegraph worker described it.

However, the old telegraph operators from the Green Harbour era were quite clear: “Green Harbour was the best!”

“Green Harbour. At the estuary of the Isfjorden, with great vistas out to sea and towards glaciers and high mountains. The place that offered such fantastic opportunities for hunting and fishing, for skiing and memorable sledge journeys. The place was so wonderfully far away from people and civilisation. Staying there has offered unforgettable memories to telegraph personnel. Life at Finneset will for most of them be remembered as the *real* Svalbard life.” This is how Green Harbour was described by one who was there. An epoch was over.

At Longyearbyen the telegraph personnel shared mess-rooms with the SNSK (Store Norske Spitsbergen Kulkompani). That was a source of mutual irritation for years, and a battle that did not end until the Telecom got their own building in 1954. Longyearbyen was owned by SNSK, and the Telecom was in many ways seen as a tenant who had to fight for their rights.

Suggestions were soon made to move to a new place: Kapp Linne outermost in the Isfjorden estuary. In a letter in the autumn of 1933, the Telegraph Manager at Longyearbyen argues strongly for this. Here are some of the arguments used:

The move from Green Harbour in 1930 was a consequence of saving on the Svalbard budget. But there was a lot of doubt whether the radio conditions were good enough, and the move was therefore intended to be temporary.

The Telegraph Manager confirms that the savings have been substantial. But the situation at Svalbard has changed considerably. In 1930, only Norway had a mining industry here, but by 1934 the Russians have started mining in two places, with a staff of some 1,500 people. And there are several ships' calls all year around.

The Russians had a series of accidents at sea in the Arctic nights of 1932. They therefore urged Norway to build a lighthouse and a radio compass station at the approach to the Isfjorden. If Norway would not do it, the Russians themselves would.

The Ministry had no choice when faced with the Russian demands, and Isfjord Radio was established on September 13, 1933, at Kapp Linne. Isfjord Radio had the "special assignment to send direction signals to ships and to look after two lighthouses".

The Telegraph Manager further indicates that Isfjord Radio has the potential to become a splendid coastal station, a first-class observation post for ice reports and an excellent meteorological station. Supervising the abandoned constructions at Green Harbour may also easily be done from here.

The conditions at Longyearbyen are described as equally bad, and the Manager suggests moving Svalbard Radio to Kapp Linne already in the autumn of 1934. Kapp Linne would then be the main station at the archipelago. This is what eventually happened.

The relationship with SNSK is also brought up. The letter closes with "I would strongly recommend moving Svalbard Radio to Kapp Linne. It would serve the public best, and it would bring pleasure and satisfaction to the employees, and last but not least, bring an end to the question of separate mess-rooms at Longyearbyen."

Svalbard at war

After Norway was attacked on April 9, 1940, Svalbard Radio and Isfjord Radio continued their transmission as if nothing had happened. They were not stopped until the Allied forces evacuated the settlers at the beginning of September 1941. The last entry in the radio diary for Isfjord is at 1901 on September 3. That was the last "met" to be transmitted.

The radio journals from that time do not reveal much information about events to do with the war situation. They mainly contain crew shifts, routine messages about the weather and notes about radio conditions. This is because all routines were changed after the outburst of the war. Information that might be of interest to foreign powers were no longer open.

The diaries were kept. They were used again when the station started up after the war. Four years of history and one page in the journal were skipped, and entries continued in the same book as if nothing had happened – a good use of resources at a time of paper shortage.

During the whole war, Svalbard was regularly visited by both German and Allied forces. Weather forecasts were of great importance, especially after Russia entered the war in June 1941. Secret weather stations were therefore established by both parties.

The Germans were most active. During the initial war years they carried out regular flights from Banak in Finnmark and Værnes near Trondheim, to Svalbard. These flights were for general reconnaisance, weather observations and for carrying supplies to the weather stations.

Some of the war-time drama is reflected in the radio diaries from the time before the people were evacuated. They are a historical source which is relatively unknown. Svalbard Radio listened, transmitted and made notes in the same way as always.

During the last days of May 1940, the ice breaker *Isbjørn* suddenly disappeared in the Isfjorden. S.O.S. messages and calls to the *Isbjørn* went on for several days, but without result. It later turned out that the ship was captured by a group of coal workers who wanted to sail to England. But the captain would not be duped, and the journey ended in a surrender to the Germans in Tromsø, with fatal results for the capturers.

In the afternoon of June 6, 1940, Svalbard Radio loses contact with Hammerfest Radio because of the bombing of the town. At night, Hammerfest Radio comes on air again with the message "Old Lgi (the radio station) bombarded. Have rigged up reserve transmitter. A couple (of persons) gone, a young boy from Hammerfest and a house maid, and one wounded."

At 11.10 on August 19, 1941, a German S.O.S. message from a vessel with the calling signal EQUX is noted: "Need doctor's help badly. Have been attacked by submarine en route from Honningsvåg to Hammerfest." The message may have been false – there is no note of a rescue operation on Svalbard Radio's part.

Photo: Pål Hermansen-NN/Samfoto

The Advent Valley

Monday March 31, 1941 saw a major mining accident at Longyearbyen. It is noted "Today at 14.30 there was a serious fire in Mine II." The radio station was on stand-by for several days after. The fire was difficult to extinguish, and with German help the mining company had extra equipment sent by plane from Værnes. The plane landed on the ice in the Advent Bay. This was the first land aeroplane to land at Svalbard and return to the mainland without refuelling at Svalbard. Roald Amundsen and Commander Byrd had landed at Svalbard in 1925, but they had been dependent on refuelling and service there. The help from the Germans was due to their need for shipping coal from Svalbard to Norway.

On September 17, 1940, a German seaplane had landed at Kapp Linne to inspect Isfjord Radio. The radio was an important weather station and had a good view of the ships passing in and out of the Isfjorden. The station was therefore of major strategic importance. On this trip was also a German meteorologist, Dr Etienne, who had the responsibility for the weather service.

On June 22, 1941, Russia enters the war. There are several Russians at Svalbard, and the Norwegians are prepared for British forces turning up. On July 31, 1941, two Canadian warships appeared in the Advent Bay. Longyearbyen was occupied and put under military command. The Sysselmann protested, but to no avail. The shipments of coal to Norway, and thereby to Germany, had to be stopped.

Naturally, the Canadians took control of the radio station. In order for the Germans not to become suspicious, traffic was maintained with false reports and weather forecasts. Fog and poor flight conditions were frequently reported in order to keep German planes away. But the Germans did become suspicious because the coal ships never returned. They sent out a reconnaisance plane which flew over Isfjord Radio on August 15, but did not observe anything unusual.

On August 24, a large British flotilla arrived to evacuate the Russians and Norwegians. During the evacuation, both Norwegian and Russian coal stores were set on fire. On September 3, 1941, Isfjord Radio transmitted its last message. At the same time they reported a cessation of transmission for 10 hours, due to necessary repairs of the constructions.

In the meantime the last forces left Svalbard. The radio silence made the Germans suspicious. On September 5, a German reconnaisance plane flying over the area reports that there were no signs of life, that the coal stores were burning, and that the radio station at Kapp Linne was not visibly out of order.

The biggest problem for the Germans was the cessation of weather reports. They were therefore quick to establish weather stations at Cross Bay (code name Knopse) and in the Advent Valley (code name Bansø) to secure accurate forecasts from the North Atlantic.

The Norwegians and the British had agreed on re-occupying Svalbard so that the mining industry could be started up again. A Norwegian platoon of some 60 men under the command of SNSK's ex-director Sverdrup was organized at the end of March 1942. Two ships were placed at the Norwegian expedition's disposal: the icebreaker *Isbjørn* and the hunting ship *Selis.*

On May 13, 1942, the two ships entered the Isfjorden. This was the start of what was later called *Operation Frithamn*. However, the ice was solid, and both ships were stuck in the ice off Barentsburg.

On the day before, May 12, a British Catalina plane had flown over the Advent Bay and discovered Dr Etienne's Henkel machine on the landing strip in the Advent Valley. The plane was fired at and destroyed. Footprints in the snow were also observed. All this was reported to the Admiralty in London via radio. The message that there were Germans in the Advent Valley was transmitted from London to *Isbjørn* and *Selis* as a warning to the Frithamn expedition. But they never received the message because the Norwegian ships only had shipping waveband receivers, while the message was transmitted on a military frequency. That turned out to be fatal for the Norwegian expedition.

In the morning of May 14, a weather observation plane from Banak flew over the Isfjorden on its daily route to Svalbard. The ships stranded in the ice were clearly visible, and a message was sent to the German Air Force chief of staff in Norway. Four long range war planes took off from Værnes the same afternoon.

Shortly after 21.00 the planes reached their destination. The *Isbjørn* was sunk, the *Selis* set on fire, and 13 people were killed. The rest of the soldiers made it to land, and sheltered in the buildings at Barentsburg.

Both German and Norwegian intelligence show that the Norwegian war efforts at Svalbard were pretty amateurish. The people on board the *Isbjørn* and *Selis* had spotted the weather observation plane, which flew at great height. But as the plane continued on a steady course, they concluded wrongly that they had not been observed.

Dr Etienne had marked off a landing spot on the ice in the Advent Bay. On May 15, two German planes landed there bringing supplies to Bansø. But the ice disintegrated rapidly, and another flight on May 18 crashed. The wrecked plane was clearly visible on the ice. On May 25 it was spotted by a British Catalina plane which was out searching for the Frithamn expedition whom nobody had heard a word from.

The survivors from *Isbjørn* and *Selis,* who had sheltered at Barentsburg, were rescued by a British cruiser on July 2. The cruiser took most of the Frithamn expedition on board and soon left Green Harbour setting out to sea. This took place without checking what was happening in the Advent Bay, only a few miles away, where the Germans were actually busy leaving their weather station. Bansø was left on July 12.

The Germans still continued their regular flights from Banak to Svalbard. Some of the soldiers from the Frithamn expedition, however, had stayed behind and had established defensive positions. They opened fire on the Germans on several occasions, both from Barentsburg and the Advent Valley. During his flight to Svalbard on July 23, Dr Etienne perished. His plane was shot at and damaged by a Norwegian machine-gun position at Longyearbyen. The plane crashed into the Hjorthamnfjellet on the east side of Advent Bay, after having collided with the aerial cable which ran from the mine high up in the mountainside.

In a raid with the German battleship *Scharnhorst* on September 8, 1943, buildings and installations at Longyearbyen, Barentsburg and Kapp Linne were destroyed.

Photo: Norwegian Telecom Museum

Svalbard Radio's new building at Longyearbyen was opened on July 29, 1954. The new building in the middle of the picture, the old telegraph building on the right

Reconstruction

Norway needed coal after the war and urgently wanted to start reconstruction. In the evening of July 1, 1945, M/S *Vårdag* left Tromsø course set for Longyearbyen, carrying complete radio equipment and an eager radio telegrapher. At around midnight he writes in his diary: "24.00. Portable transmitter mounted in lounge – temporary antenna stretched astern (in the davits). Transmitter tested with 220 V from aggregate – OK."

On July 6 the complete equipment reaches Longyearbyen. It has been a tough journey. In the diary the telegrapher notes "A lot of heavy sea; was flat out most of the time." This says something about the journey across, and every landlubber who has experienced seasickness understands the pain of the message.

On arriving there work starts almost immediately. The same day is noted: "The transmitter is temporarily put up in the duty room – next to the Sysselmann's burnt out house. The boxes with transmitter, rectifier, sundry and both antennas are brought up."

After quite a bit of trouble, the transmitter gets on air on July 12, and the first telegrams are exchanged with Hammerfest Radio. But on the night of July 15, it suddenly comes to a halt. The telegrapher reports: "Short circuit. It smells burnt. A mouse has got itself into the high voltage plugs." Whether the mouse had German or Allied ancestors is not known, but it was definitely an imported creature to the fauna of Svalbard.

It was heavy going keeping the station running. The equipment was poor and worn out, the generators and the power supplies often failed. Then there was the electronic and atmospheric noise, as always at Longyearbyen, which occasionally muffled all radio signals. The only thing to do then was to repair and keep trying.

The station at Isfjord was rebuilt in 1946. The location of Kapp Linne is radio technically a very favourable one. There are no obstacles in the south to obstruct the radio signals. Isfjord Radio has therefore naturally developed to be the main junction for all communication to and from Svalbard.

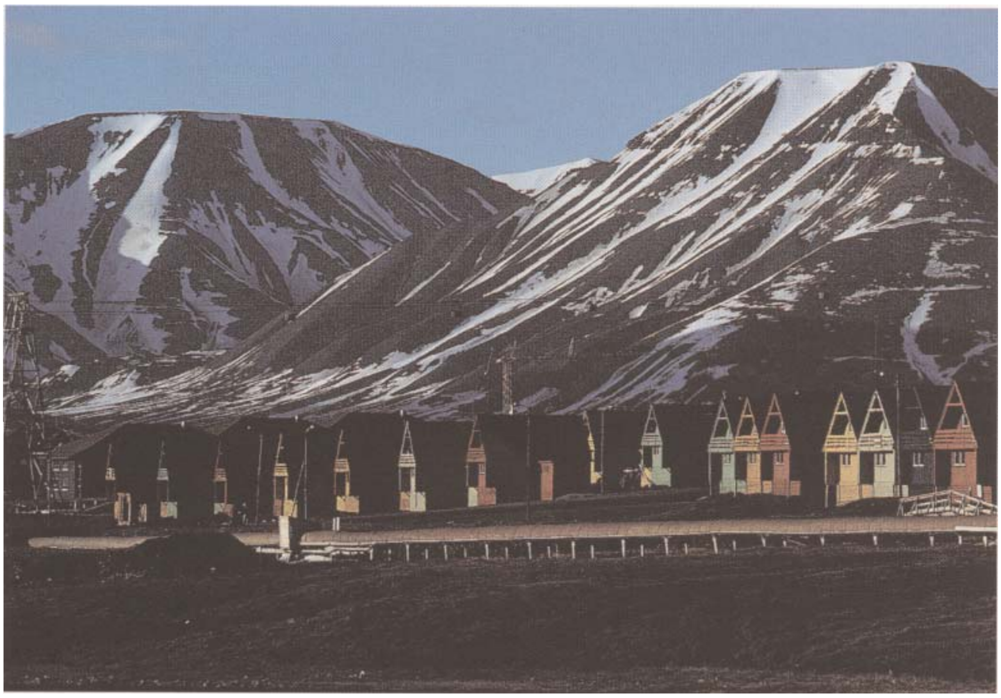
Into the satellite age

The telecommunication technology developed fast and moved the boundaries for what was practically and economically feasible. The coal working started again soon after the war. Constructions and houses were built, and management and workers moved in. In the beginning, conditions were poor for everyone, including telecom personnel.

The telegraph connection was still the life line to the mainland for business as well as welfare. It also meant safety for the settlers and ships in the seas around Svalbard. As the activities at Svalbard increased, the telegram traffic soared – the capacity could not keep up with the needs. Into the 1950s there was a lot of waiting.

When it became possible to dispatch *telephone calls* to Norway in the beginning of the fifties, telecommunication traffic reached another dimension. Lonely and well off miners had a great need for speaking with "the people back home". The queues at the telecom desk grew. It became so bad that people had to make an appointment for when to come, almost

Photo: Pål Hermansen-NN/Samfoto



A summer's night at Longyearbyen

like we make an appointment with the doctor today.

When the appointed time came and the customer entered expecting to hear a beloved voice from the mainland, the calls were often delayed. They then had to keep waiting, just like in the doctor's office. And often the attempt had to be called off because of bad radio connection with a "Try again tomorrow!"

When SNSK expanded their internal telephone network, the conditions changed remarkably for workers in the coal company. People needed no longer go to the telegraph office, first for booking a time for a call and then to show up at the appointed time. Communication capacity increased because the Svalbard community demanded it, and the time of long queues came to an end. A new telegraph station was finally built at *Skjæringa* at Longyearbyen in 1954.

In 1956 Isfjord Radio was expanded and renewed. For a time, Isfjord was an important part of the security network when the aeroplane companies started direct flights to the Far East via the North Pole. When Braathens SAFE in the 1960s started to fly regularly to Svalbard, it was the coastal radio service that provided communication with the aeroplanes.

In the autumn of 1979 the first earth station for satellite communications was opened at Isfjord Radio, marking a new era for Arctic telecommunications. Since then, there have been no other restrictions than money and good will to bar meeting all the needs for telecommunications at Svalbard.

Digital telephone connected up to the global telephone network is now being offered. The rates are the lowest in Europe, and people call freely. Data services, public paging, video conferences, broadcasting and television all have the same high quality as on the mainland. ISDN is being introduced. Only mobile phone services are missing for the offer to be complete. With a little effort it may be introduced together with the GSM development.

The coastal radio service, which handles communication with ships and aeroplanes, still has an important role. It is a manual forwarding service, but many factors indicate that even this service will become automatic and remote controlled from the mainland in a few years' time. This will be easier and cheaper for the consumer.

Since the beginning of the 1990s there has been a decrease in some of the activities at Svalbard. The old economic basis of coal mining is at the moment of less importance. Even the Russians are stepping down their mining industry. But the decline is compensated for by an increase in the interest for research, education and tourism. Several research and educational institutions are already established at Svalbard.

With increased traffic demands in the Arctic areas, good communications will increase in importance.

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Status

International research and standardization activities in telecommunication

Editor: Tom Handegård

Introduction

BY TOM HANDEGÅRD

In the period 1987 to 1994 the EU Commission pulled through the RACE I and RACE II research programmes. The programmes have been driven by the vision of a future communication infrastructure in Europe known as *Integrated Broadband Communication,* or *IBC.* The RACE programmes focused on research within integrated broadband networks and demonstrations of how services could exploit such networks. This issue of the Telektronikk Status section opens with a presentation of the EU Commission's successor to the RACE programmes: ACTS, or Advanced Communication Technologies and Services. The presentation is written by Mr. *Eliot Jensen,* who is responsible for the coordination of ACTS activities within Norwegian Telecom. As it appears from Mr. Jensen's paper, the intention of ACTS is to build on the RACE achievements and contribute further to the success of IBC by moving focus towards user-driven experimentation and trials. The paper contains an overview of the ACTS programme, as well as practical information for those interested in participation. The deadline for issuing ACTS project proposals is 15 March 1995, with the first projects starting in the second half of 1995.

Norwegian Telecom has participated in several RACE II projects. The second paper in this status section presents the results of one of them; the project CIO, or as its full name reads: *Coordination, implementation and operation of multimedia teleservices over a common communications platform.* The paper is written by Ms. *Gabriela Grolms,* who is participating in the project on behalf of Norwegian Telecom. The project designed and partly implemented a communication platform suitable for multimedia services as well as two multimedia services, a multimedia mail service and a joint viewing service. The services will be operational by the end of 1994 in several testbeds, amongst others in the CIO testbed at Norwegian Telecom Research, Kjeller.

The last three papers in the status section focus on standardisation. First, Ms. *Elisabeth Tangvik* provides an update on the work on service definitions in Study Group 1 of ITU-T. Attention is given to issues considered particularly important to Norwegian Telecom, such as new services for ISDN, global virtual network services, UPT (Universal Personal Telecommunication), B-ISDN and multimedia services, and FPLMTS (Future Public Land Mobile Telecommunication System).

Next, Mr. *Ole Dag Svebak* provides an overview of the work going on to develop the next generation of mobile telecommunication systems, expected to come into operation shortly after the turn of the century, replacing existing systems such as GSM, DECT and ERMES. In Europe the system is called UMTS, Universal Mobile Telecommunication System. The global version is FPLMTS (mentioned above). The paper outlines relevant work carried out in ETSI, ITU and RACE II.

Table 1 List of contributions to the Status section

Issue No.	Study area	Editor
3.94	Service definitions	Elisabeth Tangvik
3.94	Radio communications	Ole D Svebak
4.93	Transmission and switching	Bernt Haram
4.93	Intelligent Networks	Endre Skolt
4.93	Broadband	Inge Svinnset
1.94	Terminal equipment and user aspects	Trond Ulseth
1.94	Signal processing	Gisle Bjøntegaard
1.94	Telecommunications Management Network (TMN)	Ståle Wolland
1.94	Teletraffic and dimensioning	Harald Pettersen
1.94	Data networks	Berit Svendsen
2.94	Languages for telecommunication applications	Arve Meisingset
2.94	Message Handling and Electronic Directory	Geir Thorud
2.94	Security	Sverre Walseth

The last paper is an extensional overview of UPT written by Mr. *Frank Bruarøy* and Mr. *Kjell Randsted*. UPT is seen as a very important service in the near future. A UPT service has been specified in cooperation between Ericsson Telecom and Norwegian Telecom, and a pilot version of the service is currently being operated by Norwegian Telecom. The paper in its first part gives a quite detailed explanation of the various features of the UPT concept. It then reports on the status of UPT standardisation within ETSI and ITU, reports on relevant projects within EURESCOM, before concluding with an overview of the Norwegian UPT pilot service.

Tom Handegård is a Research Scientist working for Norwegian Telecom Research, Kjeller.

EU's research programme ACTS

BY ELIOT J JENSEN

The purpose of this presentation is to inform the Norwegian tele-science community on the emerging ACTS R&D programme, run by the EU Commission, who issued a call for proposals on September 15, with a deadline on March 15, 1995. The background, objectives and technical work-plans are briefly described. Also, some sources of available information are indicated. Finally, some decision criteria and action points are suggested for companies/entities considering to enter the ACTS programme.

1 EU's framework programmes

ACTS (Advanced Communications Technologies and Services) constitutes a part of EU's fourth framework programme for research and development during the 1994–1998 period. Through the EU/EFTA agreement, Norwegian participants have the same opportunities as partners from the EU countries including (a certain amount of) payment for the effort.

The framework programmes comprise a considerable part of the research and development financed and governed by the Community through the EU Commission in Brussels. The effort is motivated in the view of research playing a key role in the long-term strategy to strengthen growth, competition and jobs in the industry, as well as to improve the quality of life for the people. This view has been repeatedly maintained by EU leaders, most recently by the (outgoing) leader of the Commission, Mr Jacques Delors, in the White Book "Growth, Competitiveness, Employment: The Challenges and Ways Forward into the 21st Century".

The budget for the fourth framework programme amounts to ECU 11 billion, which is equivalent to just over NOK 90 billion. This is a lot of money, but per capita in the EU/EFTA countries, it is a mere NOK 50 per year.

The main part of the budget will be used in the four years 1995–1998. Most of the funds will go to industry. Companies will co-operate with universities and other institutions to form consortia in order to carry out certain research activities. Universities will have up to 100% of their costs covered; others not more than 50%. The total budget (the total amount of EU's contribution and the participating organisations' own share) for the framework programme will therefore be larger, maybe in the region of NOK 150 billion.

Even if NOK 150 billion is a very large research fund, the Commission has had to make strict priorities as to activities and time perspective. The governing criteria for selecting research and development activities have been

- a well-defined problem;
- a need for co-operation;
- a satisfactory efficiency;
- a minimum disturbance in the competition between EU suppliers.

The problem is fairly well defined, since the Commission does not wish to be a *competitor* to national R&D and neither to engage in activities which *must* be solved globally, e.g. through long term co-operation between *international* corporations on circuit technology. In principle, the work is focused on activities whose completion is expected within 3–10 years and which are to be developed into products by the participating partners. The Commission is also anxious to conduct a research policy which does not diverge from the national interests within the Community or disturb competition in business. This is not an easy job because of the close relationship between R&D and the market, where regulatory clauses play a role, and where lobbying in Brussels is done by various interested groups on a long term, strategic basis.

Figure 1 shows EU's superior strategy and criteria for the research programmes.

The fourth framework programme comprises the following fields:

- information and communication technologies;
- industrial technologies;
- environment;
- bio-technologies;
- non-nuclear energy (atomic energy has its own framework programme);

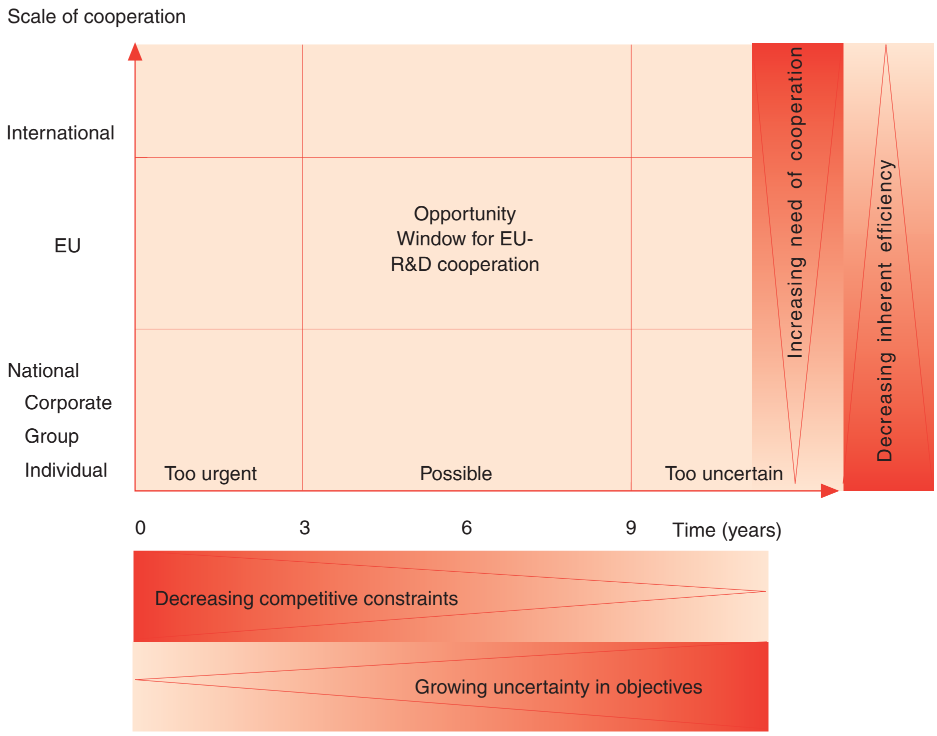

Figure 1 Opportunity Window for Co-operation on the EU-level. Time perspective in EU's R&D

Table 1 Work areas

Area		mill. ECU
1	Interactive Digital Multimedia Services	162
.1	Multimedia Communications Evolution Planning	
.2	Digital Audio-Visual Flexible Architecture and Representation	
.3	Advanced Telepresence Services	
.4	Interactive and Distributive Multimedia Delivery	
.5	Service Access for Advanced Multimedia Applications	
.6	Access Control and Protection in Distributed Multimedia Systems	
2	Photonic Technologies	104
.1	All-Optical Network Concepts and Design	
.2	Photonic Customer Access Networks	
.3	Multiplexing and Transport Technologies	
.4	Switching, Routing and Interconnects in Photonic Networks	
.5	Photonic Components and supporting technology	
3	High-speed Networking	75
.1	Functional Integration for high Performance	
.2	High Performance Networking and Access	
.3	Priority management in heterogeneous links	
.4	High speed service set-up and integration	
4	Mobility and Personal Communications Networks	115
.1	Mobile Services	
.2	System Platforms Demonstrators	
.3	Enabling Mobile Technology	
5	Intelligence in Networks and Service Engineering	100
.1	Experimental Service Development	
.2	Service Components Design	
.3	Service Creation Process	
.4	User Control and Management	
.5	User-Service Interaction	
6	Quality, Security and Safety of Communications Services and Systems	43
.1	High Integrity, reliability and availability	
.2	Confidence Monitoring	
.3	Technology for Quality and Confidence	
7	Horizontal Actions	31
.1	Domain Management	
.2	Impact Assessment	
.3	Information Infrastructure	
Total		630

- transport;
- socio-economic research with a definite aim.

The field of information and communication technologies has been allotted by far the largest budget, over 30% of the total amount. This clearly underlines EU's understanding of the importance of these technologies for future growth. The field is divided into three research programmes:

- *ACTS,* comprising the technologies for network platforms and communication services;
- *Telematics,* comprising the development which will have to be carried out by user groups (industry, institutions and public administration) in order to make use of the telecommunications of the future. Telemedicine is one example;
- *Information Technologies,* comprising the development and application of computer technology in general terms; similar to what is usually called informatics.

In all of these three programmes there are activities where Norwegian Telecom is interested in solutions, and also has the competence to participate by virtue of our own current research and development activities. However, ACTS is singled out as the most important one to us as public network operators.

2 The motivation for ACTS

Even if the cradle of telephony was in the USA, European countries have so far done well in research and market shares. However, new technology on the application and network side has brought us into a situation where the USA and Japan have become the leading countries in important fields. This fact is bringing unpleasant consequences for many of the European participants in the telecommunications sector. The recognition of the importance of this sector for the economic and social development in Europe has prompted the EU to put high priorities on research and development related to telecommunications. The research programmes RACE I and II (Research on Advanced Communications in Europe) were implemented within the second and third framework programme in the period 1987– 1994. The cost was some 1.4 billion ECU, but the effort contributed to Europe managing to hold on fairly well in the most important network related technologies and their applications, e.g. mobile and broadband communications.

The new research programme ACTS, which is expected to constitute roughly 5% of the total effort on telecommunications R&D within the EU/EFTA area, is aiming at consolidating the situation by putting a lot of effort into applications, as well as intensifying research into certain selected technologies. The speed and content may be seen in connection with the network development which the EU Commission is expecting, and which is outlined in Figure 2.

The time scale in the figure reaches well into the next century. Important prerequisites for the outlined development are:

- The development and introduction of high capacity networks, based on ATM, which are capable of co-operating with residential and regional networks, as well as other co-existing networks;
- The development and marketing of high quality broadband telecommunications services, e.g. within multimedia;
- The realisation of high capacity network access, based on optical fibre.

ACTS is a part of a large "master plan" to establish so-called "trans-European networks" within telecommunications, transport and other related areas, with a time perspective well beyond this decade. For broadband telecommunications the correlation with the research programme is outlined in Figure 3.

3 The technical content of ACTS

ACTS is managed by the EU Commission through Directorate Generale XIII (DG13), "Telecommunications, Information Market and Exploitation of Research". The DGs constitute a part of the Commission. They are directly subordinate to the EU Commissioners and may best be compared to the ministries of national governments. DG13 has published a work-plan for ACTS in co-operation with various interested groups, among them national authorities and European trade associations.

The ACTS Work-plan describes the areas of activity shown in Table 1. The distribution within the budget should be seen as a guideline and does not exclude the possibility that projects may work in several fields. It also indicates a strong preference for multimedia.

As can be seen, fields 1–6 are technically oriented, while field 7 contains bridging activities, which obviously will have to be attached great importance in such a large and decentralised research programme. Among other things, the field comprises:

- The establishment of so-called "National Hosts" (NHs) which will make network platforms available for application projects (within ACTS or other programmes) with a need for telecommunications services to test their results. The NHs (the work area is not fully defined as per September '94) may also handle certain co-ordination jobs within ACTS.
- Further work on co-ordination jobs (similar to RACE) as to harmonising results, e.g. producing suggestions for recommendations/standards to organisations like ETSI and ITU.

The Commission is particularly anxious to establish the NHs because it wants to see many application projects. The general arrangement should be ready before projects within fields 1–6 are selected. The intention is to have at least one NH in each country – Norwegian Telecom will naturally be the NH for Norway. We will offer an arrangement based on Supernett, a high capacity network between universities and other demanding users, which also has a connection to Sweden and Denmark (Figure 4).

With regard to fields 1 to 6 in the ACTS Work-plan, professionals both within and outside of Norwegian Telecom should be able to find many interesting activities. Norwegian Telecom Research also has ongoing activities within all of the fields.

4 Participation in ACTS

Participation in ACTS projects may be useful, if not unproblematic. If participation is agreed, it is necessary to subordinate to a contract between the consortium and the EU Commission, comprising

- Contributions to deliverables (technical reports, completion of equipment or carrying out experiments);
- Time limits;
- Work effort;

for a time span of 2–3 years. Similar priorities within the individual company or entity *should be clarified beforehand*. Should major adjustments become necessary during the life span of the contract, it will cause irritation with both the project partners and with the Commission.

As long as preliminary contacts are sought with the intention of establishing, or participating in, a consortium, there are obviously no obligations. But when a group of potential partners start piecing together a project proposal where each partner's wishes, special skills and resources are taken into consideration, one does take on liabilities. These liabilities are usually stated in a "Consortium Agreement" which regulates the partners' mutual rights and obligations. This is a legal document which most consortia will require the partners to sign before a proposal is submitted, or at least before a contract with the Commission is entered into.

The motivation for participating in ACTS projects may vary in different organisations/entities. Valid motivations for participation may be:

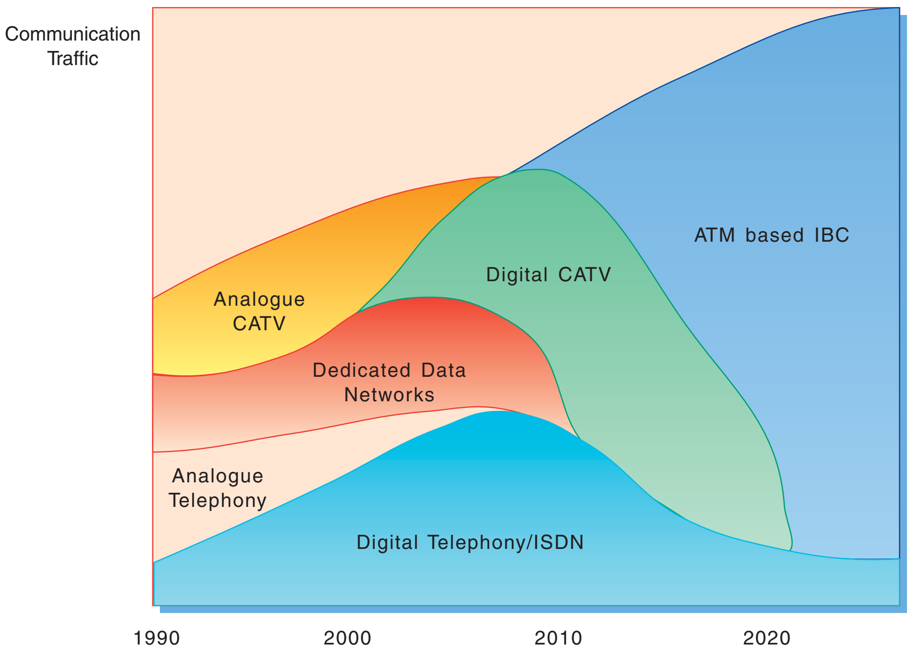

Figure 2 Evolution time frame **- CATV cable TV**
- IBC integrated broadband communication

1 Similarity to already defined research activities, where there are skills both for contributing positively in the consortium, as well as for harvesting results from the project on a general basis, with regard to further research and applications. This requires technical expertise in the field.

2 In cases where applications or operative activities may be supported by an ACTS project, and where a contribution to the consortium may be carried out reasonably well. Having technical expertise within the whole field will not be necessary, provided one has a suitable niche for one's qualifications or laboratory facilities.

3 In cases where there is a wish to develop new skills, where personnel resources exist and where acceptance from partners (and the Commission) for participation on non-technical criteria may be obtained, like the wish for a broader composition of consortia with regard to fields or countries.

The wish to provide technical personnel with international R&D experience should also be mentioned. Telia, which participated in RACE with personnel from several entities, once had an independent survey done on their participation in the programmes. It emerged from this that the entities regarded such international experience as important, on the basis of growing internationalisation and the new regulatory working conditions through EU's directives.

Doubtful criteria for participation seem to be:

1 Solely to make a profit. This does *not* apply to universities.

2 Participation mainly through sub-contractors, without having the skills, or for other reasons not possessing the resources, to take home results to one's own organisation.

Having said this, it should be mentioned that there is a market for consultancy services directly to the Commission, which will then pay 100%. Such services may e.g. concern certain co-ordination jobs, the development of technical/ administrative tools, market studies, consequence analyses, etc. We would hope that Norwegian companies gain entry to this market, even though it will not be easy!

Norway contributes some 2% to the financing of the fourth framework programme. Norwegian contributions to ACTS are therefore equivalent to some 75 man-years per year (considering the rule of maximum 50% coverage of costs). The Norwegian effort in RACE in the years 1988– 1994 has varied between approx. 10 and 15 man-years per year, out of which Norwegian Telecom has been responsible for about a half. Naturally, it ought not to be a goal in itself to achieve perfect financial balance between contribution and result for any international research programme; our national interests within telecommunications should still indicate a far stronger Norwegian effort in ACTS than was the case in RACE. Besides, experiences from RACE show that there is great competition for research resources of this kind in other European countries.

There will be two calls for proposals in ACTS:

1 Call for proposals for the first round was issued on 15 September. The last date for submitting project proposals to the EU Commission is 15 March 1995, at 1700 hours.

2 Calls for the second round are expected in the autumn of 1995.

5 First round of proposals

The documents in the call for proposals and other information may be obtained from the Commission by contacting:

European Commission,
DGXIII-B/ ACTS, BU9-4/82
200, Rue de la Loi
B-1049 Brussels, Belgium
(tel: +32 2 296 34 15, fax: +32 2 295 06 54, email: ACO@postman.dg13.cec.be).

Via Internet, documents in many different formats are available by ftp from the address:

ftp://ftp.uni-stuttgart.de/pub/org/ceu/acts.

Those who wish to be on the Commission's ACTS mailing list, should contact the above mentioned address in Brussels. In order to survey the interest for the seven fields in ACTS, the Commission has produced a questionnaire, "Expression of Interest in ACTS". The information will be used to bring potential partners together in consortia. The questionnaire is also included in the documentation from Stuttgart.

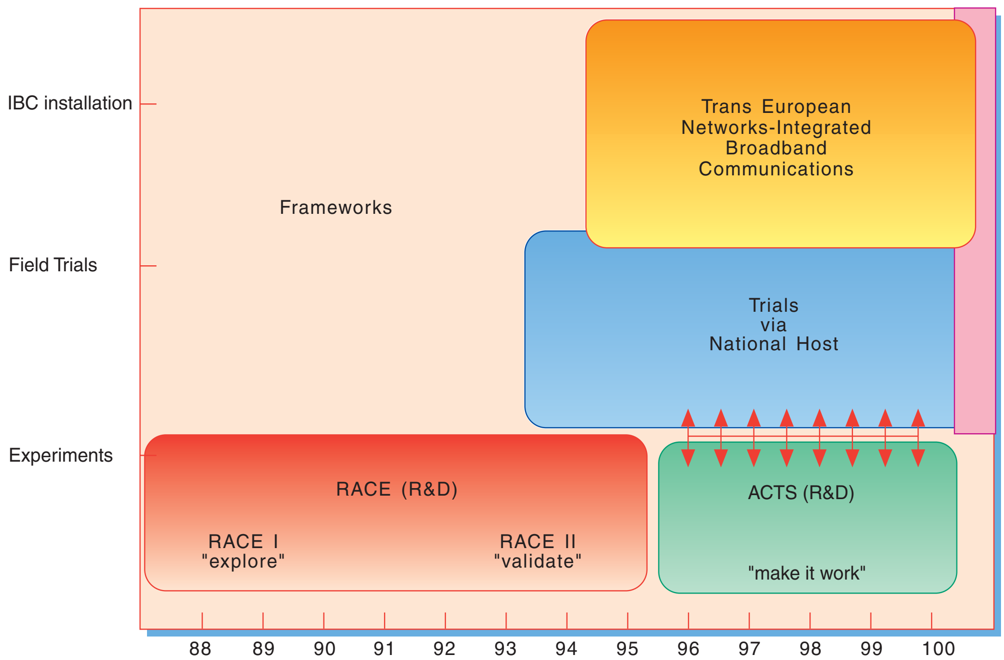

Figure 3 Phasing of IBC Implementation

The co-ordinating and advisory organ for Norwegian participation in ACTS is the Norwegian Research Council. Contact person is

Tron Espeli
Norges Forskningsråd
P.O. Box 2700 St Hanshaugen
N-0131 Oslo
(tel. 22 03 70 00, fax. 22 03 70 01,
email: tron.espeli@nfr.no).

Norwegian Telecom Research has a similar role within Norwegian Telecom. Contact person is

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N-2007 Kjeller
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email: eliot.jensen@tf.tele.no).

6 Action list for potential ACTS participants

The projects will be run by international consortia. In the initial phase it is therefore vital to establish contacts with organisations which together may form consortia in order to plan and offer the project to the Commission by 15 March 1995.

Steps in this process could be:

1. Get hold of the call for proposal documents, including the technical part (ACTS Work-plan). Obtain further information from sources like the Commission, the Norwegian Research Council, earlier participants in RACE, etc.
2. Examine one's own projects and need for R&D related to the areas in ACTS.
3. Assess one's own organisation's skills and place in the national and international professional environment.
4. Set limits for the size of one's own organisation's participation.
5. Establish preliminary contacts with other companies and professionals.
6. Participate actively in the work to form a consortium and produce project plans. This is important in order to influence the Consortium's project plans in the favour of one's own organisation.

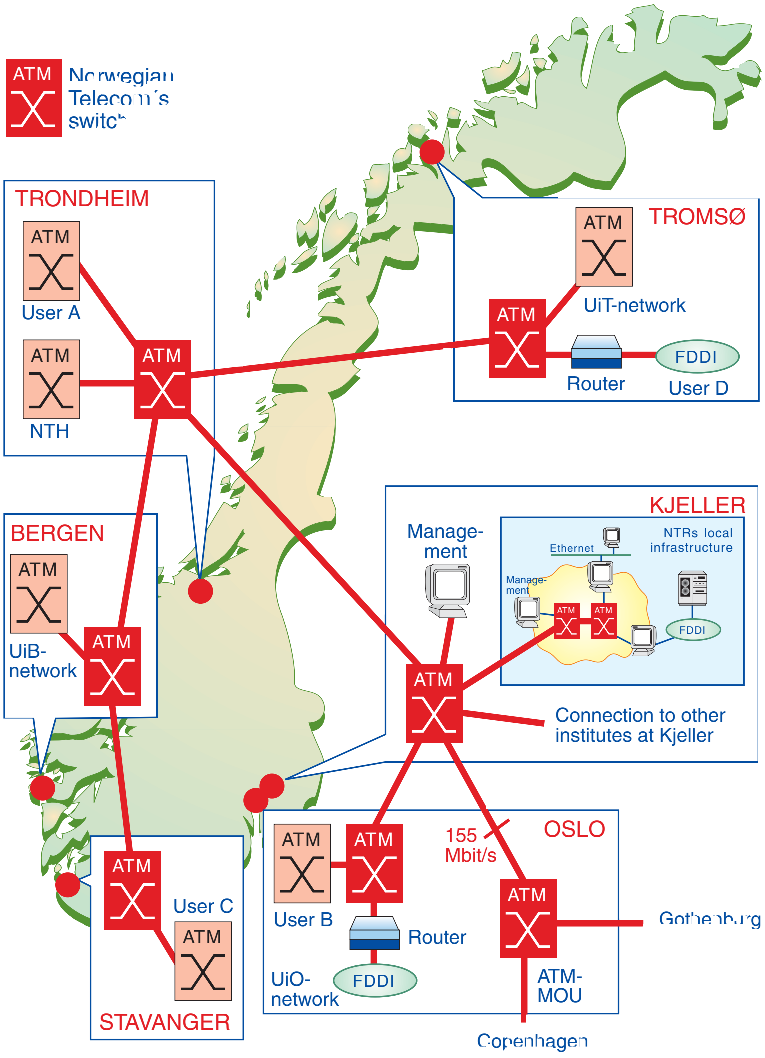

Figure 4 Supernett

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The CIO project

BY GABRIELA GROLMS

Background

The full title of the RACE R2060 project CIO "Coordination, Implementation and Operation of Multimedia TeleServices over a common Communication Platform" states the main work areas of the project (1). While implementation is the central activity of CIO, the overall goal was to harmonize these implementations at an early stage for future interconnectivity. The success of this project which covers almost all aspects of modern telecommunication, strongly depends on the co-ordination of the various activities assigned to currently 16 partners in 7 countries, with a time frame of 3 years (1992–1994).

The project has been sponsored by the Commission of the European Communities (CEC) within the framework of the Programme on *Research and technology development in Advanced Communications technologies in Europe* (RACE). It has a total budget (including partners' contribution) of roughly 12,600 kECU.

The RACE Programme intended to put into operation the vision of *Integrated Broadband Communication* (IBC) as the future communication infrastructure in Europe. The CEC chose an approach that distinguished among 3 phases: Phase I (RACE I), focusing on the system engineering, specifications and key technologies; Phase II (RACE II), focusing on integration and prototyping of new services and applications, and Phase III (ACTS), beyond the RACE Programme, consisting of user-driven experimentation and trials.

The R2060 project CIO is embedded in the RACE II – Projectline 8 which concentrates on *Test Infrastructure* and *Interworking*. By the end of 1994, CIO will provide a MultiMedia Communication Environment at various European sites *(Test Infrastructure)* with the potential for inter-Testbed communication *(Interworking),* which is well suited to host not only future ACTS activities but might become part of the future IBC in Europe in general.

Table 1 CIO Partners (1994)*

Germany	Switzerland	Portugal	Norway	Netherlands	Spain	Belgium
DeTe Berkom GmbH (Prime)	ASCOM	CET	NTR	PTT Research	Telefonica	Université Liège
DBP Telekom	ETHZ	INTERSIS				
GMD						
MediMedia Port Berlin						
Siemens AG						
TU Berlin						
Univ. Stuttgart						
Univ. Ulm						

* FCR (France) left the consortium in 1992, ACOTEC (Germany) and Siemens AS (Norway) in 1993.

Introduction

The basic idea in CIO was to implement two MultiMedia TeleServices, *Joint Viewing and TeleOperation Service* (JVTOS) (2) and *MultiMedia Mail Service* (MMMS) (3) on a *MultiMedia Communication Platform* (MMCP) (4) which supports the TeleServices in a quality which they themselves require in order to offer an acceptable quality of service to the user.

The development of a new MMCP was seen to be important due to the "different" traffic characteristics of MultiMedia applications. Today's networks in general support only a single traffic type. Data networks, for instance, were designed to transfer 'computer output', video conference networks to transfer voice together with video. MultiMedia applications combine these traffic types and require a communication platform which allows the transfer of both while maintaining their particular characteristics. Different characteristics require different actions within the MMCP which result in a corresponding quality of transport service.

The MMCP related implementations had to be restricted with respect to the number of networks and workstations which should be supported by CIO. Due to the features the specifications of ATM based networks promised, ATM was chosen as the technology for the target network. However, based on the constraints at some partners' sites and the limited availability of ATM equipment in the first project phase, FDDI and Ethernet had to be included in the Reference Architecture of a typical CIO Testbed (figure 2).

A CIO Testbed may consist of any combination of the depicted networks. It may, thus, form a multi-network environment which requires interworking units (IWU), at least for traffic routing and forwarding. Each partner may operate its own CIO Testbed, which shall prepare for, but not necessarily offer, inter-Testbed communication. Another requirement which makes a *Testbed* a *CIO Testbed* is the common CIO protocol suite for all networks within a Testbed and common to all Testbeds. CIO Testbeds could now serve as the harmonized basis for the implementation of the two MultiMedia TeleServices. It was up to each partner to install its CIO Testbed infrastructure. It was part of the project to provide each Testbed with the CIO specific developments.

Based on a comprehensive procurement analysis, where NTR (the A-lab project) was responsible for the network related issue (5), the CIO Consortium decided to focus the implementations on SUN workstations. Apple Macintosh, PC/Windows, SGI (Siemens) and NeXT have been integrated as far as appropriate equipment became available in time.

By the end of 1994, JVTOS and MMMS will be operational at various CIO Testbeds in Europe, among them NTR (Kjeller), DeTe-Berkom (Berlin), Ascom (Bern), ETHZ (Zurich), RIA (Aveiro), Siemens ZFE

(Munich) and PTT Research (Groningen). Although CIO did not aim at interconnecting the Testbeds, it has been taken into account when designing the MMCP. First presentations, among them a distributed session between the Interop '94 (Berlin) and BRIS '94 (Hamburg) over the German ATM-Pilot, proved the approach to be successful.

The MultiMedia Communication Platform (MMCP)

One of the prerequisites for common achievements and future interoperability among CIO Testbeds is the specification and implementation of a common protocol suite, which forms, together with the network infrastructure, the MMCP. The following criteria were identified in order to find a suitable candidate:

- It had to offer features which allowed the implementation of a MultiMedia Transport Service (MMTS)
- It had to exploit the features of the new ATM technology
- It had to be made available to the TeleServices early enough to finish their adaptation.

Based on these criteria the Consortium decided to use the public domain software implementation of the Xpress Transfer Protocol, XTP (6). The specification, and particularly the implementation, lacked important features with respect to a MultiMedia Transport Service and the operation on top of a switch based ATM network. Both specification and implementation had to be modified and extended. The CIO specific version is referred to as XTP eXtended (XTPX) (7). The major extensions have been made to improve the flexibility of the quality of transfer service (QoS) which XTPX offers to a MultiMedia application and its exploitation of ATM network features.

Flexibility has been achieved by means of Transport Channels. The QoS can vary among different Transport Channels. Each Channel can offer a QoS according to the particular needs of the traffic type it shall transport. The protocol had to be extended by features which allowed the monitoring of QoS and the reporting of quality changes. The user should have the choice to either adjust the requested quality or to terminate the application in case of unacceptable changes. Quality can only be guaranteed through resource reservation and policing of resource consumption. Since not all Transport Channels need to guarantee their QoS, a priority can be assigned that indicates the effort which the implementation shall make in order to maintain a service with a certain probability. It ranges between *best_effort, best_effort_ with_threshold* and *guaranteed.* The Transport Channel e.g. used to transfer voice can be assigned a higher priority (guaranteed) than a channel that transports e.g. text (best effort).

Resource reservation and policing turned out to be crucial issues for the implementation of guarantees. It is not only the *network* resource which has to be administered. Even if the network guaranteed to maintain certain traffic characteristics, the end systems and interworking units (IWU) caused changes to the traffic characteristics within the chain of involved parties. A solution to this problem requires major interaction with the system resources like operating systems, schedulers and system internal buses.

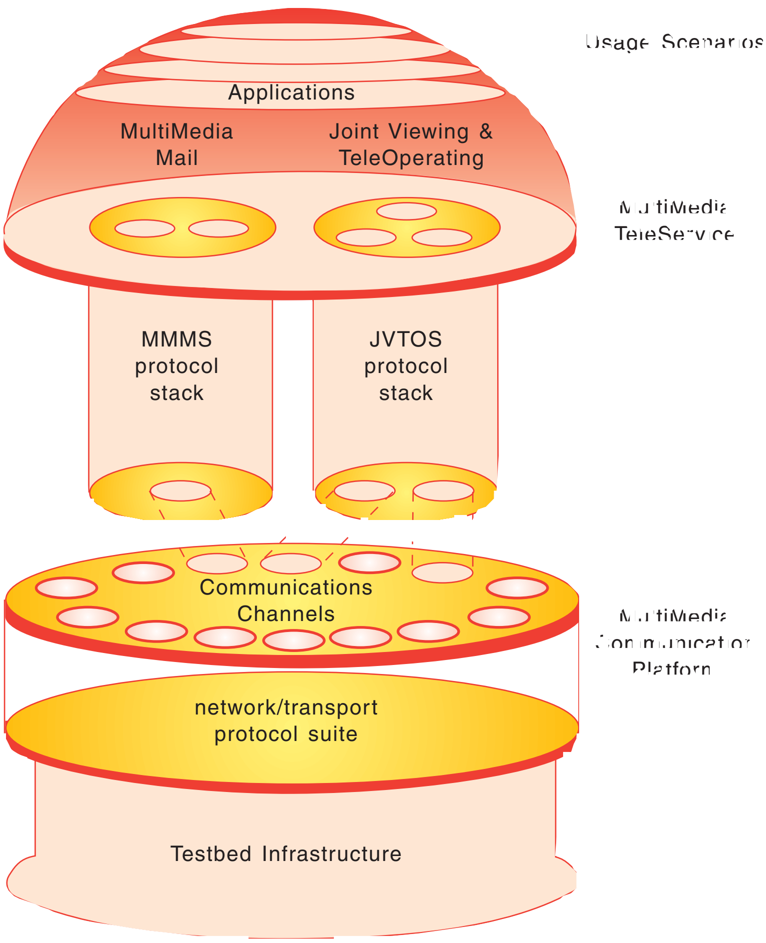

Figure 1 The CIO architecture

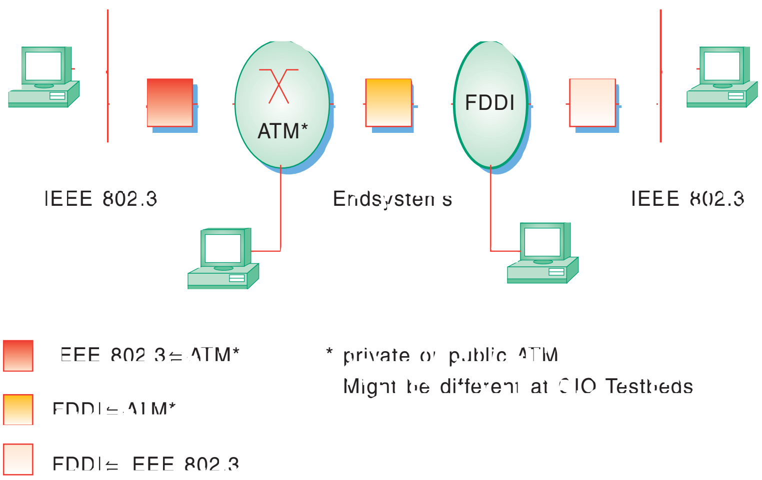

Figure 2 CIO Testbed Reference Architecture

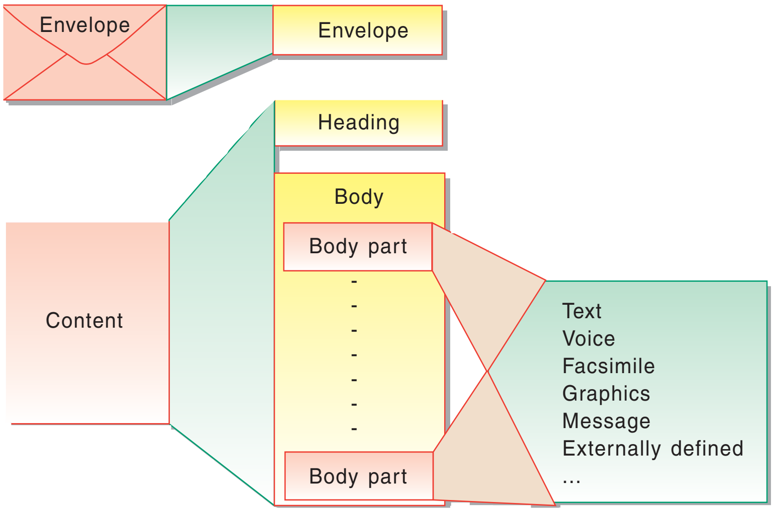

Figure 3 X.400 Message

With the requirement to offer a service quality with a certain probability and reliability in the heterogeneous multi-network, the task of the IWU exceeds routing and forwarding. IWUs must map different network characteristics onto each other in order to maintain a negotiated quality over several hops. For instance, mapping the quality which an individually accessed ATM switch can offer onto a shared Ethernet bus is almost impossible and can only be emulated, if at all, by e.g. admission control mechanisms. The networks in CIO Testbeds (figure 2) do not offer the features which are required for multimedia traffic. Not even a pure ATM Testbed could provide these features up to now due to the lack of functionality in the early versions of ATM equipment.

These constraints forced major cuts with respect to the implementation of the MMCP in CIO. Alternatives and solutions have been intensively discussed; an implementation, however, would have exceeded the project's limits.

The gap between XTPX as a protocol suite for an MMCP and its realization in an environment which is not suited to support MultiMedia communication still needs to be closed, most probably beyond CIO. It requires an intensive engagement of manufacturers with respect to the design of today's customary workstations/equipment and the commitment to use networks which do provide guaranteed transport services, as e.g. ATM. Up to now, XTPX has not been able to prove its suitability for MultiMedia applications, mostly due to the fact that the programming interface which the Teleservices require could not be finished on time. Due to the lack of functionality in the early versions of ATM equipment it could not even prove its benefits onto ATM yet. JVTOS and MMMS still operate on the TCP/IP protocol suite, however, without the advanced functionality an ATM based MMCP could support.

NTR provided the CIO Testbeds with the adaptation of XTPX onto ATM and the IWU between FDDI, Ethernet and ATM. Especially the results of performance measurements provided a deep understanding of the different techniques to efficiently operate network/transport protocols on ATM and the problems related to QoS provision in IWUs and end systems (8).

The MultiMedia Mail Service

Multimedia applications allow users to create and consume documents which integrate several 'media' like text, audio, video, still images and graphics into one context, so-called *multimedia documents.* A multimedia mail application allows the exchange of multimedia documents as electronic mail (3). Analogous to the MMCP, MMMS developments in CIO should as much as possible be based on existing specifications and implementations. Most electronic mail systems allow only the exchange of textual messages. 'New media types' are only found in some proprietary systems as for example the Sun Open Windows Mail Tool, NeXTMail, QuickMail or Microsoft Mail. Although all these systems allow binary enclosures in order to exchange sound and video clips, the message formats and addressing schemes are different for each of them and cause incompatibilities with respect to the exchange of messages among them. Since MMMS should be implemented on Sun (SPARC-station, SunOS 4.1.3), NeXT (NeXTSTEP 3.1) and PC (Windows) a vendor independent message format and exchange protocol was required. The Consortium decided to follow the approach taken by the CCITT recommendation series X.400 (88) (9), which supports multiple message body parts of various types and the integration of new types. X.400 has been 'upgraded' with some multimedia features while remaining compatible and allowing the interworking with 'non-multimedia' participants.

A message content, called body part, has a particular type. Some body part types are already defined in CCITT recommendation X.420. Among them 'ia5-text', 'g3fax' and 'externally defined'. The latter one is important for the specification of multimedia messages since it can be used to transmit non-predefined content types of the 'new media' (figure 3).

However, the X.400 (88) recommendations do not care about the structuring of messages and independence of storage limitations which are essential for the exchange of multimedia messages.

The storage capacity at the sender, receiver and within the Message Transfer System (MTS) with its 'store and forward' concept had to be adapted to the potential size of multimedia messages. CIO chose a mechanism that enables the storage of bulky body parts at a globally accessible location – a Global Store – and the replacement of this content within the message by a reference to the stored content, called *external reference*. Its structure is based on the international standard for Distributed Object References (DOR) (10).

The External Reference Production (ERP) service (11) is used for the transfer service from the sender to the Global Store. The type of transfer service for the direction from the store to the receiver may range from normal file transfer to real time data transfer. External references may be resolved by the receiver of a message depending on his interest or his capabilities to render the content, on his local environment and on timing restrictions regarding the presentation schedule of the multimedia mail. External References may even not be resolved in case the receiver is a 'non-multimedia' end system. CIO chose to use the international standard for Referenced Data Transfer (RDT) (12). Both services are based on the Association Control Service Element (ACSE) and either the Remote Operations Service Element (ROSE) or the Reliable Transfer Service Element (RTSE).

Regarding the multimedia message structure, CIO chose to align the message structure as much as possible with the multimedia document structure. Independent of the standardization progress on multimedia documents (e.g. HyperODA, MHEG, HyTime), a 'mail-like' architecture with simple structuring information was adopted. A multimedia document in CIO consists of several content parts analogous to the body parts in the corresponding message. Content parts may contain information of different media types such as text, geometric graphics, still images, audio and video. Content parts of multimedia documents must not necessarily be in sequential order. Semantical connections between content parts are provided by link identifiers called annotations, which among other things provide information on where a 'switch' to another content part can be stimulated (figure 4).

To transfer a multimedia document via an X.400 MTS it has to be converted to a conforming message (figure 3). This message represents the interchange format of a document. The interchange format of a CIO multimedia document is described through a *CIO profile*. It identifies the supported body types and the internal structure and coding for the body parts which contain 'new' media types. The mapping between the multimedia document structure and the mail structure implies that each document part of the multimedia document is encoded in a body part of the mail. Apart from the pre-defined 'ia5-text' body part all other content parts are transmitted within the same type of body part, 'externally defined'. The particular contents of this body part type are differentiated through object identifiers in ASN.1. The content types currently supported are: audio (G.711), video (MPEG), image (Tiff, Gif, JPEG), graphics and documents (Postscript), external reference (DOR) and link (ia5text).

Since X.400 only supports sequentially structured messages, the 'link' information which provides the semantical context in the document must be carried within a message through a dedicated body part of the 'externally defined' type. This enables the receiver of the message to put the different body parts into the correct relation.

The CCITT X.500 Directory Service is used to offer the user a convenient interface to the Teleservice. It incorporates editors/viewers for the particular content parts, facilities for 'link support' and external reference handling. They operate on local presentations of the multimedia document. In order to send documents as electronic mail via X.400 MHS they must be transformed to the interchange format as defined by the CIO profile. Additionally, several conversion functions and the mediation between the user interface and the chosen Message Transfer System have been implemented. The modular design makes the system adaptable to other Message Transfer Systems

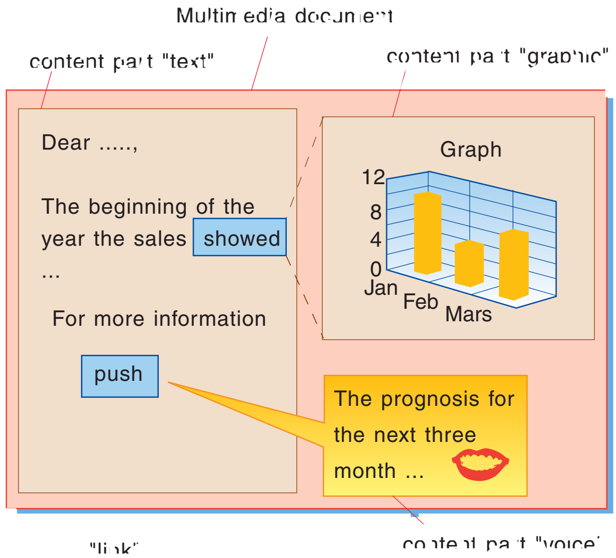

Figure 4 Multimedia Document

than X.400 through the integration of particular converters, e.g. to Internet/MIME.

Implementations of MMMS are currently using the PP X.400'88 submission and delivery channel of the ISODE Consortium Release R1v5 (13). They are available on Sun, NeXT and PC. Plans are made to operate the components for storage and retrieval at the Global Store on top of the CIO MMCP using transport channels for time sensitive data after the MMCP programming interface has been finished. The final version will integrate video sequences coded as MPEG and audio sequences coded in G.711.

Joint Viewing and TeleOperation Service (JVTOS)

JVTOS (2, 14) allows sharing of any, in most cases monomedia, computer application among several participants of a JVTOS session. The service can e.g. be used for general cooperative work, like discussion and editing of commonly viewed text and images, and particularly to demonstrate and explain the use of any other application to inexperienced persons. The features to complement shared applications by live audio and video transmission makes JVTOS a multimedia service different from 'real' multimedia applications where these features are incorporated in the application. The advantage of the JVTOS approach becomes visible in a multi-vendor environment. Apart from the new quality of complementary audio and video, users of one vendor gain access to applications running on another vendor's platform. e.g. UNIX users to Mac and PC applications. JVTOS offers capabilities for group communication and session control and it is independent from the underlying networking technology. It supports currently up to six users in a session.

The modular design of JVTOS is depicted in figure 5. The multimedia service in JVTOS is provided through co-operation

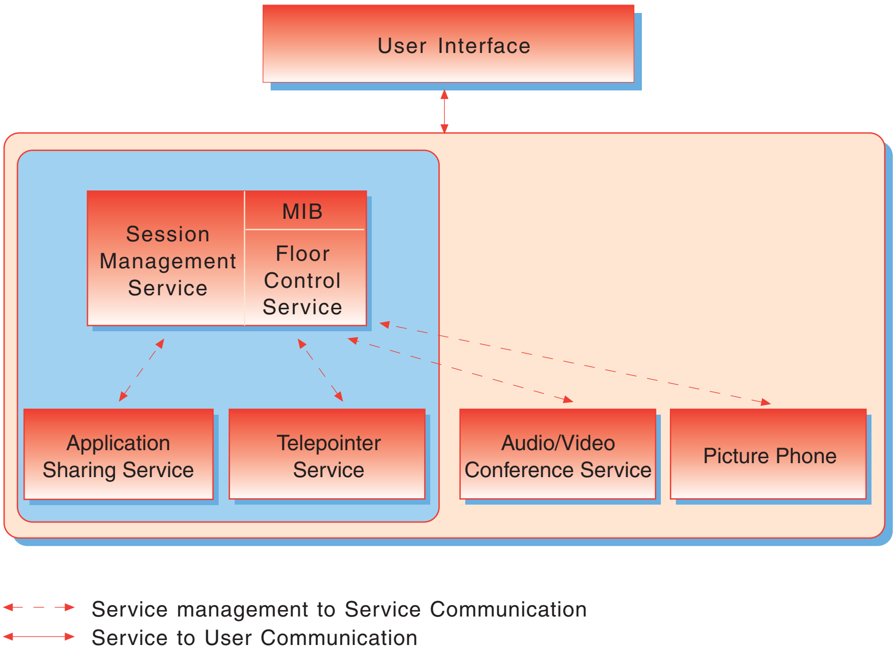

Figure 5 Components of JVTOS

among the JVTOS components under the control of the Session Management component.

Among others, the Session Management component starts and terminates components, transfers dynamic session-specific information such as adding participants to an active group or it directs the right to initiate an input to a shared application (floor).

For input and output of video and audio JVTOS needs to interact with the operating system through *continuous media interfaces*. The chosen interfaces at the particular platforms had to be enhanced by audio and video stream handlers and servers providing for duplication, conversion and mixing of multiple output streams. In order to jointly view/listen to video and audio, data must be fetched, distributed to other participants and displayed/played. These tasks are performed by the Audio/Video Communication component. It hides the complexity of audio/video processing behind an application interface which provides simple functions to transfer these data from a local source (e.g. microphone) to a remote sink (e.g. loudspeaker).

Sharing of applications in a multi-vendor environment means that application output may be presented at any platform, that application input may come from any platform and that shared applications may run on any platform. Most applications were not designed to run under such conditions. The MultiMedia Application Sharing component allows co-operation-unaware single-user applications to be shared among several workstations. Common input/output is made visible in so-called *shared windows* at each platform. Floor control is used to determine which user is allowed to direct input to a shared application. Xv has been chosen as the basic interchange protocol for application data. It is an extension of X that allows the control of still and motion video. The MultiMedia Application Sharing component is implemented on the basis of a distributed X-based multiplexer which has been extended for video support and heterogeneous platforms by features for multiplexing the Xv protocol data stream, for mapping the Xv protocol data streams to the local characteristics, for translating non-Xv protocols (Mac and PC) to Xv protocols, and for Xv resource management in a multi-user session.

The interpersonal audio-visual communication is provided by the PicturePhone component. In the first version it uses the stream handlers of the Audio/Video Communication component. It supports two-way audio and two-way video streams between all participants. PicturePhone provides stream control mechanisms to prevent participants in a multi-party session from both information loss and information overflow. On each platform the user interface to PicturePhone has been adapted to the native look-and-feel of the local window system while providing a platform common set of functions.

The co-operative work feature in JVTOS required a tool of individual pointers which allow each individual participant to point to objects within a shared window. The purpose of the TelePointer component is to monitor movements of pointers owned by a user and to display these movements at the remote users' sites. TelePointers are implemented as separate shaped windows. Moving a TelePointer means moving a window in front of a shared window which contains the object of discussion. The TelePointer component strongly relies on support from the other components. Among others, it receives information about participants from the Session Management component and the list of shared windows from the MultiMedia Application Sharing component. In order to limit the number of transport connections, this component requires multicast channels from the MMCP. Due to the delayed MMCP application programming interface, JVTOS still operates on top of the TCP/UDP/IP protocol suite. JVTOS multimedia capabilities are so far restricted to text, graphics, still pictures and motion video. Audio is supported as a complement to an application sharing through PicturePhone. The implementation at Sun and Macintosh is available, integration and interoperability at the Mac are supposed to be finished by the end of 1994. Applications can be shared symmetrically on Sun and Mac, while the PC and SGI integration will not offer full functionality.

Conclusion

The CIO project could successfully show what Multimedia Communication looks like when it is based on International Standards and today's customary equipment. Since CIO developments will be available on major vendors' platforms, CIO Testbeds are well suited to serve further projects. Moreover, CIO Testbeds are prepared for inter-Testbed-connection. Interconnected CIO Testbeds could implement the Integrated Broadband Communication Platform which the RACE programme aimed at.

CIO could reveal the weak points of customary workstations, equipment and implementations based on them. It thus offers a huge potential for improvements in these areas which are necessary for the market success of Multimedia based on ATM.

The interconnection of some of the CIO Testbeds is currently being proposed to the RACE Central Office as a project extension in 1995. It is planned to use the European ATM Pilot for this purpose. Discussions about a project definition based on CIO results within the ACTS programme have not yet been initiated.

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R2060 Deliverable M19b: R2060/NTR/CIO/DS/P/003/b1*

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* A complete publication list of R2060 is available from the author.

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Status report from ITU-TSB Study Group 1, Service Definition

BY ELISABETH TANGVIK

The objective of this status report is to present ongoing activities in Study Group 1 (SG 1) and to draw attention to some coming topics. Focus is on questions of particular interest for Norwegian Telecom. In addition, the article gives an overview of the structure of SG 1.

Study Group 1 in ITU's Telecommunication Standardization Sector has the responsibility for service definition.

- Study Group 1 should recommend the Quality of Service (QoS) for each service and interact with other study groups for particular aspects of new network performance influencing the QoS.
- Study Group 1 should define and describe services from a user's point of view.
- Study Group 1 should study allocation and global planning principles for routing codes for the telegram service, ensure their appropriate relations with network identification codes for the international telex service and, in collaboration with Study Group 2, consider telex destination codes and their relationship with other codes services.

The last meeting of ITU-TSB Study Group 1 (SG1) was held in Geneva 18–28 January 1994. The next meeting is to be held at the same place 27 September – 7 October 1994.

Structure of ITU-TSB Study Group 1

SG 1 consists of three Working Parties and one Special Working Group for Human Factors. In addition to the Chairman, there is a Deputy Chairman and two Vice Chairmen.

Figure 1 shows the Study Group 1 structure.

Working Party 1/1, Bureau, Telephone, Messaging

Working Party 1/1 is responsible for questions concerning Bureau services like Telex and INTEX, Telephone services like PSTN, Directory Assistance and Charge Card, and also Group Messaging services like Enhanced Fax, Message Handling Services (MHS) and Public Directory.

Working Party 2/1, AVMM, ISDN

Working Party 2/1 is responsible for questions concerning AudioVisual and Multi Media (AVMM) services and narrowband and broadband ISDN services.

Working Party 3/1, Telematic, Mobile, UPT

Working Party 3/1 is responsible for questions concerning Satellite, Mobile and Universal Services like Personal Future Public Land Mobile Telecommunication Systems (FPLMTS) and Universal Personal Telecommunication (UPT). WP 3/1 is also responsible for Telematic services like Telefax, Data and Videotex services.

Special Working Group, Human Factors

The special Working Group for Human Factors is responsible for human factors issues concerning more than one service, for public terminals, and for symbols and pictograms.

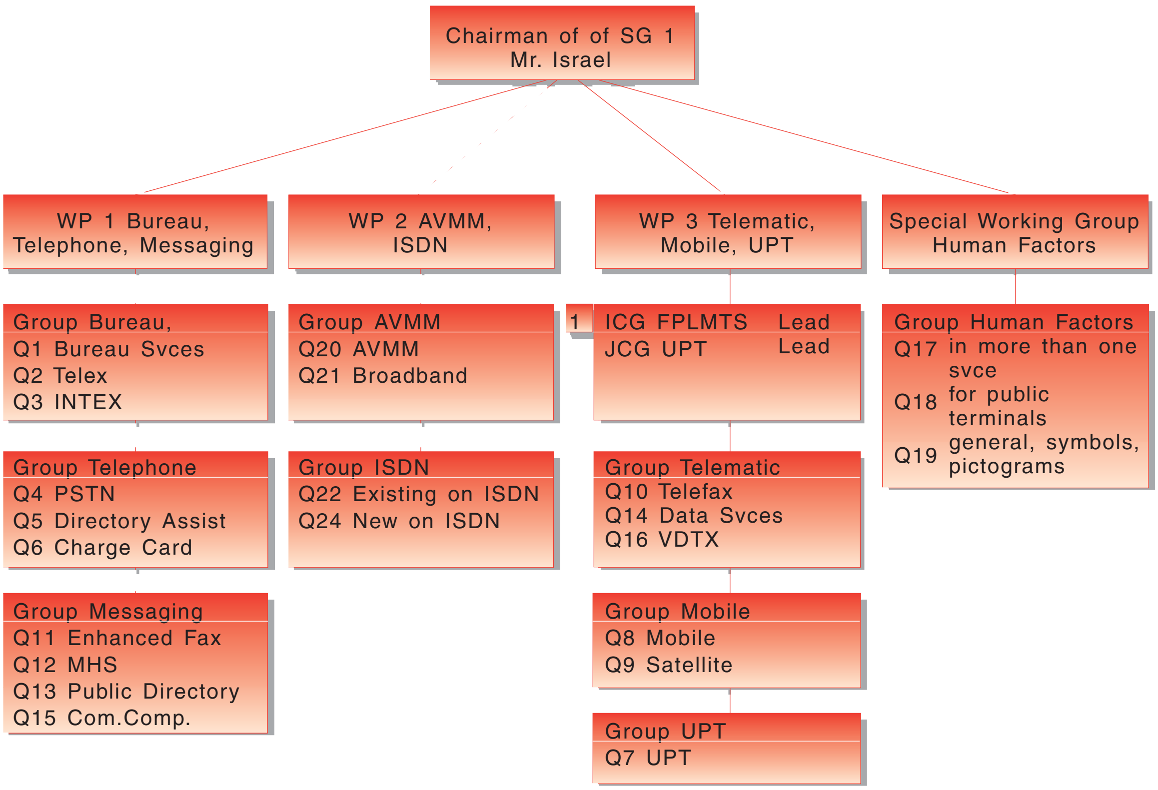

Figure 1 Study Group 1 Structure

The aim is that human factors work should be done in the normal course of the work on service definition, not as a separate activity.

Issues of major concern today

Questions followed by Norwegian Telecom

Norwegian Telecom has per date 6 delegates, following these questions:

- Q1 Bureau Services
- Q2 International Telex Service
- Q4 Development of PSTN-based Telecommunication Services
- Q5 Computerized Directory Assistance
- Q7 Universal Personal Telecommunications (UPT)
- Q8 Mobile/Personal Telephone, Telegraph, Telematic, Data and Audio-visual Services.
- Q13 International Public Directory Services
- Q22 Enhancements to Existing Services due to ISDN capabilities
- Q24 New Services for the ISDN

Determination of questions which are of primary importance to Norwegian Telecom is made on an ongoing basis. SG1 handles 24 questions in total. The number of participants at a meeting varies.

Each “Question” covers quite a wide range of issues resulting in different recommendations. The three most important issues for Norwegian Telecom per date are:

- New services for the ISDN
- Global Virtual Network Services (GVNS)
- UPT (Universal Personal Telecommunication)

New services for the ISDN

Many of the proposed recommendations for supplementary services are already implemented by Norwegian Telecom. Since we already have specified the services it is important to us to make the recommendations from ITU equal to these specifications.

The goal of Norwegian Telecom is to “continue to be the leading Norwegian telecommunications and information technology (IT) supplier and also play an important role in the Nordic and international markets”. This goal forces us to be among the first to offer new services to the users. For the telecommunications equipment manufactures the Norwegian market is only one (small) among many markets world-wide. The equipment manufacturers usually try to avoid market unique solutions. They want to follow international recommendations. This fact makes it necessary for Norwegian Telecom to take an active part in defining new services.

Of particular interest today is the work on the recommendations “Completion of Calls to Busy Subscriber” (CCBS), “Completion of Calls on No Reply” (CCNR), “Connected Line Identification Presentation” (COLP) and “Connected Line Identification Restriction” (COLR). All services are in demand and are all part of the contract between Norwegian Telecom and the manufacturers. Below is a short description of these services.

CCBS, Rec. I.253.3, Completion of Calls to Busy Subscribers enables a calling user A, upon encountering a busy destination

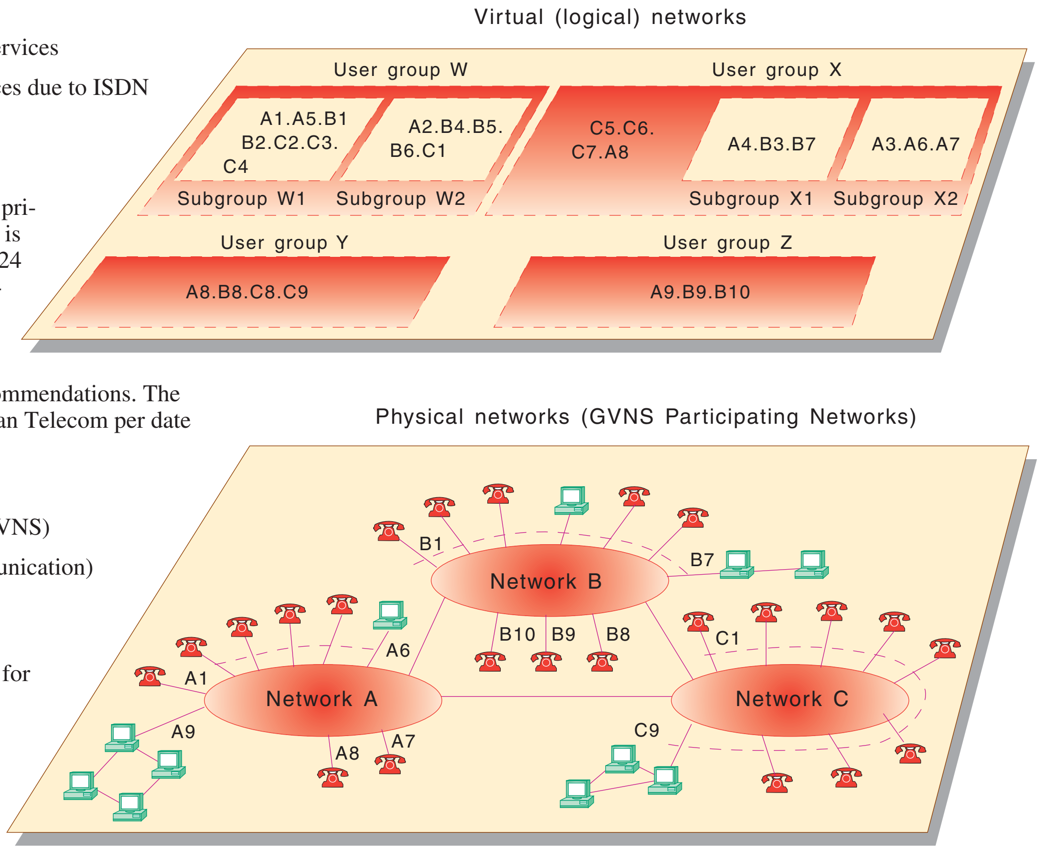

Figure 2 GVNS user groups and subgroups

Legend:

User Group W	**User Group Y**	**GVNS participating service provider for W = A, B, C**
Subgroup W1	**no Subgroups**	**GVNS participating service provider for X = A, B, C**
Subgroup W2		**GVNS participating service provider for Y = C, A, B**
	User Group Z	**GVNS participating service provider for Z = B, A**
User Group X	**no Subgroups**	**A1 ... A9 = physical connections to Network A**
Subgroup X1		**B1 ... B10 = physical connections to Network B**
Subgroup X2		**C1 ... C9 = physical connections to Network C**
		A8 = one physical connection belonging to two user groups (x and y)

B, to be notified when the busy destination B becomes free and to have the service provider re-initiate the call to the specified destination B if user A desires. This recommendation is for further study. According to the plan it will become ready for approval in May ‘95. It has a high priority in SG1, so hopefully it will be finally agreed upon in May ‘95.

CCNR, Rec. I.253.4, Completion of Calls on No Reply enables a calling user A, encountering a destination B, which does not answer the call (No Reply), to be notified when the destination B becomes free after having terminated an activity, and to have the service provider re-initiate the call to the specified destination B if user A desires. According to the plan this recommendation will also be ready for approval in May ‘95. The priority is not as high as for CCBS.

COLP, Connected Line Identification Presentation is a supplementary service offered to the calling party which provides the connected party’s ISDN number, possibly with sub-address information, to the calling party. The connected party’s number is provided to the calling user when the called user answers the call, and shall unambiguously identify the access of the connected party. The COLP recommendation is proposed for Resolution No. 1 approval at the September/October 1994 meeting.

COLR, Connected Line Identification Restriction is a supplementary service offered to the connected party to restrict presentation of the connected party’s ISDN number and sub-address information to the calling party. The COLR recommendation is proposed for Resolution No. 1 approval at the September/October 1994 meeting.

The Global Virtual Network Service, GVNS

The Global Virtual Network Service (GVNS) is an international multi-network service which provides private network functions to users at international geographically dispersed locations while minimizing the needs for dedicated network resources. It may be offered to customers above PSTN or ISDN.

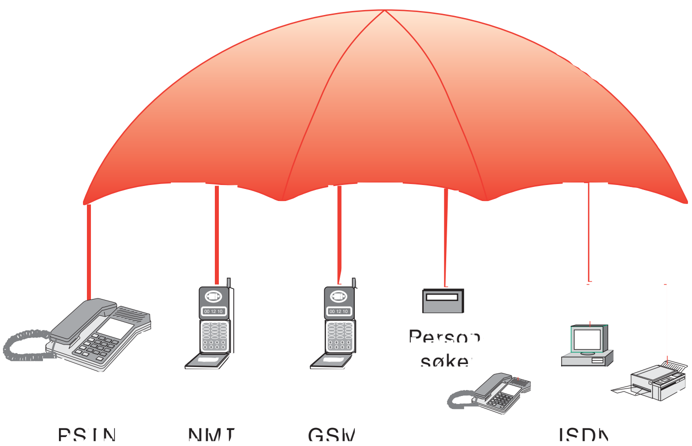

Figure 3 Personal mobility with UPT at any terminal

The Global Virtual Network Service is a communication service rich in features. It provides the functions typically associated with the private networks, but utilizes the public switched network(s). The customer’s network configuration is defined according to customer’s directions using customer-specific service information resident in multiple networks. The network configurations may be administered by the customer directly, by the GVNS participating service provider, and/or the GVNS co-ordinator.

GVNS provides the customer with global services as a result of interworking among the GVNS Participating Service Provider in various countries. GVNS may accommodate this interconnection via both ISDN and non-ISDN facilities.

Norwegian Telecom International (NTI) has already a product called VipNet International, based on the same principles. The target customers are large and international companies.

The GVNS recommendation is proposed for Resolution No. 1 approval at the September/October 1994 meeting. Norwegian Telecom takes an active part in GVNS-Forum. GVNS-Forum is an international forum for GVNS. It is important that the results from SG 1 are not in conflict with the work done in GVNS-Forum.

Universal Personal Telecommunication

UPT enables access to telecommunication services while allowing personal mobility. It enables each UPT user to participate in a user-defined set of subscribed services and to initiate and receive calls on the basis of a personal network-transparent UPT number across multiple networks at any terminal, fixed or mobile, irrespective of geographic location, limited only by terminal and network capabilities and restrictions imposed by the network operator. UPT requires increased network intelligence.

UPT means:

- Access to telecommunication services based on a unique personal identifier, or UPT number
- Personal mobility, i.e. the ability of the UPT user to access telecommunication services from fixed or mobile terminal on the basis of a personal UPT number
- Service profile with personal UPT information.

SG 1 is Lead in the Joint Coordination Group on UPT. Rec. F.851, UPT Service Description Service Set 1, is proposed for resolution No. 1 approval at the September/October 1994 meeting.

UPT draft Recommendations under discussion are:

Draft. Rec. F.852	Description of UPT Service Set 2
Draft. Rec. F.853	Supplementary Services in the UPT Environment
Draft. Rec. E.174	Routing Principles and Guidance for UPT

Draft. Rec. F.upt	Principles for Charging and Billing, Accounting and Reimbursements for UPT
Draft. Rec. Q.76	Service Procedures for UPT. Functional Modelling and Information Flows

In co-operation with Ericsson, Norwegian Telecom has established a pilot project, offering a service called "Telepersonlig" ("Tele personally"). The solution is based on the existing IN (Intelligent Network). It gives the user access to telecommunication services based on a UPT number.

Recommendations proposed for Resolution No.1 approval at the September/October 1994 meeting

Tables 1, 2, 3 and 4 show all the recommendations proposed for Resolution No. 1 approval.

Issues of major impact for Norwegian Telecom tomorrow

ISDN

It is still of importance for Norwegian Telecom to contribute to the ongoing and planned work on ISDN supplementary services.

Recommendations on Support for private numbering plans (Rec. I.255.2), Remote control supplementary services (Rec. I.258.3), User-to-user signalling (Rec. I.257.1) and ISDN frame relaying bearer service are interesting topics for the future.

B-ISDN and Multimedia services

Work has started on Broadband Video Telephony Service (Rec. F.722) and Broadband Video Conference Service (Rec. F.732).

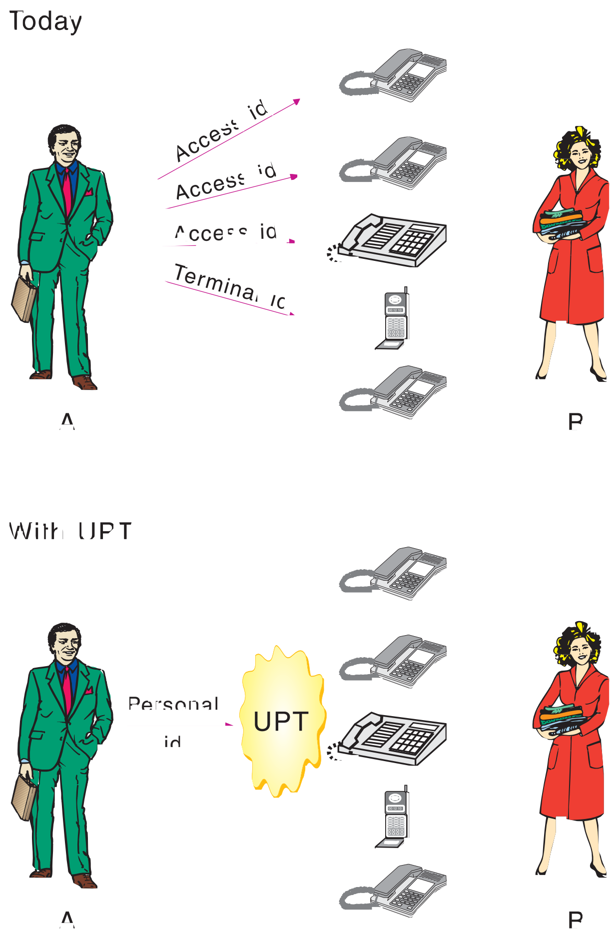

Figure 4 Today's solution and the situation with unique personal identifier or UPT

Table 1 Recommendations proposed for Resolution No.1 approval at the September/October 1994 meeting

Working Party 1/1				
Rec. No	**Rec. Name**	**Q No.**	**N/R**	**Summary**
E.109 (F.buns)	International Billed Number Screening Procedures for Collect and Third-party Calling	Q6	New	Used for determining the validity of billing calls to a telephone number on collect and third-party calls, and any conditions related to the acceptance of charges by the billed party.
E.115	Computerized Information Services for Telephone Subscriber Numbers in Foreign Countries. Reserved for Operators	Q5	Rev.	Methods to be followed in providing the customers and operators in one country with information on the national significant telephone numbers of subscribers in another country.
F.16 F.GVNS	Global Virtual Network Services	Q4	New	How the interworking service providers can provide seamless Global Virtual Network Services. Service description of GVNS that support global virtual networking.
F.18 F.bureau	Guidelines on Harmonization of International Public Bureau Services	Q1	New	The minimum requirements for a harmonized operation of existing bureau services as the telegram, telemessage and bureau services.

Table 2 Recommendations proposed for Resolution No.1 approval at the September/October 1994 meeting

Working party 2/1				
Rec. No	Rec. Name	Q No.	N/R	Summary
F.813	Virtual Path Service for Reserved and Permanent Communications	Q21	New	Virtual Path service for reserved and permanent communi-cations (VPRPC service). The provision of the VPRPC service is based on ATM virtual path (VP) connections in the B-ISDN. The VPRPC service allows communication in both directions between two users in a point-to-point configuration.
I.251.5	Connected Line Identification Presentation (COLP)	Q24	Rev.	Provides the connected party's ISDN number possibly with sub-address information, to the calling party when the called user answers the call. Shall unambiguously identify the access of the connected party.
I.251.6	Connected Line Identification Restriction (COLR)	Q24	Rev.	Offered to the connected party to restrict presentation of the connected party's ISDN number and sub-address information to the calling party.
I.258.2	In-call Modification (IM)	Q24	New	Enables a user to change within a call from one type of call characterized by one set of bearer capability, low layer and/or high layer capabilities, to another type of call with another set, without changing the end-to-end connection from a user/ network-access point of view.

Table 3 Recommendations proposed for Resolution No.1 approval at the September/October 1994 meeting

Working party 3/1				
Rec. No	Rec. Name	Q No.	N/R	Summary
F.115	Service Objectives and Principles for Future Public Land Mobile Telecommuni-cation Systems	Q8	New	FPLMTS (UMTS) are systems which will provide a range of tele-communication services to mobile or stationary users by means of one or more radio links. FPLMTS are third genera-tion mobile systems with compatibility of services within FPLMTS and with the fixed networks.
F.600	Service and Operational Principles for Public Data Transmission Services	Q14	Rev.	The international telecommunication charge card service allows the holder of a charge card to make use of a variety of services provided by the card acceptor (i.e. the public data network from which services are being obtained) and have the charges billed to the customer's account by the card issuer.
F.851	Universal Personal Telecommunication (UPT) Service Description (Service Set 1)	Q7	New	Main principles of Universal Personal Telecommunication – UPT, for example personal mobility, authentication and service profile management. Describes the essential features necessary to provide the UPT service, and the optional features which may be used.

Table 4 Recommendations proposed for Resolution No.1 approval at the September/October 1994 meeting

Special Working Group, Human Factors				
Rec. No	Rec. Name	Q No.	N/R	Summary
E.121	Pictograms, Symbols and Icons to Assist Users of the Telephone Service	Q19	Rev.	Pictograms, symbols and icons that could be used to aid users in the identification of services available and then in the use of such services.
F.902	Interactive Services Design Guidelines	Q17	New	Guidance for the design of basic procedures for the use of interactive telecommunications services using DTMF input and voice response.
F.910	Procedures for designing, evaluating and selecting symbols, pictograms and icons	Q19	New	A framework for a common methodology to be used by the ITU for the design, evaluation and standardization of symbols, pictograms and icons.

Table 5 Service categories and applications of the multimedia distribution services

Service Class			Specific Services	Possible Applications
Scheduled Distribution	Continuous Distribution	Open Group Distribution	TV/HDTV Distribution Service	• Television Program
		Closed Group Distribution	Closed User Group Distribution Service	• Pay-per-channel Television Program • Dedicated New Program
On-demand Distribution	Continuous Distribution	Open/Closed Group Distribution	Monitoring from Multiple Sites Service	• Remote Surveillance • Event Multicast
	Cyclic Distribution	Open/Closed Group Distribution	Videography Service	Multimedia program such as: • News • Advertising • Education
	Provider-on-demand Distribution	Closed Group Distribution	Video Information Distribution Service	• Tape-recorded private video, etc.
	Receiver-on-demand distribution	Open/Closed Group Distribution	Video-on-demand Service	Video program such as: • Entertainment • Advertising • Education • Business

The Broadband Video Telephony Service is a symmetrical real-time bi-directional audio-visual service which provides point-to-point communication for two individual users between two locations. The Broadband Video Conference Service provides conferencing capability for individual users or for groups of individual users. The distinction between these two services are not totally clarified yet.

Because of the integrated audio, video and data communication, the Broadband Video Telephony Service and Broadband Video Conference Service provide the means for face-to-face dialogue/meetings and the basis for co-operative work. These services may e.g. be used in the following applications:

- "Face-to-face" dialogue or "workstation" conference, providing at least head and shoulder images
- Dialogue including interactive viewing of documents such as skeletons, diagrams and charts
- Audio-visual tele-education (Distant Learning)
- Health "visiting"
- Access of the user to a video conference
- Tele-advertising
- Video surveillance of sick persons, babies, buildings, animals, etc.

There is still quite a lot of work to be done in describing how the multipoint sessions should be operated and which procedures should be followed. Work on Video Telephony in digital mobile telecommunication networks has also started (Rec. F.720, target date May '95).

Focus so far has mainly been on business communication applications. At a later stage it may be that entertainment applications for residential use will be more attractive.

The capabilities of B-ISDN makes the exchange of entertainment quality audio and video over wide-area networks feasible. The multimedia distribution services provide new types of telecommunication services that are unidirectional or asymmetric bi-directional user selective and multi-destination distributive. Draft recommendation F.MDS is a baseline document describing the Multimedia Distribution Services (target date Feb '96). Table 5 lists specific services and possible applications of each.

FPLMTS

Future Public Land Mobile Telecommunication Systems (FPLMTS, in Europe called UMTS) are systems which will provide a range of telecommunication services to mobile or stationary users by means of one or more radio links. FPLMTS are third generation mobile systems with compatibility of services within FPLMTS and with the fixed networks. FPLMTS will extend the telecommunication services of the fixed network over wide geographic areas. The FPLMTS are systems which may be terrestrial or satellite based and will utilize the frequency bands 1885–2025 MHz and 2110–2200 MHz.

There seems to be a common trend among telecommunication users world-wide to ask for more and more mobility. A huge effort from the mobile telecommunication providers and equipment dealers to gain new market shares, has forced prices of both services and equipment down considerably. According to SG 8/1, fixed use of mobile technology is expected to exceed mobile by the year 2000. Mobile radio can provide lower cost access than conventional solutions.

FPLMTS means:

- Third generation global systems
- Terrestrial and satellite components
- Fixed and mobile applications
- Service around the year 2000.

To meet the users' needs to communicate in a mobile environment it is recommended that each FPLMTS provider supports

- voice communication with other users of fixed or mobile terminals (telephone) connected to private or public networks
- data communications with other fixed or mobile terminals
- the Universal Personal Telecommunication (UPT) service.

There was a joint meeting of FPLMTS and UPT on 2 February 1994. SG 1 is Lead of the Intersector Coordination Group on FPLMTS (and UPT).

Draft recommendation F.115 identifies and defines the service principles and objectives for FPLMTS and provides a guidance for further development of FPLMTS. This recommendation is part of a family of recommendations dealing with FPLMTS. For an overview of the other recommendations, see rec. F.115. The core document for the definitions of FPLMTS is ITU-R recommendation 687.

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1 ITU, Telecommunication Standardization Sector (ITU-T). *Study Period 1993–1996. Study Group 1 – Report R1 to R26 (English).*

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Future mobile communications

BY OLE DAG SVEBAK

In Europe, the research and standardisation of future systems within the field of mobile telecommunication systems are focused on the Universal Mobile Telecommunications System, UMTS.

UMTS, and its global counterpart FPLMTS (Future Public Land Mobile Telecommunications System(s)), are third generation mobile systems expected to come into operation shortly after the turn of the century. These are based upon work in a number of research and standardisation bodies, including ETSI, ITU and RACE.

1 UMTS

1.1 Background for UMTS

UMTS and FPLMTS are intended to be compatible systems operating in the 2 GHz band, allowing global terminal roaming, at least for a limited set of services. Users may therefore use the same mobile terminal equipment to access telecommunications services throughout the world. Unlike second generation systems, UMTS and FPLMTS encompass both a land mobile component and a satellite component, thus facilitating the provision of global radio coverage.

UMTS is intended to be a major leap forward in mobile and personal communications, both in terms of services and technology. Existing systems (e.g. GSM, DECT, ERMES) are generally designed to meet the needs of particular application areas, like public cellular, private business access, paging applications, mobile data transmission and satellite communications. From an end user point of view this is not a desirable scenario, since it may be necessary for a user to have multiple subscriptions and multiple terminals to fulfil his communication needs. From an operator point of view the deployment, operation, maintenance and administration of a multiplicity of networks are a very costly option. Similar concerns apply to the manufacturing industry.

UMTS is intended to alleviate these concerns. Since the late eighties significant research activities (e.g. RACE, COST, and from early 1995 also ACTS) have been focused on UMTS. The evolution towards UMTS is illustrated in figure 1.

1.2 UMTS objectives

Some of the key objectives for UMTS which distinguish UMTS from previous systems are:

- *Integration of mobile services.* UMTS will provide services previously associated with separate systems in one integrated

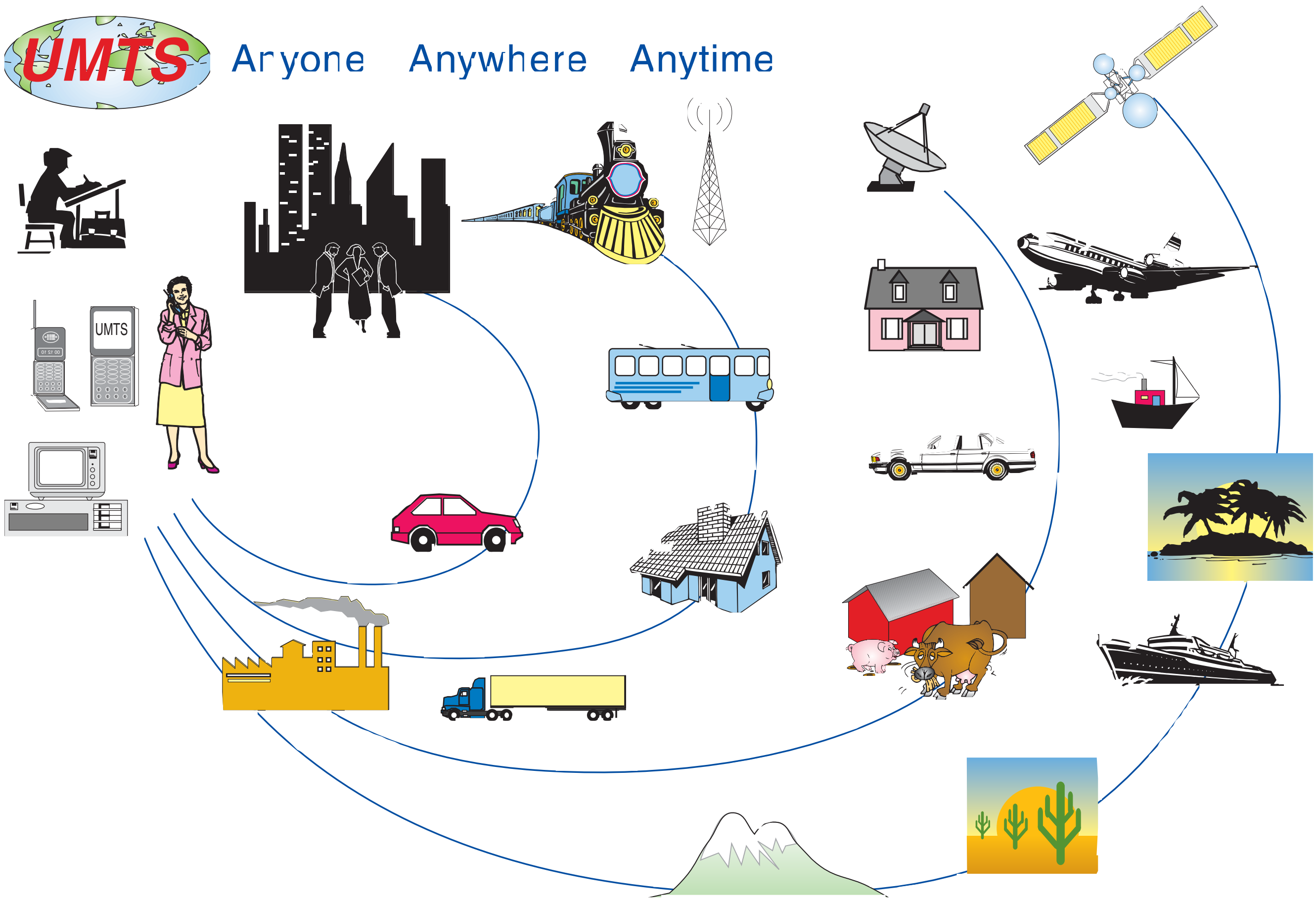

Figure 1 Evolution towards UMTS in Europe

system, as well as facilitating the introduction of new services, so that the user may access whatever services he wants in whatever environment he finds himself.

- *Choice of mobile station and service.* Users will be offered a wide choice of terminals and service provision.
- *Global terminal roaming capability.* A user may access telecommunications services in all regions of the world.
- *Support of user mobility,* e.g. in the form of the Universal Personal Telecommunications (UPT) service concept.
- *Speech quality* comparable to that of the fixed network.
- *Satellite and terrestrial based coverage.* It is expected that the satellite component of UMTS will play a major role in providing global terminal roaming.
- *Services requiring a range of bit rates* (up to 2 Mb/s is envisaged for phase 1 of UMTS) will be provided by UMTS. UMTS will also provide variable bit rate services.

A more complete list of UMTS objectives and the resulting system requirements may be found in ETSI DTR/SMG-050101 and DTR/SMG-050103, respectively. Figure 2 attempts to illustrate UMTS.

1.3 ETSI standardisation work

Within ETSI, technical committee SMG (Special Mobile Group) has been given the responsibility of standardising UMTS, and set up sub-technical committee SMG5 in 1991 to carry out this task. SMG5 acts as the system architect for UMTS within Europe, and is therefore also an important forum for the co-ordination of UMTS and FPLMTS. The work of SMG5 is largely based upon progress made in RACE and the ITU.

Within ETSI, what may be termed the “concept phase” is well under way and will be concluded in 1995. This will result in a set of baseline documents, mainly in the form of ETSI Technical Reports. These reports essentially outline the requirements, objectives and framework for UMTS, forming the basis for the standardisation phase, the bulk of which is expected to start in 1995/96. The ETSI report “Work programme for the standardisation of the UMTS” (ETSI TCR-TR 015) gives details concerning deliverables to be produced, responsibilities within ETSI, milestones and titles.

The baseline documentation and the standards have been grouped according to series of documents. These series may contain one or more reports or standards, as appropriate. The baseline documentation has been grouped according to the following series:

- The 00-series contains administrative documents, including the work programme mentioned above.
- The 01-series contains high-level UMTS technical documentation addressing system issues. This includes documentation on system objectives and overview, vocabulary and system requirements.
- The 02-series addresses service aspects, in particular the services to be supported by UMTS.

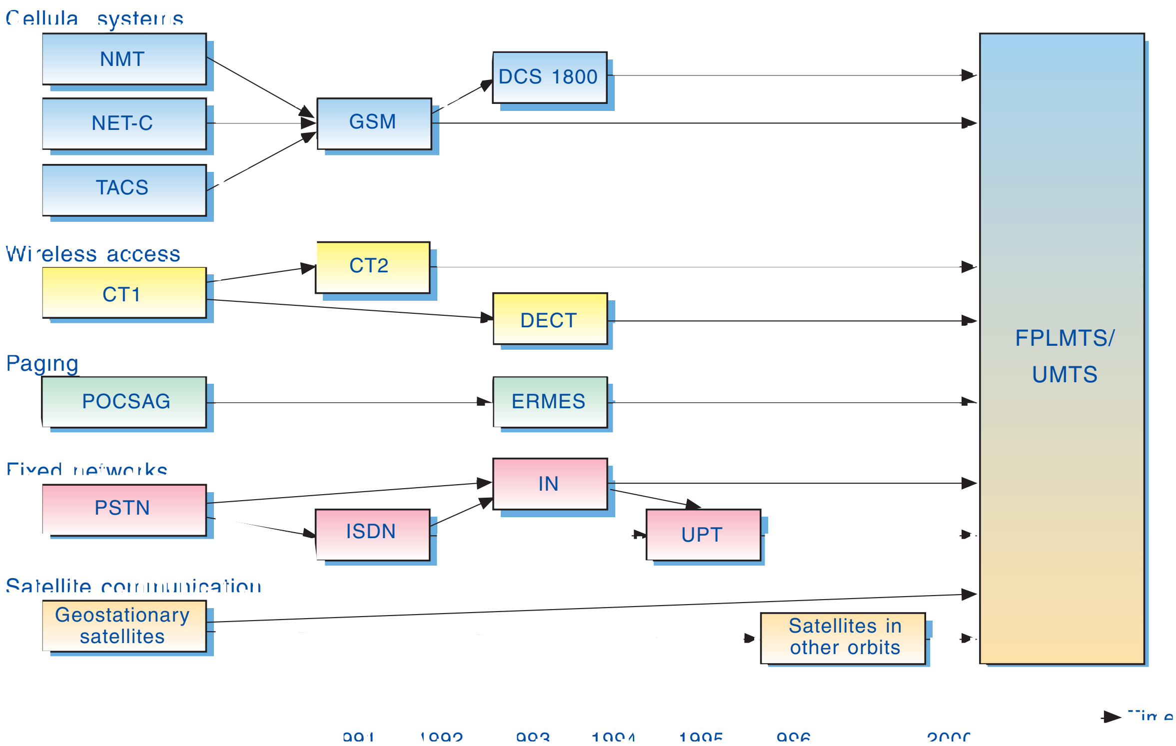

Figure 2 UMTS environments and application areas

- The 03-series addresses UMTS network aspects with respect to network requirements, interworking and integration.
- The 04-series addresses UMTS radio aspects. This includes overall requirements on the radio interface(s), a selection procedure for the choice of physical radio access principles, the choice of radio access principles and the choice of source and channel coding principles for UMTS.
- The 05-series is concerned with network management aspects of UMTS.
- The 06-series addresses voice-band aspects of UMTS, including quality requirements and the selection procedure for the speech/channel coding principles as well as voice-band data coding principles of UMTS.
- The 07-series addresses video aspects of UMTS.
- The 08-series addresses data aspects, in particular principles for handling digital data services in UMTS.
- The 09-series addresses security aspects of UMTS.
- The 12-series addresses satellite aspects of UMTS, particularly satellite integration.

ETSI has studied a number of these technical areas since 1991, including system, services, network, radio, security and satellite aspects, and technical reports are due to be approved by SMG5 in most of these areas before the end of 1994. In particular, ETR/SMG-050101 “UMTS objectives” (reflected in the section “UMTS objectives” above) and ETR/SMG-050103 “UMTS system requirements” have received significant attention in 1994. These two documents essentially form the basis for the remainder of the UMTS documentation in all technical areas.

Within ETSI/SMG5 different views with respect to the relationship between UMTS and earlier systems need to be reconciled. These views range from UMTS as the radio access part of B-ISDN to UMTS as an evolution of GSM.

1.4 Research activities towards UMTS

RACE II is approaching its finalisation, and a number of projects have contributed to the standardisation of UMTS. In particular, the work of MONET (MObile NETwork) has had a strong influence on UMTS network aspects. The main results from MONET include:

- MONET has defined a service provisioning model for UMTS. This model makes use of re-usable service components, enabling the large variety of services that is foreseen for UMTS to be described in a generic way. The model facilitates relatively easy introduction of services that have not yet been foreseen.
- MONET has produced Functional and Network Architectures for UMTS. These architectures cover different environments (public environment, business environment and domestic environment). Information flows between the different elements of these architectures have been defined. Evaluation of architectures and information flows has been performed through analytic evaluation and through simulations.
- The Functional and Network Architectures that MONET has defined for UMTS re-use Intelligent Network and B-ISDN components. This enables integration of UMTS with networks for fixed communication, in particular B-ISDN. MONET has defined requirements to IN and B-ISDN to enable such integration.
- For data storage in UMTS, MONET has developed a Distributed Data Base (DDB). Amongst others, this has been used to identify new requirements to IN inter-networking.
- MONET has defined a protocol framework for UMTS. The result is a well defined layered structure, with a clear separation between the protocol layers. Amongst others, MONET has defined a network layer for the User-Network-Interface (UNI), which enables a mobile terminal to address several network entities (instead of just one as in current networks).
- MONET has defined a Base Station Subsystem (BSS) that is independent of the type of radio access scheme that is used (TDMA or CDMA).
- In the area of security MONET has found that public key algorithms are particularly suitable to obtain the required security level for UMTS.

The outcome of the two main radio related projects (on CDMA and TDMA, respectively) are not due to be published until 1995.

It remains to be seen to what extent ACTS (Advanced Communications Technologies and Services) will influence the standardisation of UMTS. ACTS will start in 1995. The project proposals for ACTS relating to mobile and personal communications broadly fall into two categories; services and system demonstrators. Special emphasis is put on developing new services and new application areas, like broadband communications, mobile services in industrial environments, services for trains and people with special communication needs, as well as emergency services. The feasibility of the resulting proposals are to be validated using system demonstrators.

2 FPLMTS

ITU-R SG 8/1 acts as the system architect for FPLMTS within the ITU. However, significant work has been and will be done in ITU-T, notably SG1, SG11, SG12 and SG15. In order to coordinate the work on FPLMTS within the ITU, an Inter-sector Coordination Group on FPLMTS has been formed. The ICG FPLMTS is expected to meet annually to facilitate the progress on FPLMTS.

2.1 Recent progress

Work on FPLMTS has received considerable attention in 1994, and a wide range of organisations have contributed to the progress of FPLMTS. In particular, the foundation of the FPLMTS study committee in Japan indicates a willingness to give high priority to FPLMTS. In 1994 a number of draft FPLMTS recommendations have been approved by ITU-R SG 8, addressing performance requirements, network management and security aspects.

Despite the progress made, it remains to be seen whether FPLMTS will be defined in terms of a set of recommendations to which a complete system can be designed and manufactured in order to facilitate global terminal roaming, or merely as a system or service concept. The outcome of this process largely dictates the relationship between FPLMTS and UMTS.

2.2 Relationship between FPLMTS and UMTS

UMTS will as far as possible be aligned with FPLMTS. Much of the progress on UMTS has been based on work done by the ITU on FPLMTS, and many delegates to SMG5 also participate in the work of SG 8/1. Therefore, in terms of the concept for third generation mobile communication systems, UMTS and FPLMTS are well aligned.

However, compatibility requires some degree of technical similarity in terms of service provision, network architectures, protocols and procedures, interface definition and specification, etc. Therefore, it is currently not clear what the relationship between UMTS and FPLMTS will be. FPLMTS is not likely to be defined in the same detail as UMTS, since FPLMTS will need to incorporate regional differences between the Far East, North America and Europe. In some technical areas it is likely that the regional technical specifications will be compatible; the radio interface specifications are such examples, whereas in other areas detailed technical compatibility may not be necessary to meet the agreed objectives.

The currently dominating European view is that UMTS is the European implementation of the global FPLMTS, tailored to meet the needs of European users, network operators, service providers and equipment manufacturers. The work programmes for UMTS and FPLMTS are well aligned in terms of deliverables and milestones (in fact the work programme for FPLMTS is based on that for UMTS). Moreover, FPLMTS and UMTS will use the same frequency bands.

There are several issues which need to be resolved before the relationship between FPLMTS and UMTS can be clearly seen, e.g.:

- Will FPLMTS be a concept (e.g. service concept, system concept or network concept) or will FPLMTS be a standard or set of standards to which a system can be designed and manufactured?
- Will FPLMTS be uniquely defined in the sense that e.g. global terminal roaming can be achieved and interoperability facilitated?

An interesting aspect is that the relationship with FPLMTS may not be the same for terrestrial UMTS as for satellite UMTS. Due to the nature of satellite communications, it is likely that the UMTS satellite component will be global, whereas the terrestrial component of UMTS will be regional.

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UPT – Service concept, standardisation and the Norwegian pilot service

BY FRANK BRUARØY AND KJELL RANDSTED

Universal Personal Telecommunication is a dynamic and flexible service concept that is well equipped to suit the needs of customers demanding access to services when on the move. UPT has the possibility of being tailored to the specific needs of customers. It gives the users personal freedom in moving around while still retaining access to all of their subscribed telecommunications services. The service concept is subject to world-wide standardisation to ensure interoperability due to its international nature. It is a demanding service with regard to network capabilities. Therefore the service concept will be offered in various phases as the networks evolve their capabilities in order to be able to support the advanced service features available to the customers. Norwegian Telecom is now providing the first phase based on the IN platform. This will hopefully bring Norwegian Telecom up as one of the market leaders when it comes to offering personal mobility to their customers.

Introduction

The way of using telecommunications services is rapidly changing and the market demand for services offering personal mobility is growing. For personal mobility the need stems from a number of factors, some of which are stated here. Doing business may involve a lot of travelling and business people are often away from their office. Still they want to be accessible to keep close contact with their supporting base, private or business. Also the companies may wish to provide their employees with a cheap and secure tool that enables easy contact, so that for instance people with high responsibility can be available at short notice. Business people frequently need to make expensive long distance business calls when they are away from their office and want to have all these calls on a separate bill. Often there is a need to be able to make calls even if you are short of cash. Some people want to have the possibility to work from home while still being accessible and have a service that allows them to make business calls from home and have the calls charged to their companies instead of to their private account. People that move around according to a fairly stable time schedule, for instance between work and home, may for convenience reasons want to be able to receive calls as he/she moves from place to place without making any action.

To be able to cover all these needs by one service a new service concept was defined which is called Universal Personal Telecommunication (UPT). According to the definition, UPT gives the users the possibility to access telecommunications services from a variety of terminals and network access points across a number of networks. Figure 1 illustrates this concept. The terminals may be attached to fixed network access points as in ISDN/PSTN, movable as in wireless access like DECT/CT-2, or mobile like in mobile networks such as NMT and GSM. The geographic location of the terminal the UPT user wishes to use for his communication needs is of no concern to the UPT service. As such, UPT offers personal mobility for the users with

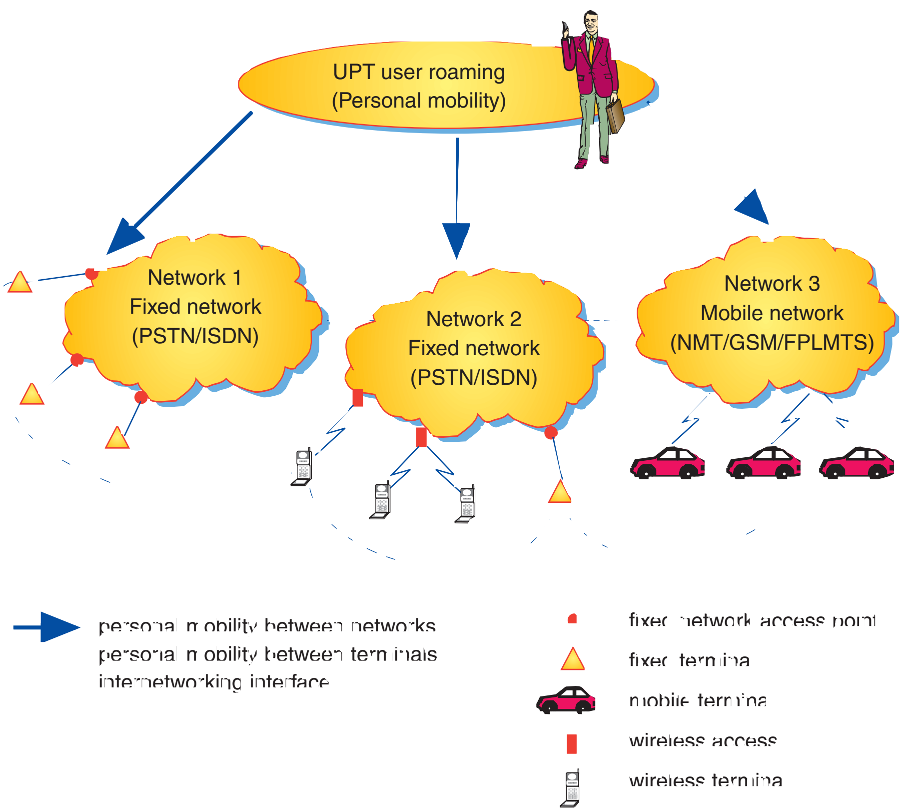

Figure 1 UPT concept showing personal mobility both between networks and terminals of various types

regard to both terminals and networks. However, there may be some restrictions imposed on the UPT service by the capabilities of the networks and terminals.

This clearly shows that UPT represents a new way of thinking when it comes to mobility for the users of telecommunications services. The interest in the UPT service among network operators is strong, and UPT is most likely to be offered on a global basis by many network operators. Because of this and the international nature of the UPT service, it is subject to world-wide standardisation in international standardisation bodies like ETSI and ITU.

UPT service concept

The principal characteristic of UPT is that it offers personal mobility meaning that UPT users will be able to move between terminals on a global basis in order to access telecommunications services at any terminal and making and receiving calls on the basis of a personal identifier, and the capability of the network to provide those services according to the user's service profile.

In fixed networks there has traditionally been a static association between the network access point of the terminal and user identification. Also in some mobile networks the association between the subscriber or user with the terminal have been fixed. This is no longer necessary as UPT tears down these restrictions and removes the fixed relation between terminal and user identification. Through UPT telecommunications services is provided on the basis of the identity of persons rather than the identity of network access point, i.e. terminals and lines. All UPT users will be allocated and associated with their own personal UPT number which acts as a basic personal user identification. The UPT number is network transparent. It is treated separately from the addressing of terminals and network access points and enables the users to make and receive calls on any terminal and at any location on the basis of their UPT number. The UPT number is known in public and is the number other users dial when they wish to call a specific UPT user. As such, this number is the equivalent to the telephone number for ordinary telephone subscriptions. However, it can also be used by network entities when they need to send a request to the UPT user's home data base. As such, the UPT number does not reveal the location of a specific access to the network, but is rather a pointer to the UPT user profile. A UPT user may choose to have more than one UPT number to cater for different applications, for example a business UPT number for business calls and a private UPT number for private calls.

The network operator or service provider also identifies each UPT user by another personal user identity for security and management purposes. It is unique to each subscription and all information that is unique for a subscription is related to this number. There is a one-to-one relationship between the UPT number and the personal user identity of a given user. This identity is not public. Still, the number may be known to the UPT user, as it will have to be supplied to the network every time the UPT service is accessed. It is supplied either by the UPT user or by a UPT device in which the personal identifier may be stored.

To access the service the UPT user has to dial a general service access number which is used when the UPT user wants to make an outgoing call or make a registration or check the status of his/her present registration or service profile.

An important aspect of UPT is that also charging and billing are done on the basis of the UPT personal user identity rather than terminal or line identity. Each user is allocated a unique personal account associated with the personal user identity and the charging is done against the UPT user's personal account. Thus, UPT offers personal charging. For use of the service the principle of split charging may be used, i.e. the charges are divided between the called UPT user and the calling user according to pre-defined agreements and rules at provision time. The charging elements may not be limited to telecommunications service usage only. It is possible to practice one stop billing principle for the UPT service, meaning that the UPT subscriber should preferably be billed by one UPT service provider. This means that UPT service provider will undertake to reimburse other service providers for the charges incurred by its roamed user. To be able to do this, bilateral agreements must be in place. Other billing methods are also possible.

The UPT service provider will in principle offer access to a range of available telecommunications services from which the UPT subscriber selects a set. As such, UPT is a service system concept that acts as an umbrella for a number of telecommunications services. The UPT subscription may typically include several options such as basic telecommunications services, supplementary services applied to each basic telecommunications service, roaming restrictions applied to each telecommunications service, and confidentiality of the UPT user's private information, e.g. the UPT user's location. Figure 2 shows a typical scenario for a UPT subscription where the UPT user may

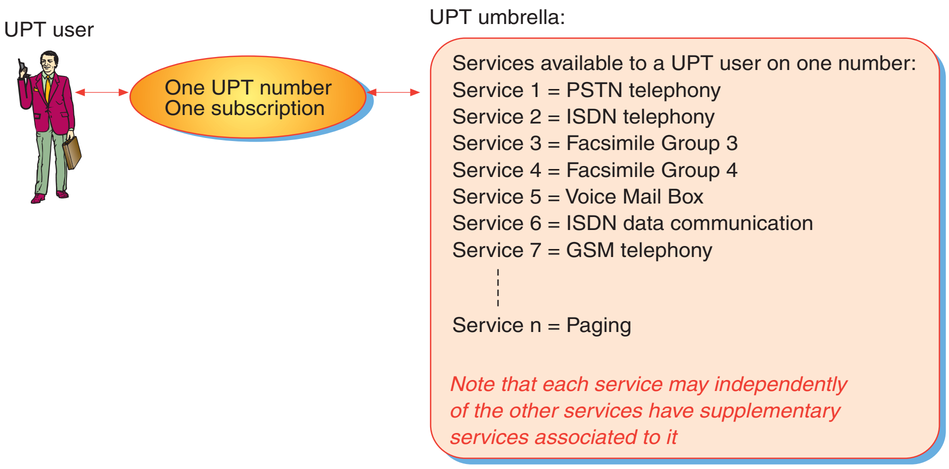

Figure 2 UPT service and number concept

have a user defined set of service available and can receive calls from any user for each of these services based on one UPT number.

In order to collect all the information related to UPT service provision for a specific UPT user in one place, a personalised data record called the UPT service profile is created in the network. Each UPT service profile is associated with a single UPT number. The services a UPT subscriber has access to and the way these services are configured is documented in the UPT service profile for that specific customer. The UPT service profile offers control and flexibility to the UPT user and subscriber as the UPT user also has access to his/her personal service profile from any network access point or terminal.

Security is very important in UPT. The interests of both UPT users and terminal owners must be taken care of. Security and privacy are offered through UPT user authentication and protection of third parties. The UPT user is offered standardised access and authentication procedures for the UPT facilities on a global basis across multiple networks. However, the UPT service can only be used if the UPT user has access to telecommunications terminals. In order for the terminals owners to be willing to let the UPT users use their terminals it is important that they are offered some form of protection against the UPT users' ability to register themselves at any terminal at any time.

UPT service features

The UPT service concept is built from a set of service features. Some of the features are mandatory for the service and are always provided to the UPT service subscribers. They represent the basic UPT service. In addition, the UPT service may offer an optional set of features that can be subscribed to. As such the UPT users may compose a personal UPT service based on their own needs. Some of the UPT features are described here.

UPT user identity authentication ensures that when a user accesses the service he must prove that he is authorised to make use of the service. The purpose of the authentication procedure is to protect the UPT user's integrity and to prevent fraud, i.e. others making illegal calls using the service user's account. Authentication is a very important feature of UPT and must be successfully completed before other service features can be invoked. The procedure might involve dialling a service access code, the UPT user identity and a PIN code.

Registration procedures enable users to make us of their service subscription across different terminals and networks, wired or wireless. The network checks that the user's service profile contains the requested service, e.g. speech, fax, data service, and will provide an association between the user's identity, terminal and location information. As a result of the registration procedure, the line identification of the registered terminal is stored in the visited network service data base together with the service profile information. There are two aspects of registration: *Registration for incoming UPT calls* and *registration for outgoing UPT calls*. Remote registrations may be performed and variations for linking of the two procedures are defined.

Incoming call registration allows UPT users to specify to the network the terminal to which calls are to be delivered and to specify how calls should be handled when the user is not registered. The user can register at any terminal by notifying the network of the terminal address, thereby establishing a link between the user's identity and the terminal identity of the terminal on which the user is registered. When registered, all incoming calls of the requested service type, addressed to the user's personal UPT number will be directed/delivered to that terminal for the duration specified by the user or until a de-registration takes place. The registration may be indefinite or for a limited period of time. The choice depends on the user's needs at the time of registration. A new registration at another terminal for the same service type will override the previous registration. The consequence of de-registration is that incoming UPT calls are routed to a standard announcement or to a default destination. The default destination can be of any kind, but it is likely that a typical destination is a voice mailbox or a secretary. The choice is up to the user to define and the information on how to handle calls when the user is not registered is kept in the user's service profile. However, it is an important feature of the UPT service that incoming calls to a UPT user will always be routed to some destination.

Outgoing call registration allows the UPT user to register at a specific network access point for the purpose of making several subsequent outgoing UPT calls from that location. After the outgoing call registration the UPT user can make outgoing calls charged to the UPT account for the duration specified by the user or until a de-registration takes place. However, the UPT user may also make direct outgoing UPT calls which are charged to his/her UPT account without any prior registration procedure. Only one user is allowed to register for outgoing calls at the same terminal at any given time.

UPT service profile management allows the UPT user to *access, interrogate,* and *modify* the UPT user's service profile. Some of the UPT user's personal data may be changed by the user himself. An example of such data is the registered number for incoming calls which is changed by the incoming UPT call registration procedure. Likewise, some of the UPT user's personal data may be monitored by the UPT user himself, e.g. to check the current registration for incoming calls.

Follow-on procedures allow the user to start a new operation once one operation is finished without having to dial the access number and follow through the authentication procedure first.

Call diversion services allow the users to re-route the incoming call to an alternative destination on the basis of various conditions. Examples are the "busy" condition and the "no answer" condition. The user may specify re-routing destinations for the various conditions independently of each other. *Variable routing* allows the users to define a personal time table for routing of incoming calls based on their own expected time schedule. Due to the information in the time table the incoming calls will be routed to different locations depending on for instance time of day and day of week. The time table may also contain information on re-routing of calls according to different conditions as described earlier.

A subscriber's service profile may contain *credit limit* parameters identifying limits to the use of the service in order to restrict the financial loss in case of fraudulent use of the service. The limiting parameter is directly compared to the content of the UPT user's account and may limit the allowed charges during a certain period of time. when the limit is exceeded the UPT user is no longer allowed to use the service.

Both the possibility to make outgoing calls and receive incoming calls may be restricted according to the subscriber's particular needs. The restrictions on making outgoing calls may include parameters like points in time when outgoing calls cannot be made, geographical areas from which outgoing calls cannot be made or numbers to which outgoing calls cannot be made. The same sort of conditions may apply for incoming calls. Screening of the calling party numbers or called party number against the UPT user's personal screening list is also available. In addition, the UPT user may define a password that has to be dialled by the calling party in order to be able to make calls to the UPT user. The reason for having these restrictions stems from the fact that the subscriber and the service user may be different persons and the subscriber may therefore have an interest in abilities to restrict the use of the service.

In addition to features described above a number of supplementary services are available both covering UPT specific supplementary services, non-UPT-specific supplementary services with UPT-specific implementations, and non-UPT-specific supplementary services without UPT specific implementations. None of these will be covered by this article.

The full service consisting of all the above mentioned components is offered as one subscription on one UPT number. The number of service features may result in quite complex and rigid menus, especially since the only terminal available within reasonable time frame is the telephone. Therefore the user is generally guided in his usage by voice menus.

UPT functional service architecture and relation to IN

The information related to the service subscribers, the service profiles, is not stored in local exchanges. Because the UPT customer cannot be associated with a specific network access point the information instead has to be stored within the network in centralised data bases. Also service processing logic is contained in centralised entities. The service logic typically interfaces to the database and to specialised resources able to provide voice announcements to the user, for instance for guidance through extensive service menus or to prompt for information that has to be collected for further service processing. Figure 3 shows the functional service architecture model for UPT.

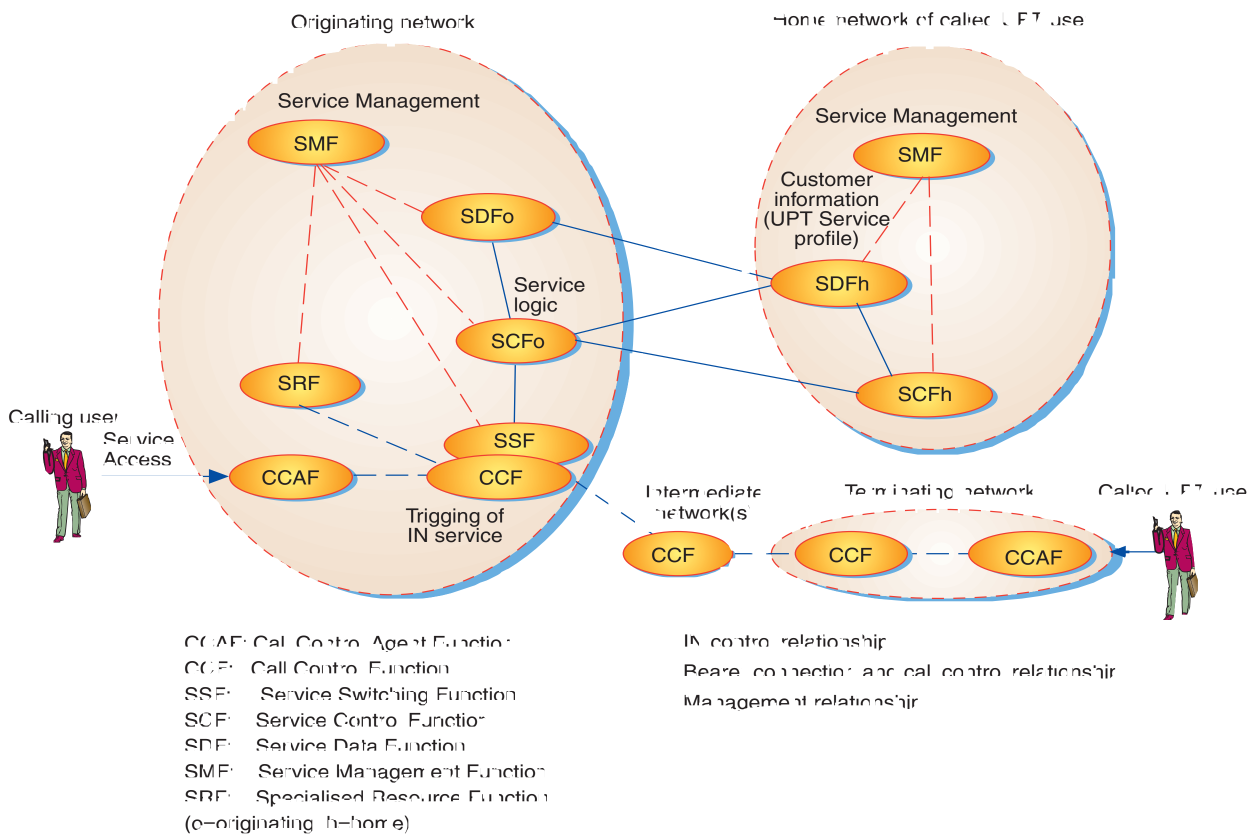

Figure 3 UPT functional model for the service architecture

Providing the UPT service requires the availability of data bases accessible to the UPT user to update his/her current location. Thus, the registration procedures described earlier is a database issue. Take for instance the case of registration for incoming UPT calls. The binding between the UPT number and the number of the terminal where the UPT user is located must be stored in some database and be updated when the UPT user changes location. To illustrate how the UPT service works in the model, the case of an incoming UPT call is discussed. This will show that delivery of an incoming UPT call is basically a number translation service. The dialled number is a UPT number and is translated in one or several data bases. In general, a call is routed to an appropriate UPT serving exchange, where the call is recognised as UPT and a query is sent to the UPT user's service profile which is identified by means of the dialled UPT number. The UPT user's service profile translates the dialled UPT number into the destination terminal number associated with the terminal at the current location designated by the called UPT user, and returns this number and possibly other routing information to the UPT serving exchange. Upon receipt of this number the UPT serving exchange routes the call to the destination according to the appropriate routing principles.

UPT is not suitable for implementation as a switch-based service. However, the Intelligent Network architecture is well suited for implementing UPT. The main goal of the IN architecture is to allow rapid and less expensive deployment of new services to users. IN also provides the infrastructure required to support UPT as UPT involves multiple IN components and requires co-operation between multiple networks. The UPT needs a significant amount of data stored in the SDFs and will use the advances in network intelligence and signalling. The Intelligent Network will support the necessary database requirements and provide personal mobility and call, connection and service management functions for UPT. The Signalling System Number 7 network, with suitable application protocols for UPT, will provide the messaging backbone for UPT service. The home network is responsible for billing a UPT user. The home network maintains the user's service profile.

UPT will be offered in various phases. The reason for this is that the introduction of UPT must be done according to the network capabilities available in the different networks at the point in time of service provisioning. The first UPT service provision will start with a simplified set of UPT features. As new network capabilities are introduced in the networks which are able to handle more complex tasks the UPT will be upgraded with more advanced service features in order to support more advanced scenarios. A typical example of a service feature that cannot be implemented in today's network is outgoing call registration. This feature requires functionality that presently does not exist in the IN CS-1 standards. Also CS-1 does not support the possibility to offer access to data services within the UPT concept.

Overview of standardisation on UPT

The previous sections should give the reader the understanding that there is a tremendous number of issues with regard to UPT that need to be solved and which are important to standardise in order to be able to support the customers with a consistent service access interface and consistent service behaviour as the users move around in various networks and use terminals with variations in capabilities. The standardisation studies on UPT are ongoing in international bodies on a global basis. The two most important standardisation bodies from our point of view are ETSI and ITU. The focus in this article is on ITU-T, but ETSI is also discussed to some extent.

UPT standardisation in ETSI

STC NA7

Sub Technical Committee NA7 has the overall responsibility for the standardisation of UPT in ETSI. NA7 produces technical reports which are used by other STCs as a basis for UPT standardisation and which communicate ETSI's views on UPT to other organisations. NA7 also produces standards in areas which are not covered by other STCs, as is the case with the UPT security architecture. The work in NA7 is organised in Working Group 1 *Service Aspects,* WG2 *Network Aspects* and

UPT service concept:	
ETR 055	UPT; the Service Concept (Parts 1 to 10) (The parts have numbers ETR 055-1 to ETR 055-10.)
UPT phase 1:	
NA-71101	UPT Phase 1: Service aspects: Guidelines
NA-71102	UPT Phase 1: Network aspects, Overview
NA-71202	UPT Phase 1: Service requirements on charging, billing and accounting
NA-71203	UPT Phase 1: Service requirements on security mechanisms
NA-71205	UPT Phase 1: UPT subscription and UPT service profile
NA-71206	UPT Phase 1: UPT user procedures and user states
NA-71207	UPT Phase 1: UPT man-machine interface
NA-71208	UPT Phase 1: Service requirements on numbering, addressing and identification
NA-71209	UPT Phase 1: Service requirements on protection of third parties
NA-71210	UPT Phase 1: UPT supplementary services
NA-71301	UPT Phase 1: Requirements on information flows and protocols
NA-71302	UPT Phase 1: Network considerations and requirements on dialling, routing and numbering
NA-71303	UPT Phase 1: Network architecture and functionalities for interworking
NA-71304	UPT Phase 1: Network functionalities for feature interaction
NA-71305	UPT Phase 1: Network functionalities for charging, billing and accounting
NA-71401	Specification of the security architecture for UPT phase 1

Figure 4 NA7 documents

the UPT Security Experts Group. In addition there are special subject meetings on for instance human factors and management.

NA7 divides UPT standardisation into three phases. Each phase contains a set of UPT capabilities and features which are tailored to the foreseen capabilities of the Intelligent Network at a specified point in time. Each phase will extend the previous phase with new features, support for new types of networks and other capabilities. In addition, there are deliverables which are independent of the phases and which give a general and long term view on UPT.

NA7 has completed the work on UPT phase 1, which is called the Restricted UPT Service Scenario. It has restricted capabilities with regard to networks, services, security and user friendliness. In phase 1 full UPT functionality will only be accessible in PSTN and ISDN, with voice and telephony type services. The most necessary UPT procedures are supported: Registration/deregistration for incoming calls, outgoing UPT call set-up and UPT service profile interrogation/modification. The authentication protocol is one-way with a fixed PIN or optionally with Variable Authentication Codes. A UPT device may be used for authentication, but this is restricted to sending DTMF in the direction from the user to the network. Figure 4 contains the titles of some of the NA7 documents which are related to the general service concept and to phase 1 of UPT.

Phase 2 of UPT is called the Basic Scenario. The target date for phase 2 standards is the end of 1995. It will extend phase 1 with more capabilities, and the goal is to maintain compatibility with phase 1. Support for UPT in radio mobile networks is provided and especially the integration of UPT in GSM is emphasised. This will for example make possible the charging of the UPT subscriber instead of the GSM subscriber and make the routing more efficient (avoiding tromboning). New features in UPT phase 2 are amongst others registration for outgoing calls and access to data services. A chip card is being specified which will offer more secure authentication and a better user interface for access to UPT. The chip card is intended to be used with card reading PSTN, ISDN and GSM terminals and with DTMF sending devices with acoustic coupling to analogue telephones. In UPT phase 1 only the SCF-SDF interface was utilised (Service Control Function to Service Data Function). For phase 2 also the SCF-SCF and SDF-SDF interfaces are being considered.

Other ETSI STCs

Below is a brief description of some Sub Technical Committees which are important for the UPT work.

HF1	Human factors, man-machine interface description
NA1	UPT service description
NA2	Routing, numbering and addressing
NA6	Will co-operate with NA7 on network aspects and security aspects
SMG1	Support of UPT in GSM
SMG5	Support of UPT in UMTS
SPS2	UPT protocol at the IN level
TE9	IC card and card terminals

Future organisation of UPT work in ETSI

It is being discussed in ETSI to replace NA7 with a Project Management Team for technical co-ordination in the area of UPT. The work with technical specifications would then be distributed to other Sub Technical Committees. For example could the work on service specifications be transferred to STC NA1 and the work on network architecture and capabilities could be transferred to STC NA6. NA7 has, however, started the work on UPT phase 2 and further NA7 meetings are planned on this subject.

ITU (International Telecommunications Union)

In ITU Telecommunications Sector (ITU-T) the work on UPT related Recommendations is proceeding in a number of Study Groups. In addition, some studies are being done in one Task Group in the ITU Radio communications Sector (ITU-R) in relation to studies on FPLMTS (Future Land Mobile Telecommunications System). Standardisation of UPT in ITU turns out to be quite complex, and in order to overcome the complexity a joint co-ordination group on UPT is formed.

ITU-T Joint Co-ordination Group on UPT

The JCG-UPT provides overall co-ordination of the work of ITU-T devoted to developing Recommendations on different aspects of UPT and to harmonise the interaction of the Study Groups involved in the work. This involves activities in ITU-T Study Groups 1, 2, 3, 4, 7, 11, 13 and 15. The JCG-UPT co-ordinates development of standards for enhancement of network capabilities and switching. In this way potential duplication of work can be avoided.

The JCG-UPT see to that all SGs make work plans for their study on UPT, track the progress of the UPT work and ensures that all work items are covered by at least one SG, facilitate liaisons between SGs on related items, proposes additional work if necessary, puts priorities on work to be done, and review the structure of Recommendations dealing with UPT to determine whether they are sufficiently harmonised and, if they are not, recommends appropriate actions. Figure 5 shows the organisation of ITU-T Joint Co-ordination Group with all relations on the standardisation work on UPT and thereby provides a quick overview of SGs involved in standardisation of UPT in ITU-T.

As mentioned before, UPT will be offered in different phases and this is also reflected in the standards. In ITU-T the Recommendations for UPT service set 1 is expected to be finalised at the end of 1995 and for UPT service set 2 at the end of 1996. Figure 6 shows some interesting Recommendations from the service point of view. In the following the various Study Groups involved are described.

ITU-T Study Group 1 (Service Definition)

SG 1 is working on stage 1 UPT service description and has the lead role in the standardisation work on UPT.

One of the study items allocated to SG 1 is Question 7/1, *Universal Personal Telecommunication,* which deals with what service principles and operational provisions are required to facilitate international implementation of UPT. The issues being considered in the study group are user perception of the UPT service, user interface, interaction with fixed location and mobile service provision, security of access to services, privacy – especially of location and service data, compatibility with existing and evolving network services, international availability, operational aspects of charging and recording of call data, which features should be essential and which additional, interaction with network based supplementary services and how to introduce UPT in a staged manner. The work will result in Recommendations such as F.851, *UPT Service Set 1 Service Description,* which has an expected completion date at the end of 1994, F.851, *UPT Service Set 2 Service Description,* and F.853, *Supplementary services in the UPT environment.*

ITU-T Study Group 2 (Network Operation)

A number of Questions in SG 2 are related to the work on UPT. Q.5/2, *Application of numbering and addressing plans for fixed and mobile services,* addresses general numbering principles and is responsible for defining what new recommendations are required. Since UPT numbering presents new problems, there may be a need for new support. The output from this work is Rec. E.168, *UPT Numbering*.

Q.6/2, *Routing and interworking plans for fixed and mobile networks*, addresses the ongoing introduction of new services, and the technology and functionality required to support them. Issues are routing planning and strategies, including principles applicable to all types of network. Recommendations will be developed and maintained for routing, mobility and interworking. For UPT the outcome is Rec. E.174, *UPT routing plan*.

Q.8/2, *Service quality of networks*, addresses the service quality aspects in the design of UPT. Service quality is related to all aspects of network assessment and in particular with network management. Recommendations for UPT will be made, such as E.Dupt, *Measurement of UPT service quality parameters*.

Q.9/2, *Network management*, addresses the need for enhancement of network surveillance and control capabilities to support an effective network management for the introduction of UPT. A TMN Recommendation will be developed for UPT.

Q.15/2, *Traffic measurements to support network operations,* addresses traffic measurement capabilities necessary to support network operations for UPT including signalling traffic. Q.16/2, *Traffic engineering for networks supporting mobile and UPT services*, addresses work on traffic engineering for networks supporting UPT, both in the user plane and for signalling. Output from the work are Recommendations such as E.750, *Introduction to the E.750 series of Recommendations on traffic engi-*

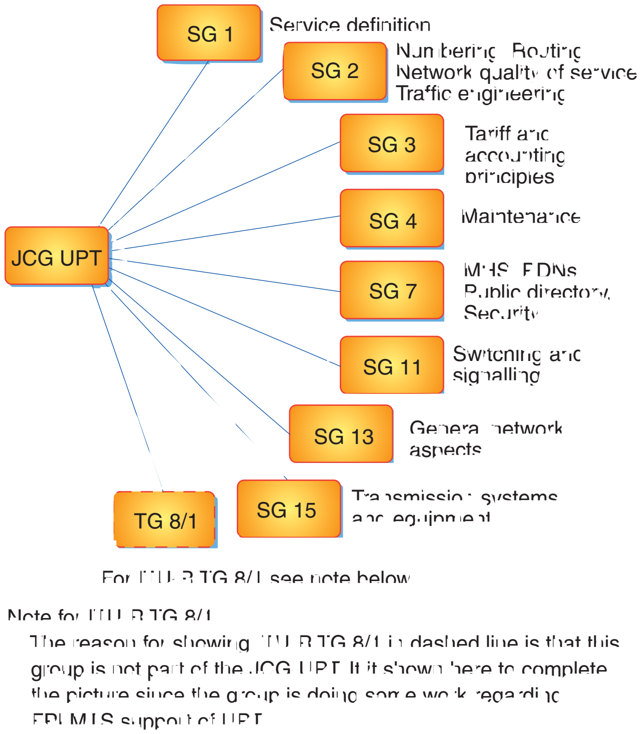

Figure 5 Organisation of ITU-T Joint Co-ordination Group on UPT standardisation

UPT Recommendations regarding service aspects

Approved:	
Recommendation F.850	Principles of UPT
Recommendation I.373	Network Capabilities to support UPT
Recommendation I.114	Vocabulary of terms for UPT
Recommendation E.168	Application of E.164 Numbering Plan for UPT.
Under discussion or for approval:	
Draft Recommendation F.851	UPT Service Description Service Set 1
Draft Recommendation F.852	Description of UPT Service Set 2
Draft Recommendation F.853	Supplementary Services in the UPT Environment
Draft Recommendation E.174	Routing Principles and Guidance for UPT. This Recommendation is ready for approval at the end of 1994.
Draft Recommendation D.upt	Principles for Charging and Billing, Accounting and Reimbursements for UPT. This Recommendation is ready for approval at the end of 1994.
Recommendation Q.76	Service Procedures for UPT. Functional Modelling and Information Flows

Figure 6 Some ITU-T Recommendations on UPT

neering aspects of mobile networks and UPT, E.765, *Personal mobility traffic modelling,* E.75, *Reference connections for UPT*, E.775, *UPT grade of service concept*, E.776, *Grade of service parameters for networks supporting UPT*, and E.785, *Traffic engineering methods for networks supporting UPT.*

ITU-T Study Group 3 (Tariff and accounting principles)

SG 3 is working on charging, billing and accounting. Two of the SG 3 Questions are of particular interest to UPT, namely Question 17/3, *Charging and accounting principles to be applied to universal personal telecommunications* and Question 20/3, *General charging and accounting principles for services supported by the Intelligent Network*. The UPT service is evolving rapidly and charging and accounting principles will need to keep pace with the service evolution. Therefore, it is important to find the appropriate requirements to reflect market and technology conditions. On the other hand, a range of sophisticated services will be provided by the Intelligent Network infrastructure and it would be beneficial to have a common approach to the charging and accounting principles applied in IN in order to obtain consistency in the principles that are applied to services making use of the capabilities in IN.

Output of the work on UPT are new Recommendations in the D-series such as Rec. D.280 on *Principles for Charging and Billing, Accounting and Reimbursements for UPT,* which is targeted for end of 1994.

ITU-T Study Group 4 (Network maintenance)

Quite a few SG 4 Questions are related to the work on UPT. Output from SG 4 is mainly Recommendations in the M-series. Q.1/4, *Terms and definitions*, makes available suitable terms and definitions needed for TMN activities in the areas of services and networks. Q.2/4, *TMN capabilities on the F interface*, addresses extensions and further development of human-machine interoperability requirements and TMN workstation interface requirements. Q.4/4, *Maintenance of mobile telecommunications systems*, addresses plans for UPT and extension of other networks to interface with or to provide UPT, and the need for maintenance procedures for UPT. Q.6/4, *Maintenance philosophy, principles and organisation for networks and services,* addresses a more efficient approach to manage new technologies and capabilities for e.g. UPT. For example, a more automated environment is expected. Q.19/4, *Common channel signalling maintenance*, addresses maintenance principles, concept, fundamental architecture, information exchange format and procedures for common channel signalling. Impact of IN interworking is important and has relations to UPT. Q.23/4, *Telecommunications Management Network – TMN*, addresses improvement and extension of the concept of TMN and the integration of it into the management of new telecommunications services and networks. This is relevant for UPT. Tasks are TMN principles and architecture, TMN management services, TMN information modelling, TMN methodology, TMN terminology and TMN co-ordination. TMN-IN relationship is of concern also to UPT.

ITU-T Study Group 7 (Data networks and open system communications)

The SG 7 is responsible for security services, mechanisms and protocols. The group has been working to define, in a general way, the various types of security breaches that can be encountered, and to develop protocols to provide the necessary security mechanisms to overcome these breaches. The Recommendations for UPT under development fall into categories such as security architecture and models, overview and definition of security threats, and protocols to provide mechanisms to overcome various breaches.

Q.14/7, *Message handling systems – MHS*, addresses among other things the needs for enhancements of the X.400-series to enable message handling systems to participate in UPT. Q.15/7, *Directory systems,* addresses the X.500-series of Recommendations regarding the need for enhancements to the directory in order to better support users of the directory, for instance to facilitate management of the directory or distribution of information. Enhancements required to the directory to support ITU-T applications such as distributed data base queries for UPT are being studied.

ITU-T Study Group 11 (Switching and signalling)

SG 11 is responsible for development of Recommendations for all aspects of switching and signalling to support UPT provision, and substantial work is involved in extending network functionality for UPT. SG 11 has taken the lead in developing network signalling for UPT and is well advanced in development of protocol based technologies to support other aspects of services such as service management. Service features can only be introduced in accordance with network capabilities and network evolution needs to be consistent with other services. Thus, the dependence of service features on network capabilities is an important co-ordination requirement and has led to alignment on the work plans between SG 1 and SG 11 with respect to service needs and priorities.

Internally, SG 11 has adopted a project approach to its work on UPT, and has set up a project management group on UPT in order to improve internal co-ordination on this topic. On a larger scale the work of SG 11 also benefits from the broader approach to co-ordination made possible by the JCG, which also brings in other requirements.

SG 11 is the most complex of the Study Groups with regard to UPT. A number of Questions address the various issues of UPT, and the work load of each Question is considerable. The Questions are listed below:

- Q.1/11 Switching functions and signalling information flows for implementation of basic and supplementary services
- Q.2/11 Structure and performance of signalling networks
- Q.6/11 Intelligent Network capability sets
- Q.7/11 Signalling, Call handling and management requirements for UPT
- Q.15/11 Updating and enhancement of ISDN user-network interface call control protocols

Q.21/11 Updating and enhancements of ISDN network node-to-node interface call control procedures

Q.25 Definitions of managed objects in switching and signalling network elements used for the definition of the TMN interface.

The study areas above will cover the task of describing the overall technical requirements from UPT in respect of signalling procedures and protocols to support call control, mobility and service management. This includes overall signalling information flow for basic and supplementary services, and the procedures within the network for the establishment and control of these services. SG 11 will provide Stage 2 Recommendations for services based on UPT, and identify requirements (in addition to Stage 2 requirements) to be placed on Stage 3 definitions of UPT signalling, for DSS1 and for digital mobile access signalling, and for ISUP enhancements for UPT. Following from this, SG 11 will provide UPT enhancements for both access and network protocols. Furthermore, studies will identify requirements for UPT functional distribution within fixed or mobile (land, satellite) networks and for interworking between these and in respect of multiple service providers. The studies will also identify UPT signalling requirements on Intelligent Network Application Part protocol (INAP) and provide Recommendations for Stage 3 protocol designs based on use of INAP.

With regard to management, SG 11 works on standardisation of IN Capability Set 2 and later Capability Sets, in relation to provisioning of service management facilities relevant to UPT. The work covers Stage 2 design and Stage 3 protocol design for UPT service management using service profiles, and the definition of UPT managed objects, including UPT service profiles.

Also, SG 11 will identify the specific UPT requirements placed on switching functionality; provide a description of network technical capabilities in relation to UPT phases. As such, the implementation of UPT Service Set 1 has been split into two steps by SG 11 to take into account the capabilities of the IN Capability Sets: UPT Service Set 1 on IN CS-1 is scheduled to be complete (including the stage 3) by the end of 1995, and UPT Service Set 1 on IN CS-2 is scheduled to be complete by the end of 1996.

Examples of output is Rec. Q.76, *Service procedures for UPT*, and Recommendations on Stage 2 and 3 for support of UPT SS1 on IN CS-2, description of DTMF user interface and procedures (stage 3) based on CS-1 as well as CS-2, and Stage 3 for support of UPT SS1 on IN CS-1.

In addition to the above a new work item was started during September 1994, which is Q.29/11, *Methods and procedures for access and information security in use of network services*. This study addresses security aspects for UPT. Services such as UPT, which aim to provide universality of access will introduce new risks of fraudulent misuse and difficulties in monitoring real time use of the service. Also, service management by subscribers and users of UPT will create new needs for protection of sensitive information held in the network. SG 11 will concentrate on methods and procedures to achieve a given level of security performance for UPT and will give advice on network functions required for UPT within current networks, and network functions needing enhancement. The first Recommendations for security requirements, methods and procedures for UPT (service set 1) are expected at the end of 1995, and will provide a description of requirements for user-network and network-network protection from fraudulent operation and misuse.

ITU-T Study Group 13 (General network aspects)

SG 13 is responsible for studies related to general network aspects and impact of new system concepts. New network structure and functional requirements to support new technologies are part of the concerns of SG 13. Ongoing work on UPT is covered by several SG 13 Questions.

For the introduction of UPT, the consideration of harmonisation with IN architecture and signalling is important. Q.1/13, *Network capabilities for networks other than B-ISDN*, has in its studies a particular interest in work on provision of UPT services by all kinds of networks, including those with IN functionality. In relation to this the Question is studying the problems concerning interaction and/or interworking between fixed and mobile networks. The work will result in Recommendations such as I.373, *UPT network capabilities*, I.37y, *UPT network requirements*, and I.5xz, *UPT/mobile interaction*.

Q.22/13, *UPT performance,* is concerned with the fact that for successful introduction of UPT, an appropriate UPT performance specification is essential. Considering that UPT provides for personal mobility, it is important to be able to recommend performance of impairments of UPT connections such as network performance impairments due to UPT user identity, call loss due to inability to locate the UPT user, connection set-up time due to locating a UPT user, and network performance impairments due to addition of networks or systems to a fundamental network. The work will result in Rec. 13 I.35x “Framework for UPT performance”.

Q.26/13 *(Vocabulary for general network aspects)* addresses the need for having a consistent vocabulary for terms and definition of general network aspects and is resulting in Rec. I.114, *Vocabulary – UPT.*

ITU-R Task Group 8/1

In the ITU-R (Radio communications Sector) Study Group 8 on mobile communications aspects, Task Group 1 is working on FPLMTS (Future Public Land Mobile Telecommunication System). There is some commonality between the two service concepts FPLMTS and UPT in many areas. Examples of commonalities are found within service and definitions, numbering and addressing, architecture, signalling and protocols, security aspects, data requirements and terminology. Also, FPLMTS will support UPT and TG 8/1 has made a framework document on the relation of FPLMTS User Mobility and UPT.

EURESCOM

Project P102 UPT

EURESCOM project P102 started working with UPT in October 1991 and delivered their final report in April 1993. The pro-

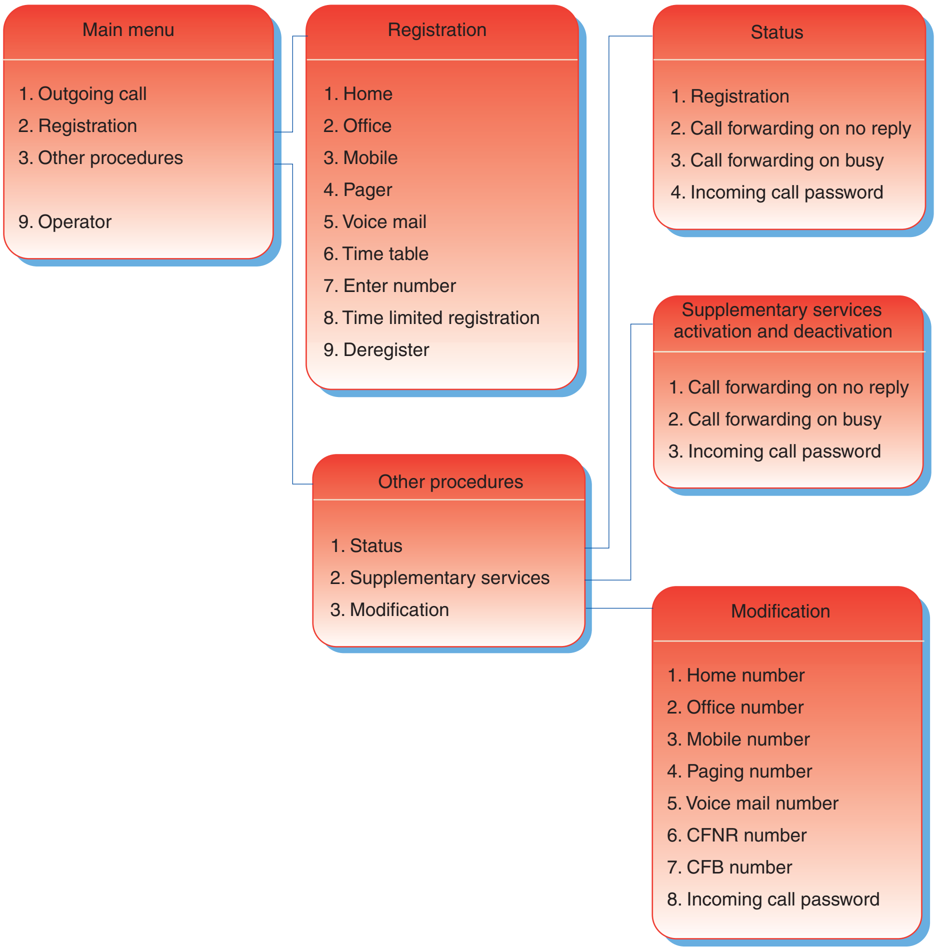

Figure 7 Main menu of the UPT pilot service

ject concluded that each EURESCOM partner is able to introduce a pre-UPT service in 1993/94. It is feasible to implement the pre-UPT service on the general IN platform that is available in 1993/94. The estimated market window for the pre-UPT service is from 1993 until 1996/97, when a UPT service based on ETSI phase 1 probably can be implemented.

The basic service features offered by the pre-UPT service are incoming UPT call, outgoing UPT call and registration for incoming calls. It will most often be implemented by a home based solution which does not require interconnection of different networks at the IN level. Although simple, the home based solution has some inherent advantages. The user will experience the same interface to the service regardless of network access point and there are no problems with accounting and transfer of personal UPT user information between network operators. World-wide access to the pre-UPT service may be provided by the Freephone service, thus eliminating the charging of the network access subscriber, but the UPT user must be provided with a list of Freephone numbers for access from different countries, unless an international numbering plan for Freephone is available. The main disadvantage of the home based solution is that it is technically inefficient. Even when the UPT user is located outside the home network all incoming and outgoing UPT calls and all accesses to the service profile require a bearer connection leg to the home network.

Project P230 PEIN

P230 mainly studies interconnection of European IN networks. Task 4 of P230 studies support of personal and terminal mobility by IN. This includes GSM, cordless terminal mobility, UMTS and UPT. Mobility requirements will be specified both for the IN inter-networking architecture of P230 and for the IN architecture in an evolutionary long term perspective. Task 4 will work until the end of 1994.

The Norwegian UPT pilot service

Norwegian Telecom will operate a UPT pilot service in the autumn of 1994. 300 customers will be invited to participate in a service trial. Norwegian Telecom and Ericsson Telecom have co-operated in specifying and implementing the service and it has been tested and used by employees of the two companies.

The service features include most of the ETSI UPT phase 1 features. Variable routing based on day of week and time of day is supported. If a UPT user works at home some days of the week, the UPT user's calls can for example be automatically routed to the office on Monday to Wednesday and to home on Thursday to Friday. To make it easier to register for incoming calls some specific numbers are stored in the service profile and may be selected from a menu. The number at home and at the office may be stored and also paging number, cellular phone number and the directory number of the UPT user's voice mail box. Call forwarding on busy and on no reply is also supported. Basic protection against fraudulent use of the service is achieved by giving each user a secret PIN to be used for authentication. If an unauthorised person gets access to a UPT account the potential financial loss cannot exceed the credit limit associated with the account. If the accumulated charges in a time interval exceeds the credit limit the UPT account is blocked for further use.

Some features are included in addition to ETSI UPT phase 1 features. Because the UPT user in some cases pays a part of the cost for incoming calls, the UPT user may want to control which persons are allowed to call the UPT number. This is implemented by requiring the calling user to enter the correct password before the call is set up. Other restriction features which have been implemented are screening of calling and called party number based on the prefix or the whole number and barring of service access dependent on day of week and time of day.

The user interface requires the use of a telephone with DTMF sending capability or a portable DTMF sender with acoustic coupling to the telephone handset. The user is guided by recorded voice prompts. After the UPT access number has been dialled the user is prompted to dial his/ her account number and PIN. The network checks that the PIN is the one associated with the account number. When the network has authenticated the user a recorded voice message informs the user about the choices in the main menu. Sub-menus exist for service profile modification and interrogation (figure 7). The user can for example activate call forwarding on no reply for calls to the user's UPT number or the user can enquire about the current registration for incoming calls. In the latter case the voice response is either of the form "You are registered on the office number" or the digits of the registration number are read. If the user needs assistance he/she can select a menu choice which sets up a connection to an operator (attendant). The feature which ETSI calls Global Follow-on allows a user to invoke several different UPT procedures after each authentication. In our pilot service this is implemented by returning to the main menu after the procedure associated with a menu choice has been completed. The main menu is also presented to the user when the user is engaged in an outgoing UPT call and the called party disconnects.

Due to the limitations of the current IN network and IN internetworking the network structure of the pilot service corresponds to the home based solution which is described by EURESCOM P102 (see above). This means that all UPT service accesses and all calls to the UPT number must be routed via the home network, in this case the Norwegian Telecom telephone network. In our home network the UPT service processing and switching is also centralised to a single Service Switching and Control Point. The UPT user may, however, be registered in another network than the home network. As long as the call to the UPT number originates in the home network, the routing will be efficient. In other cases tromboning may occur. Suppose that the calling user and the UPT user are located in the same GSM network. The calling user is charged for leg from GSM to the UPT home network, and the UPT user is charged for the leg from the UPT home network to GSM (split charging). The total charges are at least double the charges for a GSM call. Another problem occurs if the GSM terminal has roamed outside its home network. Then the GSM subscriber is charged for part of the UPT call.

Acronyms

ATM	Asynchronous Transfer Mode
B-ISDN	Broadband ISDN
CT-2	Cordless Terminal – Version 2
CCF	Call/Connection Control Function
CCAF	Call Control Agent Function
DECT	Digital Equipment Cordless Terminal
DSS1	Digital Signalling System Number 1
DTMF	Dual Tone Multiple Frequency
ETSI	European Telecommunications Standards Institute
ETSI STC NA7	ETSI Sub Technical Committee Network Aspects 7
FPLMTS	Future Public Land Mobile Telecommunications System
GSM	Global System for Mobile communications
IN	Intelligent Network
IN CS-1	IN Capability Set 1
INAP	Intelligent Network Application Protocol
ISDN	Integrated Services Digital Network
ISUP	ISDN User Part
ITU	International Telecommunications Union
ITU-T	ITU Telecommunications Sector
ITU-R	ITU Radio communications Sector
JCG	Joint Co-ordination Group
MHS	Message Handling System
PIN	Personal Identification Number
PDN	Public Data Network
PSTN	Public Switched Telephone Network
Q	Study Question (note: used in ITU)
SCF	Service Control Function
SDF	Service Data Function
SG	Study Group
SMF	Service Management Function
SRF	Specialised Resource Function
SSF	Service Switching Function
TMN	Telecommunications Management Network
UMTS	Universal Mobile Telecommunication System
UPT	Universal Personal Telecommunication
UPT SS1	UPT Service Set 1

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