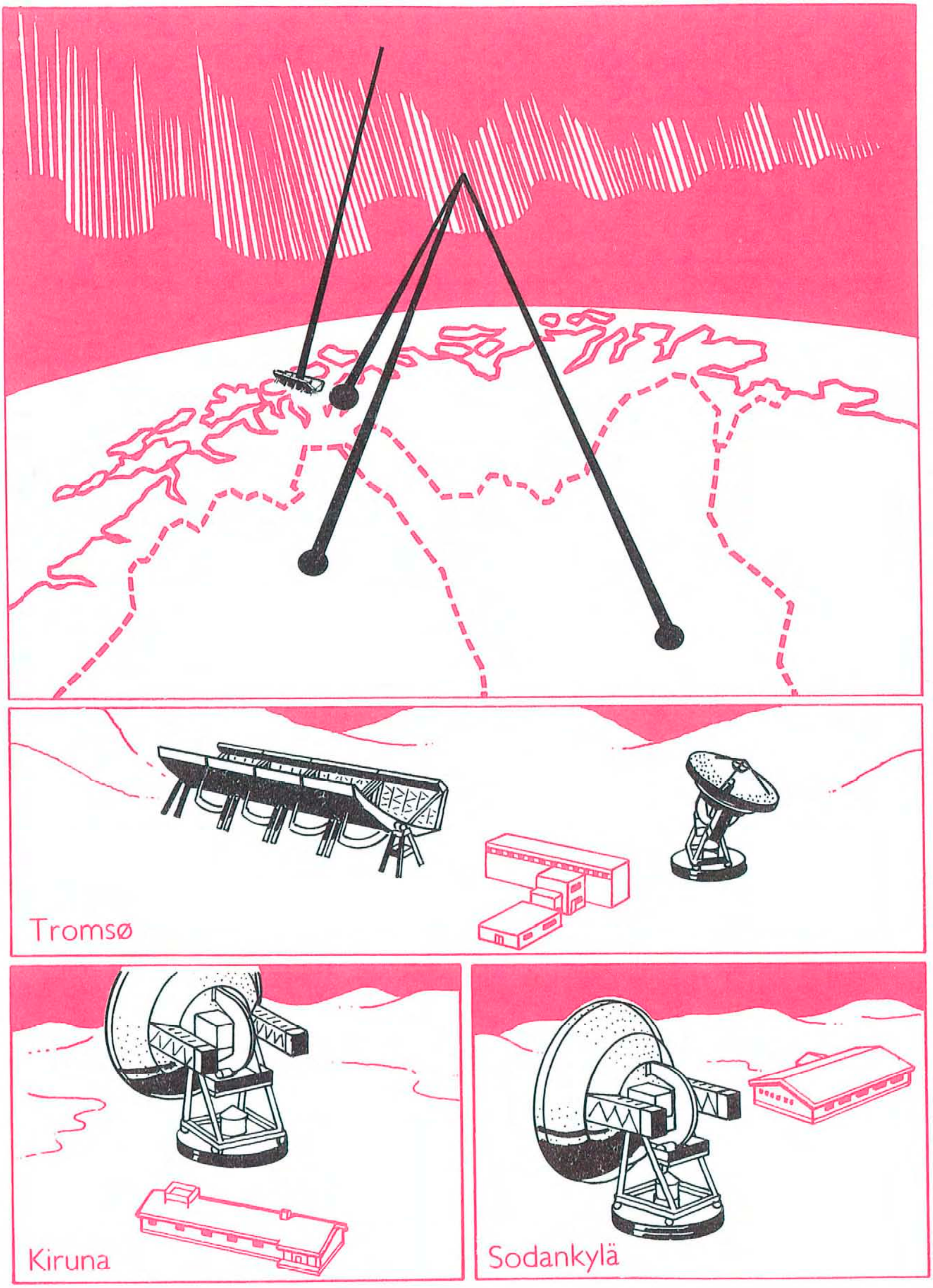
EISCAT

EUROPEAN INCOHERENT SCATTER SCIENTIFIC ASSOCIATION

ANNUAL REPORT 1977

S-981 01 KIRUNA, SWEDEN, PHONE (0980) 18740


Tromsø
Kiruna
Sodankylä

CONTENTS

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HEADQUARTERS SENIOR STAFF DURING 1977

T HAGFORS	—	DIRECTOR
K FOLKESTAD	—	ASSISTANT DIRECTOR
S WESTERLUND	—	ASSISTANT DIRECTOR
G G HODGSON	—	BUSINESS MANAGER

INTRODUCTION

In this second annual report the emphasis remains on the construction of the facilities and the gradual build-up of the staff.

The contract for the construction of the UHF antennas has been completed, and delivery of the antennas will occur during 1978. All the computers have arrived at the observing sites and programming has started in preparation for the operational phase. The civil work for the buildings, platforms and UHF antenna foundations is in progress.

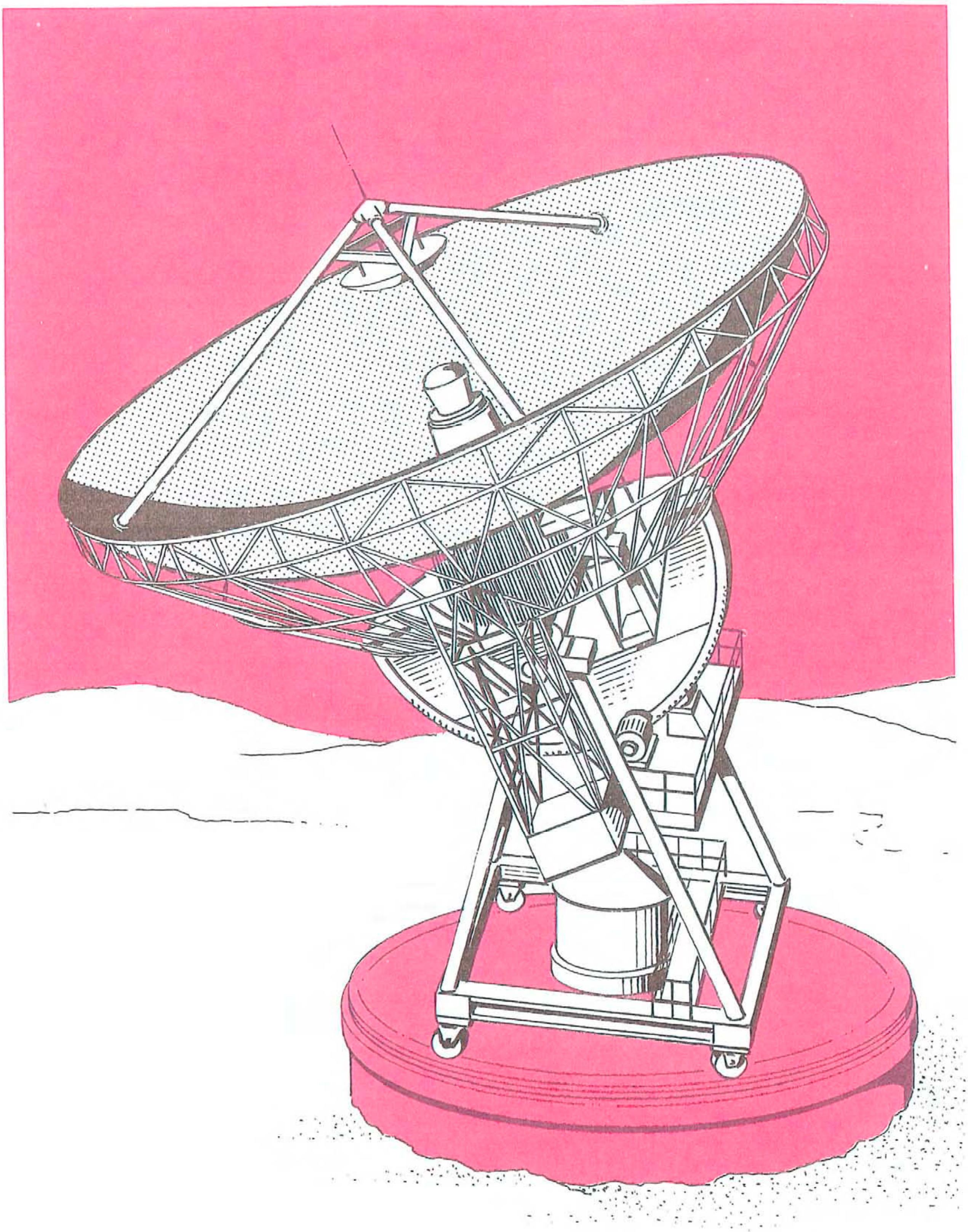
A most important and difficult decision has been made in relation to the VHF antenna. Careful scientific considerations concerning the relative merit of sensitivity and steerability has lead to a bias in favour of the latter with the result that none of the antenna options under serious consideration as described in last year's annual report could be used. Tenders have now been invited for an entirely different antenna concept and bids are expected during the early part of 1978.

Nearly all the work appears to progress according to a schedule which would allow EISCAT to start UHF observations early 1979.

The only part which could upset this schedule is the transmitter which may be delayed because of unexpected difficulties with the high power klystrons.

The progress which has been made during 1977 justifies the optimism and expectations for scientific success which were expressed in the previous report.

Tor Hagfors
Director



The UHF-Antenna

INSTRUMENTATION

General

During 1977 all the major parts of the equipment have been defined and EISCAT has either taken delivery of some of the items, such as the buildings at the receiver sites and the control and analysis computers, or has placed orders for other parts such as the UHF antennas and the low noise amplifiers. The only major investment item which remains to be ordered is the VHF antenna.

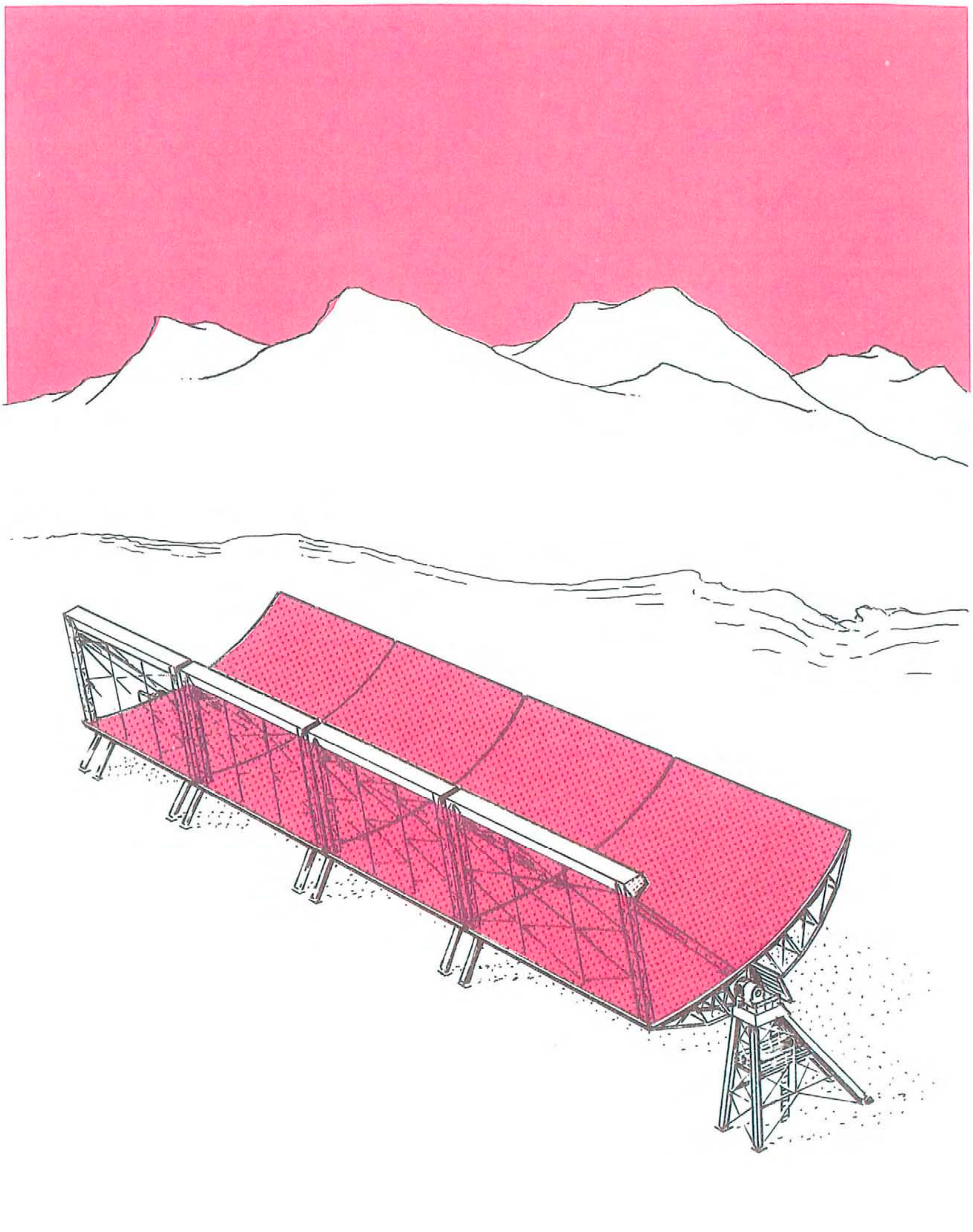
As the UHF antennas and the VHF antenna were not defined in the previous annual report and, therefore, could only be described in broad terms, we shall elaborate on the antenna properties and design. In the case of the UHF antennas we shall refer to the manufacturer's specifications. In the case of the VHF antenna we shall refer to the EISCAT tender specifications for detail.

The definition of the control and data analysis system has progressed during 1977 to the extent that a much more realistic outline configuration can be given.

The UHF Antenna System

During the negotiations with the firms which submitted bids for the UHF antennas it became clear that budgetary constraints would force us to purchase single 32 m diameter receiving antennas rather than the originally planned pairs of 25 m antennas at Kiruna and Sodankylä. Furthermore, the dual beam concept, which can be implemented with two offset feeder horns, proved to reduce the antenna efficiency and to make operation extremely cumbersome and was, therefore, abandoned.

The contract, which was awarded to Toronto Iron Works (TIW System, Ltd) and signed during February, is for three 32 m solid surface, single-beam parabolic antennas fed by a Cassegrainian system. The bandwidth for transmission (Tromsö only) is 5 MHz and for reception 25 MHz. In order to optimize the match between the transmitter and the receiver, complete polarization flexibility is built into the system. Polarization can



The VHF-Antenna

be adjusted continuously by remote control during operation. The antenna efficiency, excluding the polarization network and the receiver protector switch (Tromsö only), is 71 % and the estimated antenna noise contribution is 21 °K. The reflectors are electrically heated to prevent the buildup of ice and snow. The antennas can work to specifications up to 12 m/sec wind and with some deterioration in specifications to 25 m/sec.
Not included in the TIW contract are foundations. They are being constructed by Svenska Väg AB at Tromsö and Kiruna, and by Pohjansepot OY at Sodankylä.

The antennas will arrive at the sites during April and May of 1978, with acceptance tests scheduled for September and October of that year.

The VHF Antenna

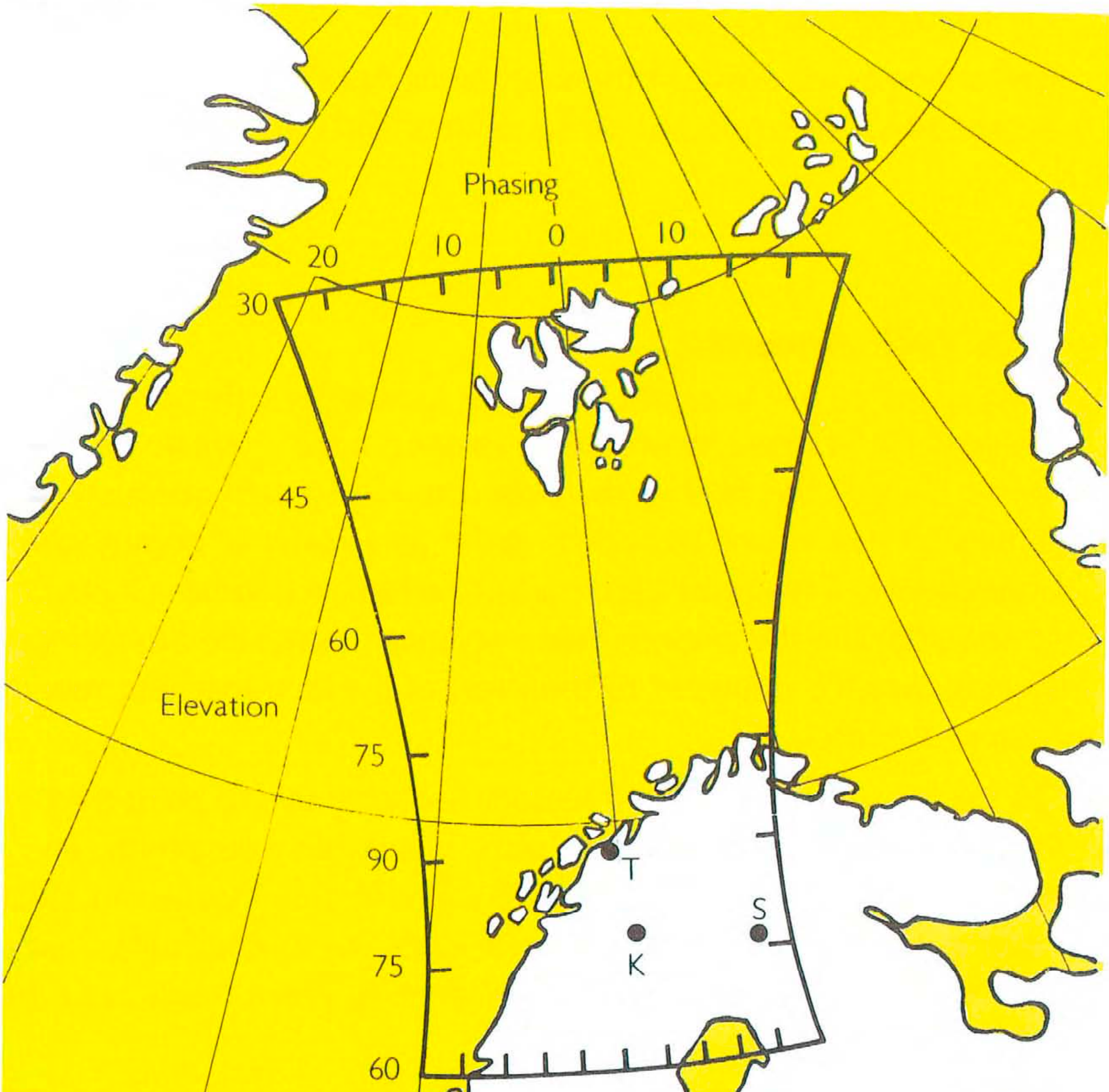
Discussions in the Scientific Advisory Committee (henceforth SAC) revealed that a strong desire has developed in the scientific community for a capability to observe the polar cap region with adequate radar sensitivity. This desire has come about as a result of recent satellite observations of the polar cap region. The highest L-value will obviously be reached with the antenna beam pointing toward the North Magnetic Pole, which is displaced to the West of the local magnetic meridian by approximately 25°.

On the other hand, there are reasons for being able to point the beam exactly in the magnetic meridian plane in a region near zenith. This requirement arises out of a desire to use the VHF incoherent scatter radar as a diagnostic instrument in HF ionospheric modification experiments, in which some of the most interesting phenomena occur near this plane.

As in the case of the UHF antennas, the emphasis thus has been shifted from sensitivity to steerability. None of the concepts previously considered to be potential candidates for the VHF antenna can fulfill the requirements of a beam steerable to an elevation angle of 30° to the north at azimuth 25° West of North and allowing the beam to be aligned rather exactly with the magnetic meridian in a region near zenith.

These scientific requirements have narrowed the choice of antenna types and have made the task of tendering easier.

The tender, which was issued during September, allows for two options — a fully steerable parabolic dish or a parabolic cylinder — both with a physical aperture area of about $10^4 m^2$. The tender specifies the parabolic cylinder option in detail and leaves the parabolic dish antenna to be specified by the bidder.



VHF antenna coverage at 1000 km altitude.

Computer, Control and Data Handling Equipment

Computers are needed by EISCAT for reduction of the observed data, to extract the physical parameters, to control the transmitter and receivers during the observations and to integrate and smooth the data delivered by the correlators.

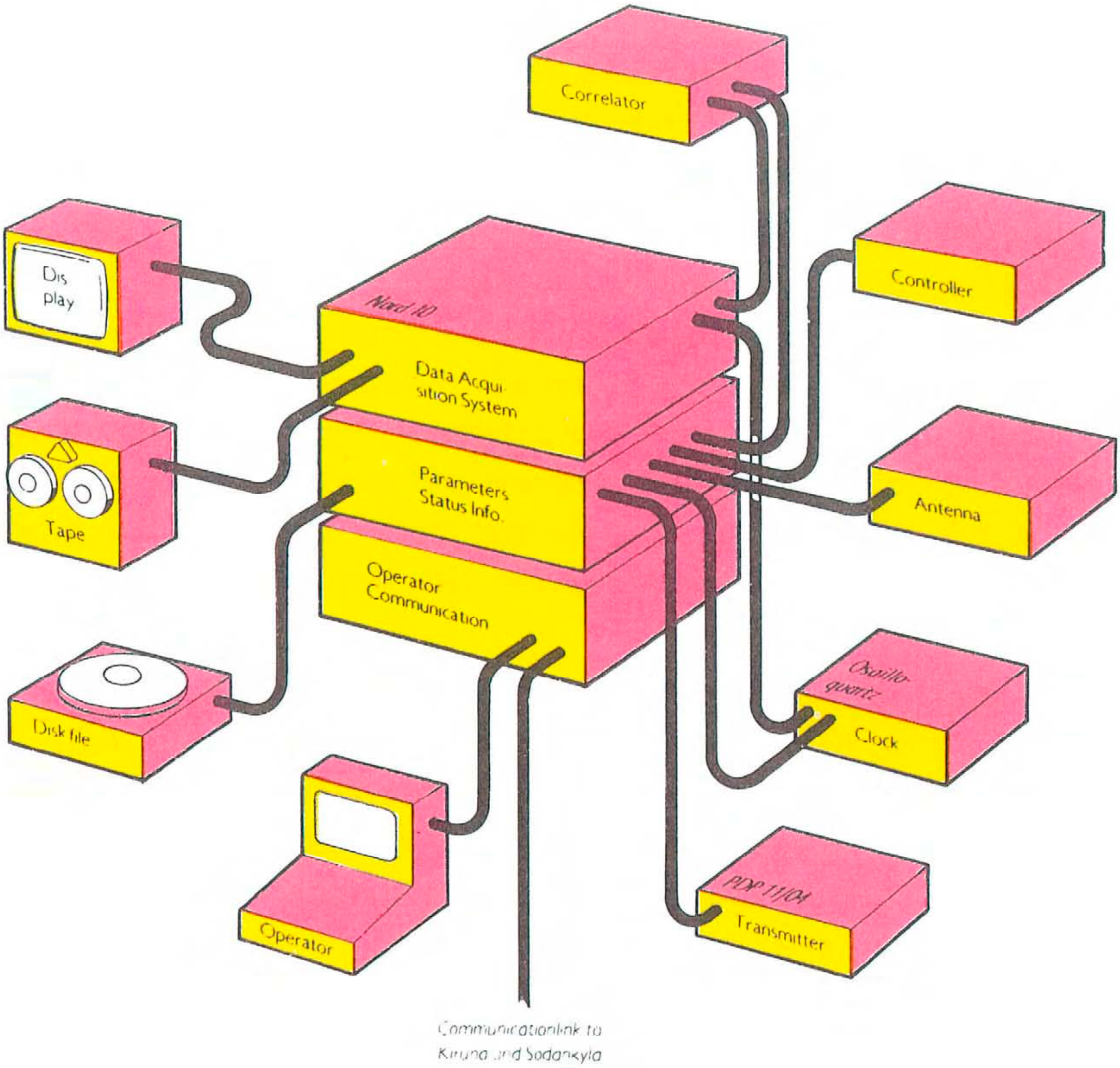
The four NORD-10 computers, which were ordered from Norsk Data A/S, were all delivered on time and passed their acceptance tests with only minor difficulties.

The general purpose computer, shared by EISCAT and Kiruna Geophysical Institute, is the largest with 96 thousand 16 bit words for memory. To process and copy the data from the observations, there are three 9-track magnetic tape drives and a 7-track drive which can be used to transfer data to and from other installations if necessary. A 33 Megabit disc unit holds all the system programs and processing programs and files that EISCAT may require. A Benson plotter can be used to produce graphs of functions derived from the data. Available are also a line printer and paper tape unit.

Access to the system is through any one of 8 terminals, one of which is a Tektronix 4004 on which can be displayed graphs and charts. The time-sharing system (SINTRAN-III) has operated satisfactorily since its installation in February when the machine was delivered. Other software has so far proved satisfactory, including compilers, file access subsystems, editors, and plotting packages.

The three on-line computers are also operating well at the close of 1977, although the final software and hardware for the communication lines are not due until mid-1978.

Each has 64 thousand 16 bit memory, four 5 Megabit disc units, a 9- track magnetic tape drive, paper tape peripherals and 3 terminals. One of the terminals can be used to display graphs, another various monitoring data, and the third is for controlling the antenna, receiver and clocks.



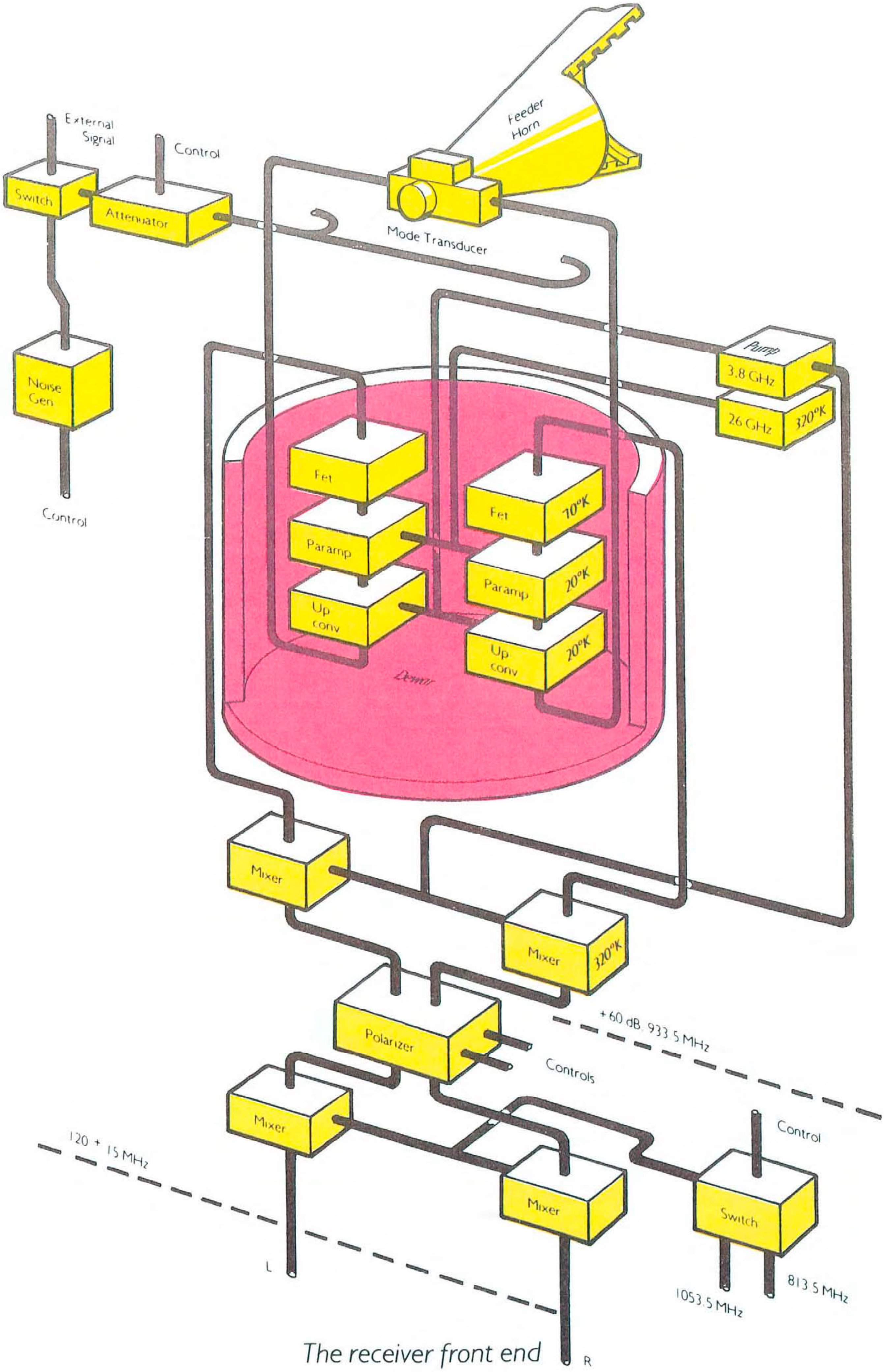
The Tromsø computer system

General purpose computer	
CPU:	NORD-10
MEMORY:	96K 16-bit words
INPUT:	Paper-Tape reader, 300 ch/s Card Reader, 285 c/m
OUTPUT:	Line-Printer, 600 l/m Paper-Tape Punch, 75 ch/s Plotter, 75 cm, Benson 1220
BACKING-STORE:	Magnetic Disc, 33 Mb Magnetic Tape, 3x9-track 800/1600 bpi 1x7-track 556/800 bpi
TERMINALS:	2x Decwriter, 30 ch/s 3x Vistar GTX Alphanumeric Display 1x Beehive Addressable Screen 1x Tektronix 4006 Graphical Display
OPERATING SYSTEM:	SINTRAN-III C.

The correlators and radar controllers are being developed at the Tromsö University and are progressing well. They are both, in principle, special purpose computers whose programs are loaded from the NORD-10 on-line computers at each site.

The correlator is designed to do some data processing on the incoming signal at a rate very much faster than that of the on-line computers. The design has undergone a fairly major change to increase its flexibility, but there is still reason to expect it to be interfaced with the NORD-10 early in 1978.

The radar controller is designed to control all the functions of the radar systems which operate at a speed too great for on-line computer control. It is loaded with its own program before an experiment starts, and is at all times under the overall control of the on-line computer. A more detailed description will be given next year.



The receiver front end

Receivers, Frequency and Time System

The UHF preamplifier is built by the AIL Division of Cutler Hammer. The total gain is 60 dB. The design is unconventional, see illustration. In the first stage, a parametric upconverter cooled to 20°K, the signal is amplified by 5 dB and upconverted in frequency to 4.75 GHz by pumping with a frequency of about 3.8 GHz. The next stage is a conventional parametric amplifier also cooled to 20°K and providing 15 dB of gain. After a 15 dB Field Effect Transistor (FET) amplifier, cooled to 70°K, the signal frequency is coherently converted down to the original input frequency in a mixer, using the upconverter pump source as local oscillator.

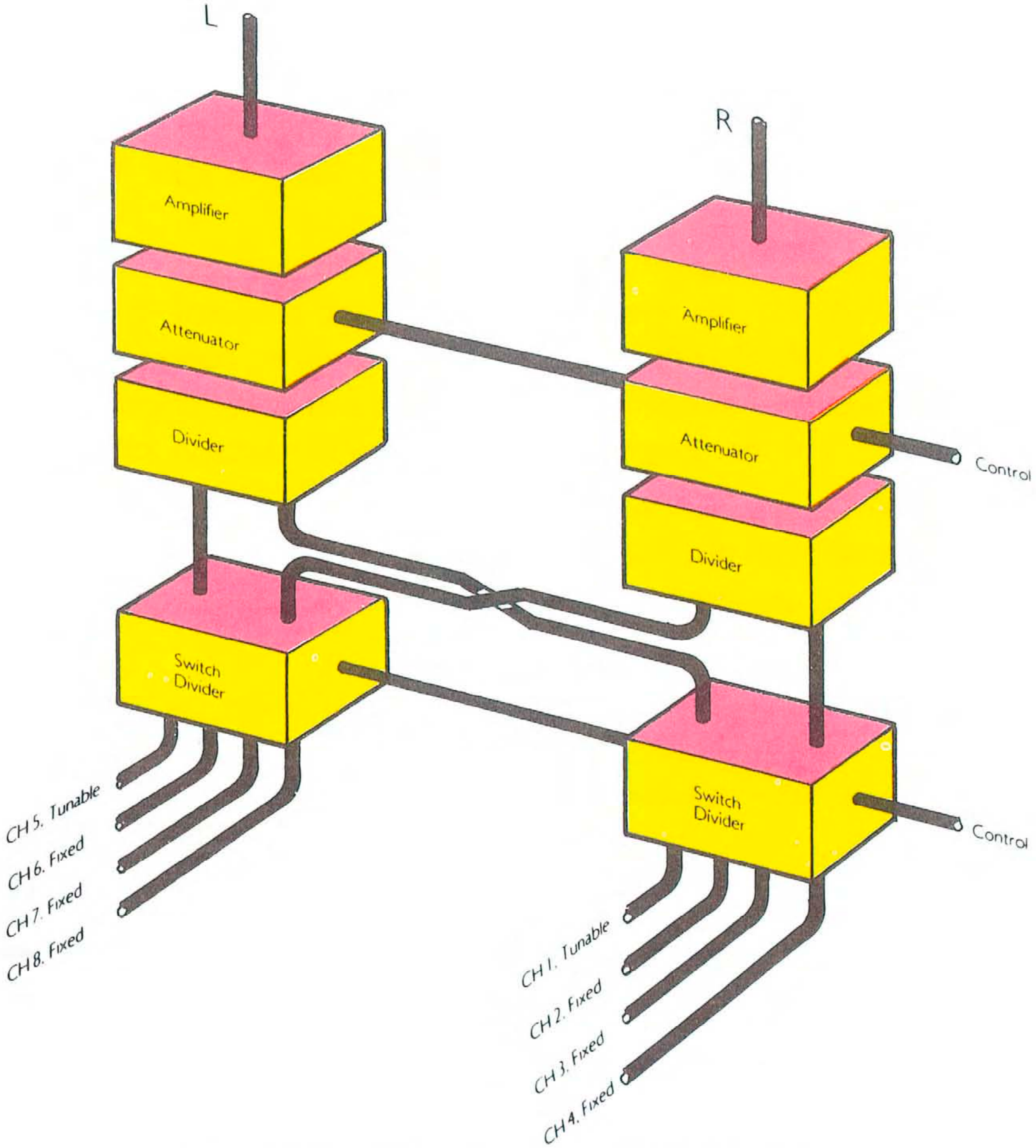
A transistor amplifier on the output provides the additional gain needed for a total of 60 dB. The mixer/amplifier and the pump oscillators are all temperature stabilized at 320°K in order to improve gain and phase stability of the preamp.

For calibration purposes a noise signal with a power corresponding to 0°, 30°, 100° or 300°K can be injected through directional couplers on the inputs. Alternatively a signal provided from an external source can be injected.

By setting the polarizer, an arbitrarily polarized signal can be received in any of the two channels designated L and R in the figure. The illustration shows the configuration in Sodankylä and Kiruna where the polarizer is made in coaxial cable. In Tromsö, the polarizer is constructed in waveguide and is placed in front of the preamplifier. This increases the system noise in Tromsö but is necessary since the same polarizer is used for transmission and reception.

After amplification and conversion in the antenna as shown on page 12 the signal is brought into the receiver building, amplified, and divided into eight channels see page 14. This arrangement allows simultaneous reception of eight frequencies. The channels are of two kinds. Six channels are tuned to fixed frequencies, corresponding to six transmitter frequencies, and the two remaining channels are tunable to any frequency in the 30 MHz wide band.

Initially only the two tunable channels will be provided. The six fixed frequency channels will be added later.



The intermediate frequency distribution system

The two A/D converters delivered for each receiver will be able to sample at rates from 1 kHz to 500 kHz. The sampling frequency is set from the computer and start and stop sampling commands are given by the Radar Controller. The A/D converters, including sampling frequency generators, and the matched filters are being built at the Department of Electrical Engineering at Oulu University.

The filters are matched to a 13 bit Barker code and accept baud lengths from 1 microsecond and up. The eight input signals are multiplexed to one channel to the Correlator. A total of four filters will be provided, three for UHF and one for VHF.

Because of the stringent synchronizing requirements EISCAT need very accurate clocks. Three Cesium clocks were bought during 1976. They have been tested extensively, first at the National Calibration Centre of Sweden and then in Kiruna. The experience has not been entirely satisfactory. Five major failures have occurred and on a few occasions the clocks have failed without any indications of the cause.

With this experience in mind it has been decided to add a LORAN-C receiver at each site. The clock output from the LORAN-C receiver is capable of giving an accuracy of about $\pm$ 3 μs. This is less than we need but the combination of the LORAN-C and the Cesium clock is expected to give relative accuracies, between the three site clocks, of better than a microsecond. The LORAN-C clock also has the advantage that it can be set accurately without bringing in time from the outside if it should stop. It will, therefore, reduce the number of Cesium clock transports.

A further possibility is to synchronize against a common TV transmitter. Between Kiruna and Sodankylä this method is easily implemented, since one TV transmitter may be observed from both sites. Between Kiruna and Tromsö the situation is not so straight forward since two different TV transmitters in the Norwegian chain must be observed. The synchronization will then depend on the delay in the microwave communication chain between the two TV stations being constant.

Transmitters

The transmitter contract was placed last year. For a brief outline of the technical specifications of the transmitters and the supervision arrangement, we refer to last year's Annual Report.

The development in 1977 has been both encouraging and, in some respects, rather disappointing. We have been pleased to note a consistently high quality of the workmanship of the hardware so far completed. In some parts of the transmitters provisions for testing and system monitoring are more flexible and complete than asked for.

Our disappointment stems from a substantial delay in the delivery schedule. In part the slow progress has been caused by limited engineering capacity at the manufacturer. However, the major delay appears to be due to unexpected difficulties met by the supplier in the production of the UHF klystron. At the end of 1977 the klystron, rescheduled for delivery in December, was still far from completion. It does not seem realistic to expect the first transmitter delivered to the site before the late summer or early autumn of 1978. This might place the site acceptance tests well into 1979.

Premises

The headquarters office is in rooms rented from the Kiruna Geophysical Institute. The work on the station building at Tromsö started in August 1977, under control and supervision of Statens bygge- og eiendomsdirektorat. All major concrete construction was completed there at the end of the year. Severe winter conditions, with heavy snowfall and frost from the middle of November, delayed the progress of the steel erection operations. It is not expected, however, that the overall completion date of the building, as indicated in the Annual Report of 1976, will be unduly altered. The high voltage power line is ready and the transformer equipment will be installed in the spring of 1978.

The Kiruna building and its equipment was placed at the disposal of EISCAT in 1977. At Sodankylä, space in an existing building was allocated to the project.

ADDRESSES

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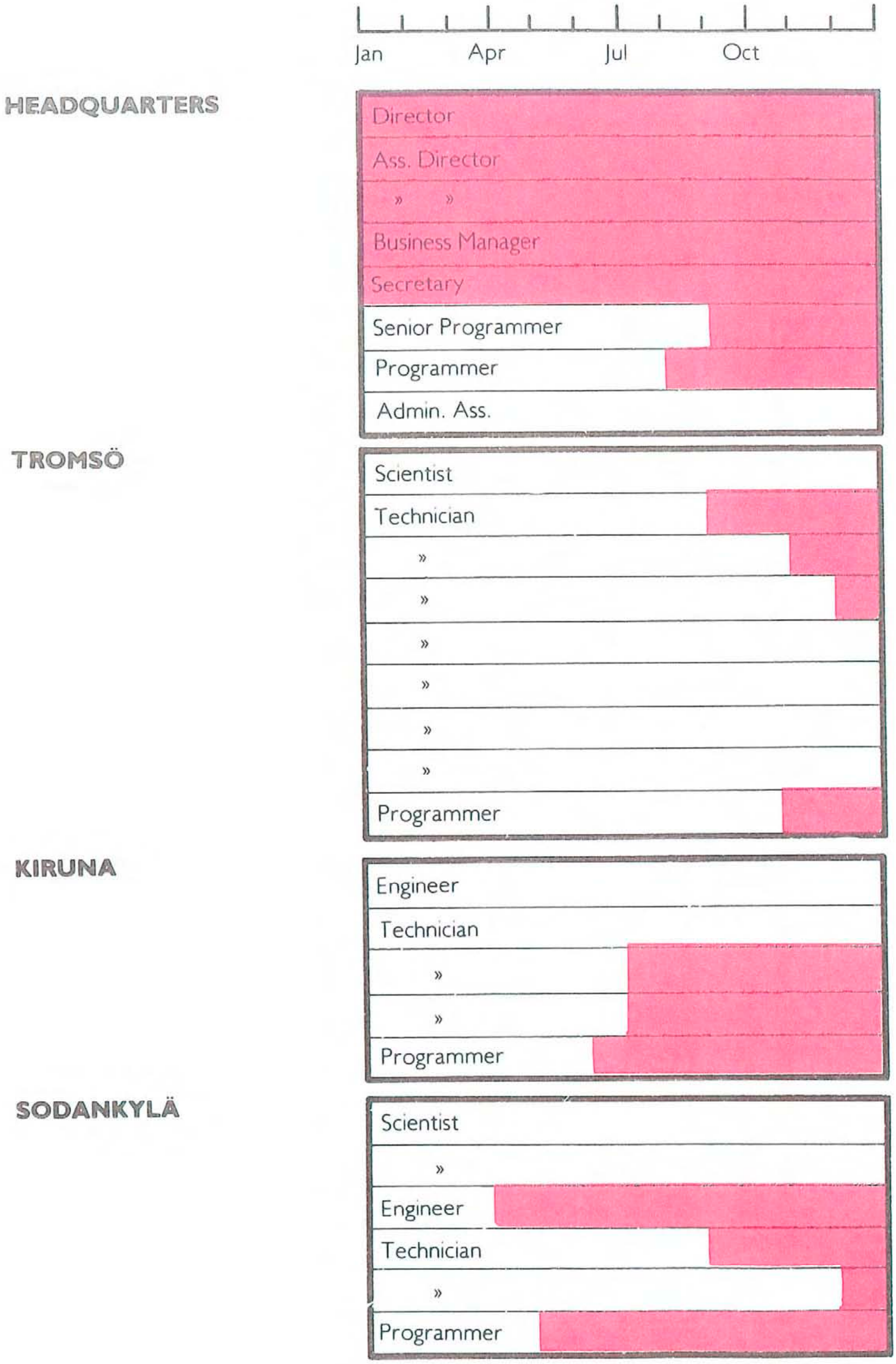
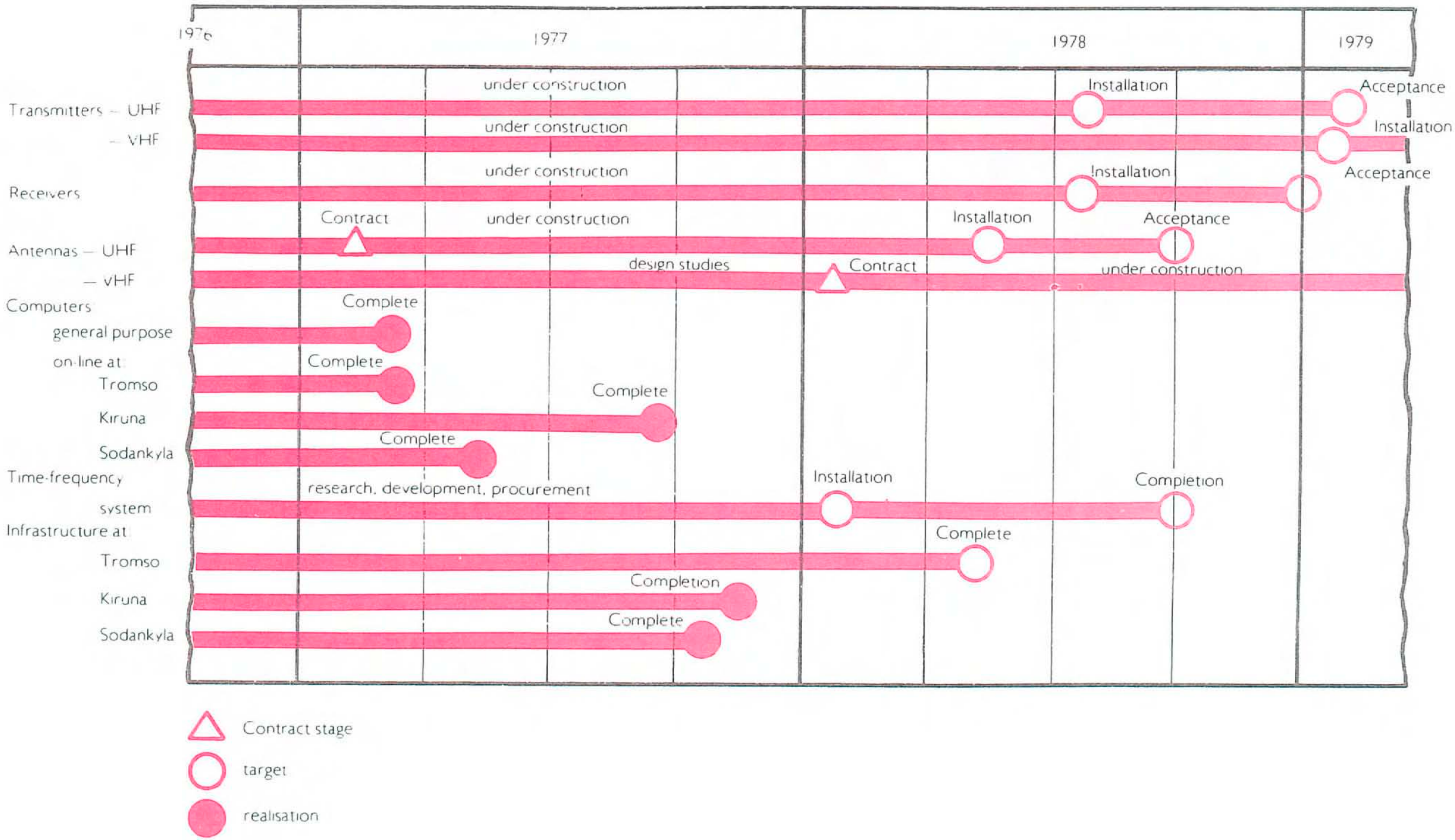
STAFFING
1977



TIMETABLE

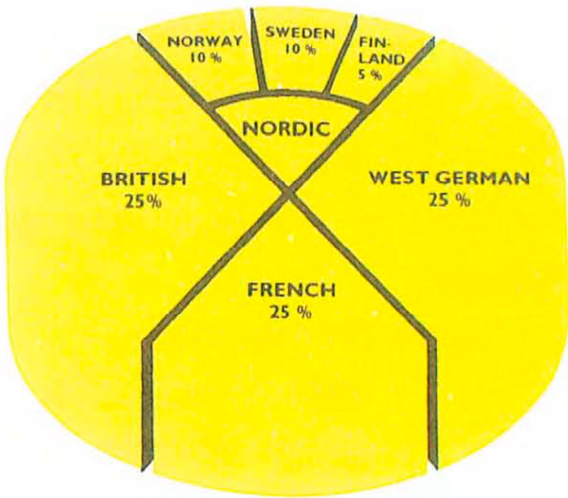


1976
1977
1978
1979
Transmitters — UHF
— VHF
Receivers
Antennas — UHF
— vHF
Computers
general purpose
on-line at:
Tromso
Kiruna
Sodankyla
Time-frequency
system
Infrastructure at:
Tromso
Kiruna
Sodankyla
under construction
under construction
under construction
under construction
Installation
Acceptance
Installation
Installation
Acceptance
Contract
Installation
Acceptance
design studies
Contract
under construction
Complete
Complete
Complete
Complete
research, development, procurement
Installation
Completion
Complete
Completion
Complete
Contract stage
target
realisation

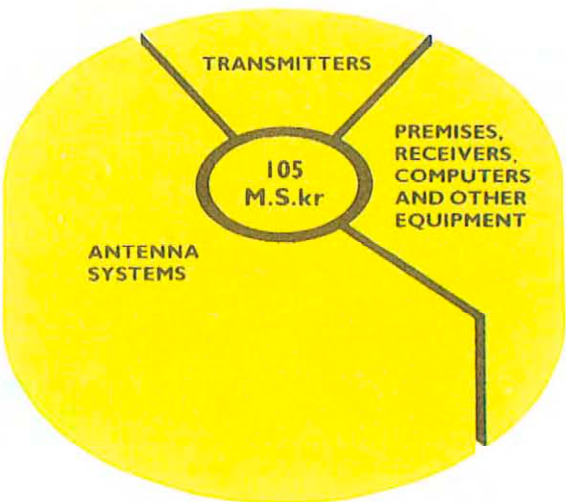
FINANCE AND ACCOUNTS

The investment programme, adjusted for inflation and devaluations, now exceeds 100 million Swedish crowns, of which 33 million in cash and 6 million in kind have so far been allocated.

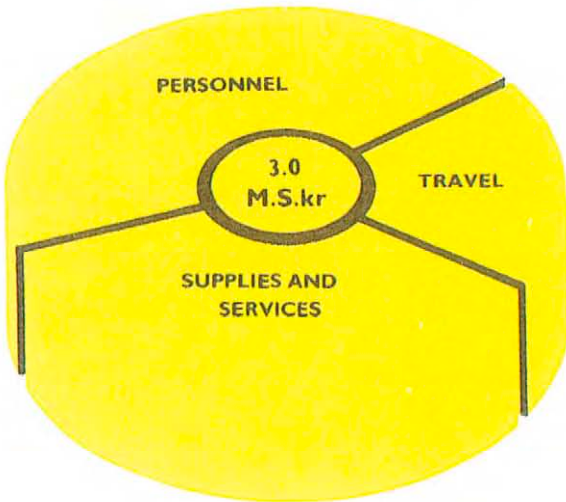
Operating costs in the year, although up on 1976, were still less than half of the figure eventually expected when in full operation.



SOURCES



INVESTMENT



OPERATING COSTS, 1977

BALANCE SHEET, 31 DECEMBER, 1977

(thousands of Swedish crowns)

		1977		1976
Liabilities				
Associates: contributions		34,832		7,779
general reserve		1,823		98
special reserve		9,468		10,186
contingency provisions		737		74
		46,860		18,137
represented by:				
Assets				
Fixed: premises		1,524		19
transmitters (under constr.)		13,449		5,589
antennae (under constr.)		12,796		-
receivers		423		-
frequency/time system		194		-
data processing system		638		219
motor vehicles		99		79
ancillary equipment and furniture		71		44
		29,194		5,950
Current: debtors	1,598		321	
cash	6,600		1,521	
reserve account	9,468		10,186	
miscellaneous	-		159	
		17,666		12,187
		46,860		18,137

Note (1): Fixed Assets are shown "at cost" pending agreement on the depreciation policy to be applied.

(2): "In Kind" expenditure by Nordic Associates is only included to the extent that fixed assets have been formally handed over as contributions to EISCAT.

Photograph, front cower:
Torbjörn Lövgren
Print: Kiruna Tryck Kiruna 10.78

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