MICROWAVE ACTIVITIES FOR SATELLITE COMMUNICATION IN SWEDEN

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ABSTRACT

Microwave activities for Satellite Communication in Sweden started in 1965 with the development of a complete experimental 4-6 GHz all solid state transponder designated for the ninth flight of the Eldo launcher. This was a very ambitious entrance into a market where the Swedish contribution has never exceeded 1 % of the world s total expenditure.

Our contribution in the last few years has been aimed mainly at four areas.

- Propagation experiments in the 11-14 GHz band (OTS)
- Maritime and mobile communication
- TV broadcast
- Telemetry and telecommand antennas

This paper briefly reports on microwave technology specifically developed within the context of the areas mentioned above and also some results from related studies and experiments.

INTRODUCTION

Restricted national funding has imposed limitations in technology coverage as well as in the number of space active companies and institutions in Sweden. The bulk of the microwave development work is done by L M Ericsson. Important research programmes have been carried out by Chalmers University of Technology, The Swedish National Defence Research Institute, The Swedish Telecommunication Administration and The Microwave Institute Foundation. The Swedish space microwave community is thus very limited.

Since 1970 when the first Swedish transponder made a very short trip in space, flight hardware development has been restricted to subsystems and components. A Nordic broadcasting satellite and a Swedish scientific satellite are being discussed but, until they become a reality, we are concentrating our hardware work on the ground segment and selected components in the space segment, e g antennas and oscillators.

PROPAGATION EXPERIMENTS

Radiometric measurements at 11 and 14 GHz have been conducted since 1972 by the Swedish Telecommunication Administration in Stockholm. The launch of the Orbital Test Satellite, 1977, enabled correlation with transmission measurements and allowed observations on depolarization due to rainfall.

All the Nordic Telecommunication Administrantions are cooperating in the OTS propagation experiment. The results are of greatest importance for confident design of satellite services in the 11-14 GHz band.

The Nordic area is a very large region with substantial variation in propagation conditions. Elevation angles range from 5 to 30 degrees and the precipitation statistics show very large variations. Test results show that for instance in Stockholm one can expect more than 2 dB rain attenuation a few hours per year but more than 5 dB attenuation due to snow accumulation on the antenna!

The ground stations used in these experiments are designed for high measurement accuracy (0.1 dB). They include a transmitter as well as a receiver and can easily be converted to carry narrow band traffic. Almost identical stations are operated by administrations in Switzerland, Austria and the Republic of Eire. The present propagation experiment can easily be modified to include a data transmission experimental network and make further use of the extended lifetime of the satellite. This possibility is at present being investigated.

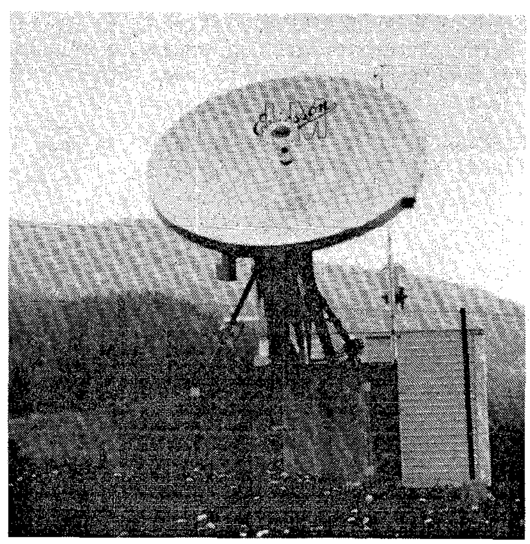
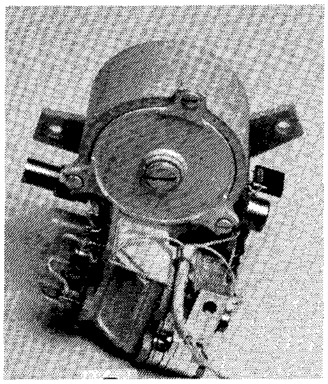


Fig 1 - An OTS ground station.

OTS carries a Swedish Beacon generator for down-link propagation measurements. This generator is a cavity stabilized impatt oscillator. The initial frequency setting was made at launch in March 1977. Maximum relative frequency drift measured so far is $3 \cdot 10^{-5}$. This stability is achieved thanks to a very thorough and costly development. Numerous processes in connection with invar and vacuum technology are space qualified. The frequency change corresponds to a dimensional change of about 10^{-4} mm or a gas pressure difference between the outside and inside of the cavity of about 1 mm Hg.



Silver plated invar cavity

Silicon impatt diode amplifier

Stability: 10^{-5}

FM-noise: 1 Hz/Hz

Mass: 200 g

Fig 2 - Beacon Generator

MARITIME AND MOBILE COMMUNICATION

The European Marecs satellites will be part of the first international maritime satellite communication system Inmarsat. The system concept adopted calls for extreme requirements on the local oscillator subsystem with respect to long term frequency stability, noise close to carriers and spurious suppression. The physical realization includes most of the classical microwave techniques.

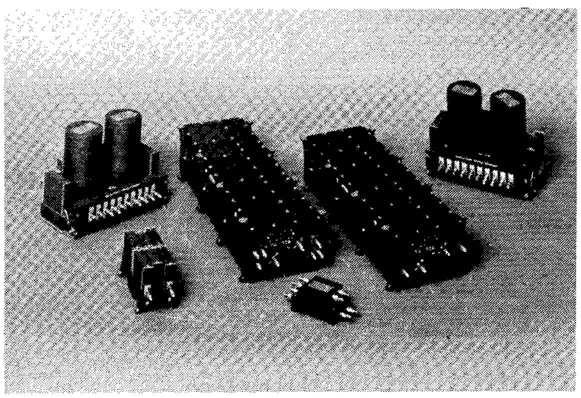


Fig 3 - Marecs local oscilator system

Frequencies: 60, 280, 300, 320, 1280, 1440, 3840, 6000 MHz

Stability: 10^{-6} (7 years)

Mass: 11.4 kg

Multiple beam satellite systems are feasible and very promising for future mobile services. This has been demonstrated within the payload development program, MAM, the Multibeam Array Model. This system is of a planar phased array type, where beamforming is performed at IF and where power amplification is performed at RF before the antenna elements. The integrated system has been tested and the performance was very close to predictions.

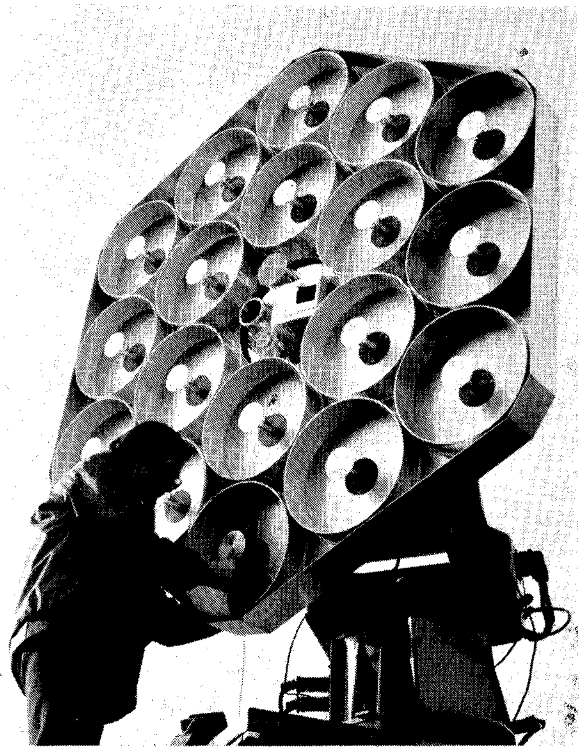


Fig 4 - Multibeam Array Model

19 beams
18 elements
23 dB gain

The improved system performance can either be capitilized via cheaper mobile terminals or via higher satellite capacity. (MAM is more thoroughly presented at ICC 80).

CHALMANT (CHAlmers L-band Maritime ANTenna) is a phased array ship terminal antenna which has been successfully tested onboard a small Swedish Navy vessel. The main idea is that the antenna is roughly directed towards the satellite and that the beam is then locked to the satellite by electronic tracking in two dimensions.

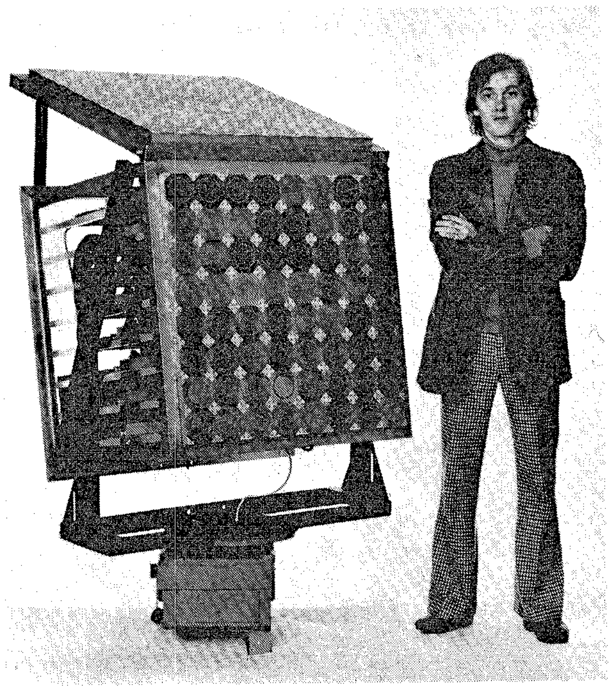


Fig 5 - Chalmant front view

TV BROADCASTING

TV Broadcasting is of potential interest for the Nordic countries due to their demographic unity and close cultural relations. Two official reports concerning a Nordic TVBS - Nordsat - have been published on behalf of the Nordic Minister Council.

Swedish microwave industry has participated in these studies and carried out system studies and design of the antenna sub-system.

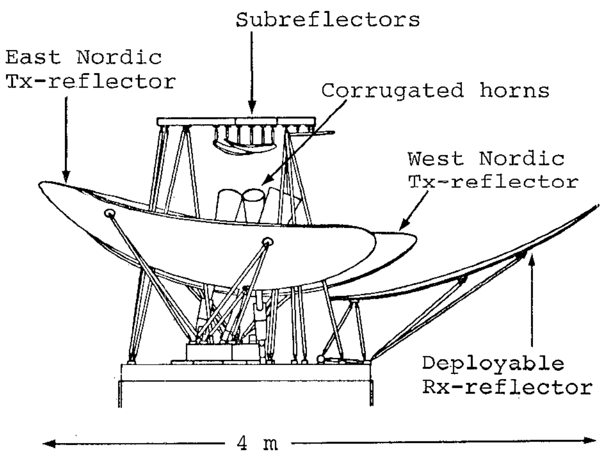


Fig 6 - Proposed Nordsat antenna

This very advanced satellite will require a total available power of about 4 to 9 kW, depending on the mission requirements. This might be compared to the 1.2 kW required by Intelsat V. The antenna system shall illuminate two regions, one western and one eastern Nordic service area both with elliptical beams approximately $1.8^{\circ} \times 0.8^{\circ}$. Thirteen TV-channels will be transmitted to the Nordic countries, eight to the eastern zone and five to the western zone.

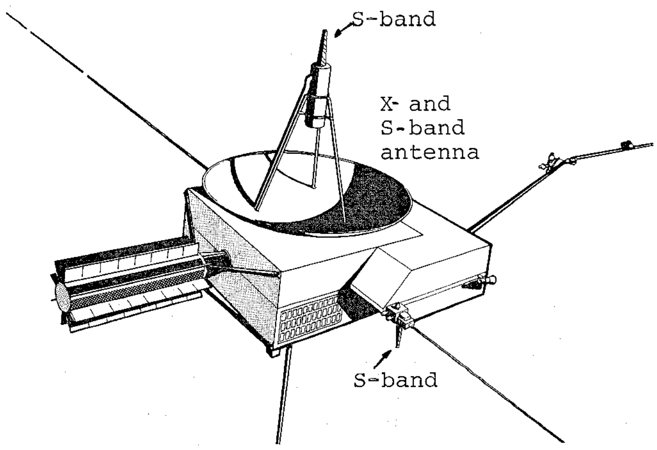
To be able to meet the very stringent requirements on the pointing accuracy the antenna subsystem includes an RF sensing equipment. This equipment measures very accurately the pointing error to a beacon signal transmitted from a control station located within the service area.

An operational Nordsat system will require at least three satellites in orbit (two active and one spare). The number of satellites required during a period of 14 years will be six to eight.

In many respects the Nordsat system including space segments, control and up-link stations, home and community receivers is a challenge to the Nordic microwave industry.

TT & C ANTENNAS

Most European scientific satellites are equipped with Swedish TT & C antennas. Geos, ISEE-B and Exosat and the future ISPM are examples of such satellites with TT & C communication on S-band and in some cases VHF and X-band.



ISPM Satellite
International Solar Polar Mission

Fig 7 - ISPM antenna system