I. BERNTSSON

OPERATIONAL EXPERIENCE OF A U.H.F NETWORK

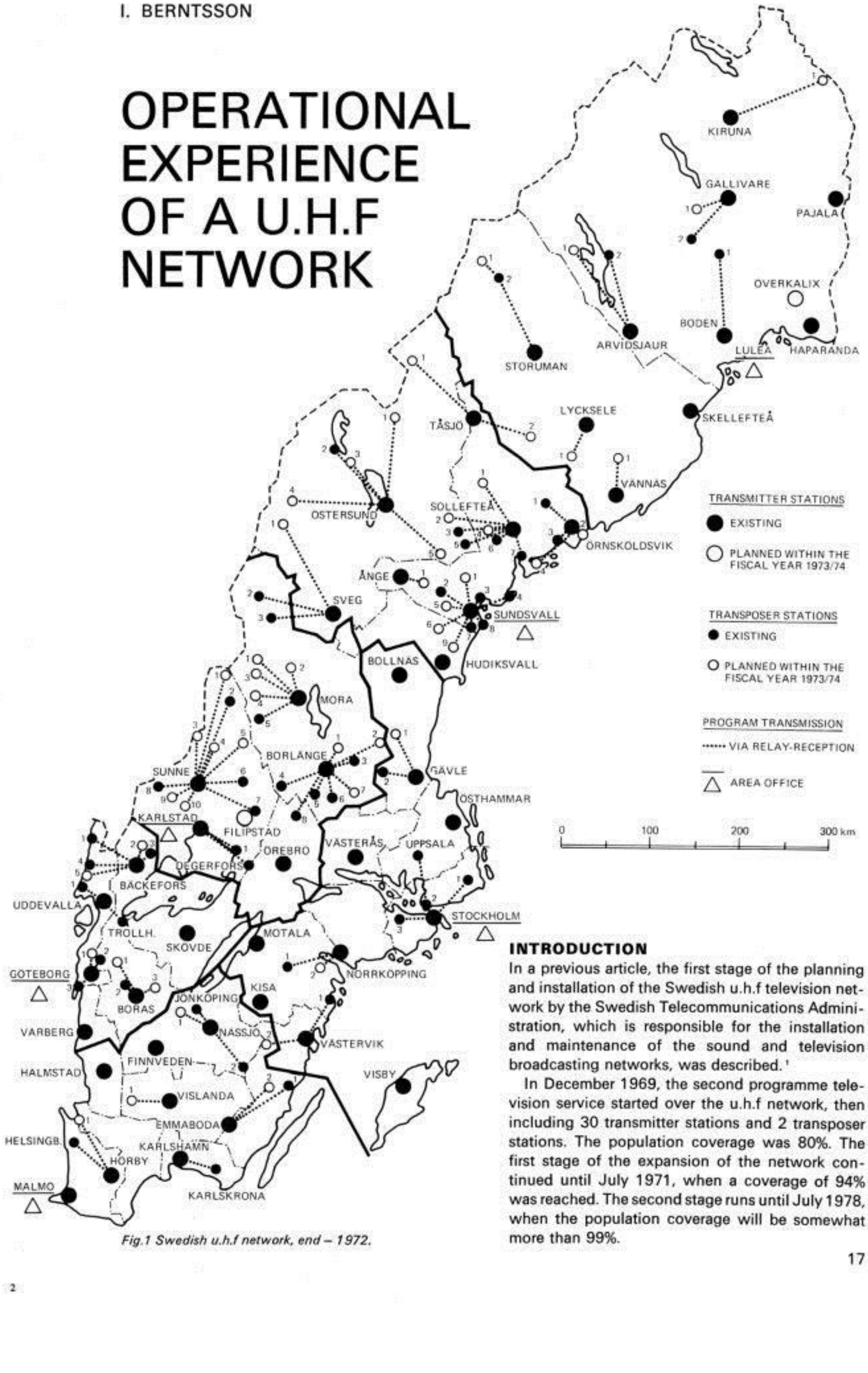

Fig.1 Swedish u.h.f network, end – 1972.

INTRODUCTION

In a previous article, the first stage of the planning and installation of the Swedish u.h.f television network by the Swedish Telecommunications Administration, which is responsible for the installation and maintenance of the sound and television broadcasting networks, was described.[1]

In December 1969, the second programme television service started over the u.h.f network, then including 30 transmitter stations and 2 transposer stations. The population coverage was 80%. The first stage of the expansion of the network continued until July 1971, when a coverage of 94% was reached. The second stage runs until July 1978, when the population coverage will be somewhat more than 99%.

PRESENT U.H.F NETWORK

By the end of 1972 47 u.h.f transmitter stations and 49 u.h.f transposer stations were in operation, as indicated in figure 1. The total operating time per year, including test chart and programme transmission, is 4,300 hours.

Tables 1 and 2 give information about the number of transmitters and transposers of each type, vision output power, type of amplifier valve and cooling system.

At present, most of the transmitter stations are operating without stand-by equipment and only eight of them are equipped with a stand-by transmitter, normally identical with the transmitter in operation. All the transposer stations are operating without stand-by equipment.

RELIABILITY

Reliability is defined as the equipment reliability of the transmitters and transposers, only failures causing transmission interruption being considered.

TRANSMITTERS

When the first u.h.f transmitters were ordered, (in 1967), the contracts concerning klystron transmitters included a reliability clause, stating that the contractor should guarantee a certain failure rate.

During a specified time of investigation, normally starting after a running-in period of 2,000 operating hours, the failures have been closely examined by the Administration and reports have regularly been sent to the Contractor in question. With the guidance of these reports, the Contractor has modified the transmitters in order to improve the reliability. In all cases the guaranteed failure rates have been fulfilled at the end of the investigation period.

Figure 2 shows a mean time between failure (m.t.b.f) curve for the 40kW klystron transmitters equipped with one vision and one sound klystron. In the vision transmitter there is an intermediate amplifier valve. The curve includes the running-in period and exceeds the regular investigation period.

It may be of interest to know that the m.t.b.f of the present v.h.f television transmitters used in Sweden is about 170 hours with the dominating failure type being valve failure.

The failure rate (number of failures per 1,000 transmitter hours) for the individual parts of the 40kW klystron transmitters is listed in table 3. The figures are representative of the situation at the end of the investigation period.

Comments relevant to table 3 are:

The driver is fully solid-state, except for an intermediate amplifier valve, which is the source of some of the failures caused by drivers. Another failure source has been semiconductors.

The vision and sound output amplifiers include the klystron and the associated cooling system. Most of the failures have been caused by the klystron, including the cooling system. It has recently been established that a number of the klystron failures have been caused by faults in the transmitter power supply.

The failure rate tendency indicates an improved reliability of the klystron amplifiers and also that the life time of the sound klystrons is longer than that of the vision klystrons. (The relation between vision and sound output power is 10:1).

The main reasons of the high-tension supply unit failures have been transformer failures and flashover between conductors.

As indicated in table 1 the number of u.h.f tetrode transmitters is rather limited and consequently the total number of operating hours. A calculation of the failure rate of such transmitters therefore might be misleading, but the general tendency is that the tetrode transmitters are less reliable than the klystron transmitters, mainly due to the tetrode amplifiers.

TRANSPOSERS

As shown in table 2 there is a limited number of each transposer type and only more recently have rather large quantities of certain types been ordered. Therefore a reliability clause has been included in the contracts only for the transposers ordered recently.

Because of the limited number of operating hours

Table 1 *U.H.F transmitters in operation at the end of 1972*

Vision Output power kW	Number of transmitters	Type of output amplifier (Vision/Sound)	Cooling
40	46	Klystron/Klystron	Vapour
10	2	Klystron/Klystron	Vapour
10	2	Klystron/Klystron	Forced air
20	2	Tetrode/Tetrode	Vapour
5	4	Tetrode/Tetrode	Forced air

Table 2 *U.H.F Transposers in operation at the end of 1972*

Vision Output power W	Number of transmitters	Type of amplifier	Cooling
1000	11	Klystron	Forced air
200	8	TWT	Forced air
200	7	Triode + Tetrode	Forced air
50	7	TWT	Forced air
50	16	Triode	Forced air

Table 3 *Number of faults per 1,000 operating hours for klystron transmitters*

Part of transmitter	Number of faults per 1,000 hours
Driver	0·30
Vision output amplifier	0·23
Sound output amplifier	0·14
Diplexer	0·19
High tension supply unit	0·15
Power supply and control unit	0·11
Remainder	0·04
	1·16

per transposer type, calculations of the failure rates might be misleading. However, a tendency has been observed, that the reliability has generally been less than expected considering the solid-state design of the drivers and the modern technical standard in general. Especially has there been trouble during the starting sequence. As an exception to this general tendency, the 1,000W klystron transposers have proved acceptably reliable.

One of the reasons why the Swedish Telecommunications Administration has bought a number of different types of transposers is to determine the most reliable and economic amplifier arrangement. Because of the limited number of operating hours, it is at the present stage impossible to state a general and distinct opinion. (Concerning the 50W transposers, however, the triode amplifier valve seems to be the most favourable alternative.)

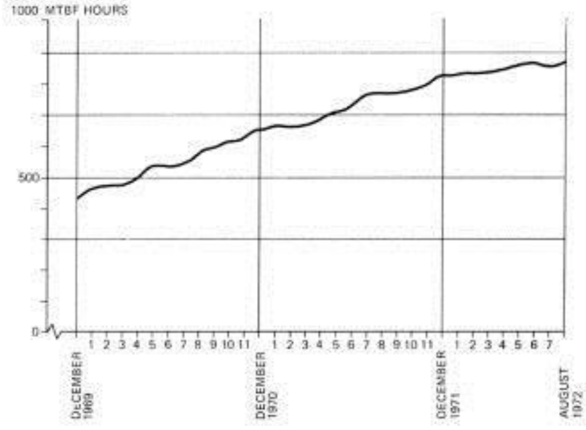

Fig.2 M.T.B.F for klystron transmitters.

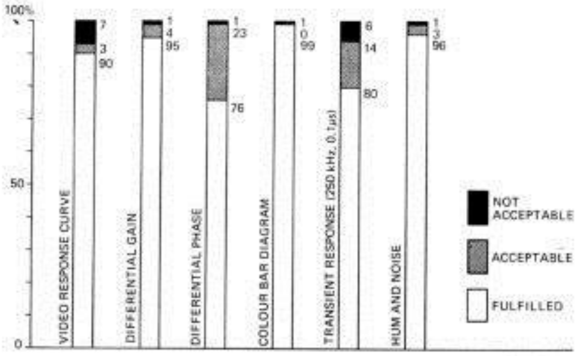

Fig.3 Vision klystron transmitters, performance test results.

PERFORMANCE STABILITY TRANSMITTERS

The performance of the t.v transmitters is checked regularly, with an interval of two months. For these tests, signals are generated at each individual station, and test results displayed on an oscilloscope and also photographed.

The following vision transmitter tests are carried out:

Overall frequency response
Transient response (250kHz)
Differential gain
Differential phase
Colour bar vector diagram
Hum and noise

The test values may deviate somewhat from those guaranteed by the Contractor concerned before a transmitter adjustment is considered to be necessary. Three different grades of test value are used for checking purposes:

Fulfilled, i.e the test value is within the tolerances specified in the contract
Acceptable, i.e no action has to be taken
Not acceptable, i.e some kind of action has to be taken
Table 4 lists the test signal limits.

The diagram in figure 3 indicates the result of regular tests carried out on the 40kW klystron transmitters over a period of one year.

About 70% of the klystron transmitters operate with i.f modulation, the rest with r.f modulation. No difference has been noted between the two modulation methods concerning performance stability and reliability.

With respect to modulation methods, video corrections may be carried out in three different ways;

Table 4 *Tolerances for performance tests of t.v transmitters*

Performance tests	Tolerances					
	Fulfilled		Acceptable		Not Acceptable	
	MHz	%	MHz	%	MHz	%
Video response curve	1 ref	100	1 ref	100	1 ref	100
	2	112–89	2	112–85	2	> 112, < 85
	3	112–84	3	112–80	3	> 112, < 80
	4	105–80	4	105–75	4	> 105, < 75
	4·43	100–75	4·43	100–70	4·43	> 100, < 70
Differential gain	≤ 10%		> 10% ≤ 20%		> 20%	
Differential phase	≤ ± 3°		> ± 3° ≤ ± 6°		> ± 6°	
Colour Bar Vector Diagram	Corresponds to the differential gain and phase tolerances					
Transient response	Standard graticule is used					
Hum and noise	≤ 1%		> 1% ≤ 1·5%		> 1·5%	

Fig.4 Transposer station in winter with maintenance staff transportation vehicle.

fully on video, fully on i.f, or a combination of these two methods. The choice of video correction method has no influence on the possibility of adjusting vision transmitters in order to fulfil guaranteed performance data.

Even though the operational experience of the use of u.h.f tetrode transmitters in Sweden is rather limited, it is evident that the performance stability of this transmitter type is much less than that of klystron transmitters. It is also more difficult to adjust tetrode transmitters in order to fulfil guaranteed performance data.

The performance of the sound transmitters is checked regularly, twice a year. Their stability is very good.

TRANSPOSERS

The performance of the u.h.f transposers is normally checked in connection with some fault correction, e.g. valve replacement. The performance test includes:

- R.F frequency response
- Intermodulation
- Linearity

At present the performance stability generally is very close to what has been estimated.

MAINTENANCE

As far as maintenance is concerned, Sweden is divided into six areas, as indicated in figure 1.

The transmitter stations are staffed during tele-

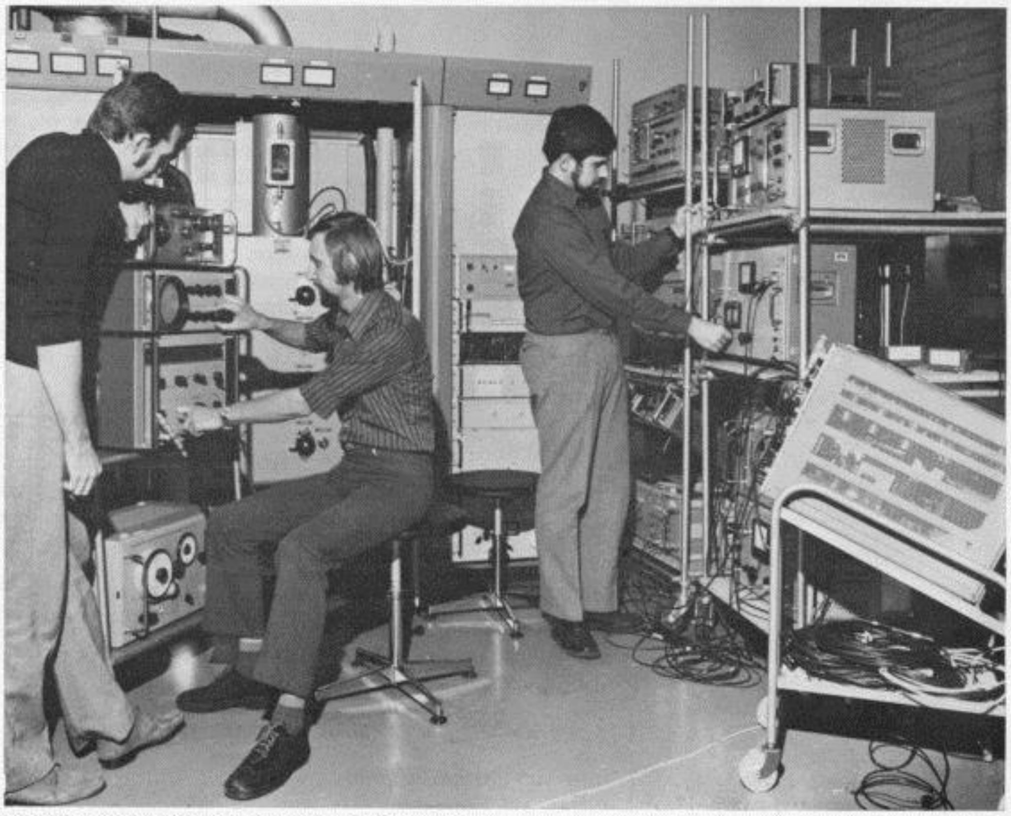

Fig.5 Transmitter station, test set-up for transmitter overhaul.

vision transmission hours. The transposer stations are completely unstaffed.

Considering the high reliability standard of the the two Swedish t.v networks, measures have been taken to destaff the transmitter stations during the late hours of the night. This has been done by connecting the t.v transmitters to an existing remote control and supervision system which has been established for the f.m sound broadcasting transmitters placed in the same station buildings.

Most of the fault correction work, as well as the performance tests, are carried out by the staff of the individual transmitter stations. More complicated faults, as well as overhauls (twice a year) are handled by specialists from the area offices.

Stations without a stand-by transmitter are equipped with spare modules (frequency-conscious units), with other spare modules and components kept in a central store.

The staff of a transmitter station is normally responsible also for the maintenance of the adjacent transposer stations but, to repair complicated faults and to overhaul the transposers, specialists from the area office are normally called in. Transposer spare parts normally are stored within each area.

The module design of the solid-state drivers of u.h.f transmitters and transposers made it possible to repair faulty modules at a central workshop and therefore such a routine was introduced. The intention was to put the repaired modules into service without or with only minor adjustments. Because of a too high interaction between different modules, however, it has generally proved impossible to fulfil this intention. As a rule, more extensive adjustments, with the use of advanced test equipment, have been necessary.

To make it possible for the users to take full advantage of the module design, the manufacturers should pay special attention to problems in connection with the replacement of modules aiming at a minimum of adjustments and the use of simple measuring equipment.

REFERENCE

1 S. E. Soderstrom: A U.H.F Network For The Swedish Second Television Programme, Sound and Vision broadcasting, Vol.12, No.1, Spring 1971.