WEST GERMAN MICROWAVE ACTIVITY - STATE OF THE ART IN SATELLITE COMMUNICATIONS

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Summary

The paper deals with the West German contributions to the growing field of microwave technology with special emphasis on satcom applications. After briefly reviewing the historical development, the earth stations and some new satellite systems are described in more details. Research and development activities in industry and governmental laboratories conclude the overview.

History

West German Satellite Communications really began after the first German earth station at Raisting became operational in June 1965 and made contact with the North American earth stations at either Andover (USA) or Mill Village (CA) via Intelsat I, formerly called Early Bird. This first geostationary communications satellite was able to perform only a point-to-point radio link, therefore the European earth stations at Goonhilly (GB), Pleumeur-Bodou (F), Raisting (D) and Fucino (I) had to alternate over a period of several weeks, providing the first satcom traffic in the North Atlantic region using the allocated frequency band of 4/6 GHz /1/.

Further developments were made in the following stages - 1967: contract for the development of the French-German communication satellite project "SYMPHONIE"; 1969: switch-on of the next earth station Raisting 2 and launching of the first German national space program research satellite "AZUR";197o/71:completion of the German ground control centers for space TTC & M (Tracking, Telemetry Command and Monitoring)GCC (German Control Center) in Oberpfaffenhofen and Z-DBS (Zentrale-Deutsches Bodenstations-System) in Weilheim; 1972: switch-on of Raisting 3; 1973: first operation of the research earth stations Raisting-SYMPHONIE for satellite communications and Leeheim 1 for radio propagation at frequencies above 1o GHz; 1974/75: launching of the French-German experimental satellite "SYMPHONIE 1 and 2" and of the US American-German scientific satellite HELIOS A for sun research and finally the establishing of another TTC & M-earth station at Rehbach for GEOS and METEOSAT experiments; 1976: launching of the second sun-research-satellite HELIOS B and of the ESA-Satellite GEOS; 1977: launching of the metereological satellite METEOSAT and foundation of EUTELSAT; 1978: the preoperational model OTS of a European communications satellite for testing the new frequency bands at 11/14 GHz was launched and a second location for communications with earth stations in Germany was opened with the switch-on of the first 11/14 GHz-station Usingen 1 /2/.

In the spring of 198o standard telephone traffic and TV-exchange are preformed by the PTT-earth stations Raisting 1, 2 and 3 via the three Intelsat IV A (Flight 1, 4 and 6) to 41 other earth stations throughout the world.

Earth Stations

Whereas the space segment in a satcom system has to distribute communication traffic over an intercontinental or a regional area, normally today in a multiple access mode, the purpose of the earth station is to connect the satellite transponder with the national terrestrial network. There are two places in West Germany which have been found to suit the conditions for microwave satcom ground stations. One is situated near Raisting, about 5o km SW from Munich and the other is near Usingen, about 3o km NW from Frankfurt. Because every satellite needs its own ground antenna with the accompanying up-link transmitter and down-link receiver, several earth stations have been built in the meantime in Raisting. Two further stations Raisting 4 and 5 are in the progress of being built. All the Raisting stations are equipped for up-link frequencies of 5.925 - 6.425 GHz and for down-link frequencies of 3.7 - 4.2 GHz. Up till now all radio links from Raisting 1 with Intelsat IV A (Indian Ocean) and from Raisting 2 and 3 with two Intelsat IV A (Atlantic) have been accomplished through Frequency Modulation/Frequency Domain Multiplexing/Frequency Division Multiple Access (FM/FDM/FDMA). On the other hand however , the new earth station center in Usingen will be able to work above 1o GHz and this means up-links of 14.o - 14.5 GHz and down-links of 1o.95 - 11.7 GHz. The first station Usingen 1, which is today used in transmission experiments with the European Orbital Test Satellite (OTS), can operate as well in the above mentioned FM/FDM/FDMA mode, as also in the future system of Pulse Code Modulation /Phase Shift Keying/Time Division Multiple Access (PCM/PSK/TDMA). In addition, the antenna reflector and feeder are designed for dual polarization mode operation, enabling the use of the same 11/14 GHz frequency band twice (frequency re-use). The new stations Raisting 4 and 5 are being constructed by the main contractor Siemens AG. The station Usingen 1 was built by the main contractor AEG-Telefunken and has already been handed over to the Deutsche Bundespost (PTT). The microwave performance of the above mentioned stations are summarized in Table 1. Raisting 5 and Usingen 1 are both being considered for operation with Intelsat V because of its double satcom bands capability.

In 1982, it is the German PTT's intention to use 1o earth stations, which fulfil the Intelsat specifications for large stations of type A and C. Apart from these two centers for telephone- and TV-traffic, earth stations in West Germany have also been established for TTC & M purposes in Weilheim and Oberpfaffenhofen under the management of the Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt (DFVLR) and in Leeheim for propagation test measurements purposes, under the management of the PTT.

European and National Space Projects

Since 197o, European space programs for different satcom systems have been defined and developed. The first experimental space craft OTS (Orbital Test Satellite) for above-1o GHz-propagation and for communications experiments was launched in May 1978 and has

since then been successfully operated by the European Space Agency (ESA), which represents 11 member states. The main feature of the European satellite program is the modular concept which enables the ESA to combine subsystems for various parts and to produce these independently at the same time in different places. The next satellite, scheduled for 1981, is called ECS (European Communication Satellite) and is planned for commercial use. Its capacity will be about 12ooo telephone channels and two additional channels for TV-exchange. It should link, at 11/14 GHz, 25 stations which are at distances ≥ 8oo km apart in Europe and the nearby non-European Mediterranean region. The main contractor for ESA is the British Aerospace Dynamic, who are responsible for the development and construction of OTS and ECS. The communications payload of ECS is being built in Germany on subcontract by AEG-Telefunken. Another application of the European modular system is the maritime version, MARECS, which will supply communications between merchant shipping in the Atlantic region and fixed stations on land. It operates, unlike ECS and OTS, in the 4/6 GHz and 1.5/1.6 GHz-bands.

One of the most exciting projects at the moment in Europe is a satellite-borne broadcasting system, in particular for TV supply to the individual home receivers (TV-SAT). In contrast to the more political discussions of whether or not, and which countries should be supplied by the same satellite (eg. a German-Italian TVSAT, a Scandinavian NORDSAT etc.), the technical concept and its required components have already been developed.

The main features of these national TV projects are the following:

I. modular system for easy manufacturing and integration,

II. narrow beam width (less than 1^{o}) of the satellite transmitter antenna because of the small illumination area of most European countries,

III. high steering accuracy of $< o.1^{o}$ for the beam axis, which requires a control of angles and attitude by RF-sensors and a 3-axis stabilization,

IV. providing a homogeneous 12 GHz-power-density of -1o3 dBW/m^2 to enable low cost home reception (6 dB/K minimum value),

V. establishing a high power efficient 12 GHz-transmitter in the TVSAT, which means a TWT amplifier of some hundred Watts.

At the World Administrative Radio Conference 1977 (WARC 77), the frequency band for TV satellite broadcasting in Europe had been allocated at 11.7 -12.5 GHz (down-link). This 8oo MHz wide band is divided into 4o TV-channels (27 MHz bandwidth) and each nation is allowed to use 5 out of the 4o channels. The 5 channels for each nation are arranged in a 4oo MHz-wide band to reduce the costs of the home receiver front-end. Allocation of the up-link frequencies within the 17 - 23 GHz region are still being discussed, however the RF-beacon should be near (approximately 4oo - 8oo MHz) to the down-link frequency band.

It is possible that a German TVSAT, as a first preoperational model, could be launched in the next 2 to 3 years.
Figure 1 shows two European satellites in comparison for size and performance.

STATION	RAI1	RAI2	RAI3	RAI4	RAI5	USI1
DOWN – LINK : EARTH STATION RECEIVER						
FREQUENCY	4 GHz	4 GHz	4 GHz	4 GHz	4 GHz	11 GHz
GAIN	58.4 dB	59.7 dB	59.7 dB	60.9 dB	60.9 dB	64.4 dB
BEAM WIDTH	0.2°	0.17°	0.17°	0.14°	0.14°	0.09°
POLARIZATION	cir / lin	cir	cir	cir	cir	lin
G / T	40.7 dB/K	42.2 dB/K	42.2 dB/K	41.6 dB/K	41.6 dB/K	40.8 dB/K
UP – LINK : EARTH STATION TRANSMITTER						
FREQUENCY	6 GHz	6 GHz	6 GHz	6 GHz	6 GHz	14 GHz
GAIN	61.5 dB	63.4 dB	63.4 dB	65.5 dB	65.5 dB	66.2 dB
BEAM WIDTH	0.13°	0.11°	0.11°	0.09°	0.09°	0.07°
POLARIZATION	cir / lin	cir	cir	cir	cir	lin
TX-POWER	1×TWT: 2kW 1×TWT: 3kW	3×TWT: 3kW	4×TWT: 3kW	6×TWT: 1kW 2×TWT: 0.6kW	4×TWT: 1kW	3×TWT: 2kW
SATCOM Frequencies:	4 ≙ 3.70 - 4.2 GHz 11 ≙ 10.95 - 11.2 GHz, 11.45 - 11.7 GHz				6 ≙ 5.925 - 6.425 GHz 14 ≙ 14.00 - 14.5 GHz	

Table 1 WEST GERMAN EARTH STATION FOR PTT SATCOM SERVICES
(Antenna gain, beam width and polarization, G/T and TX-power)

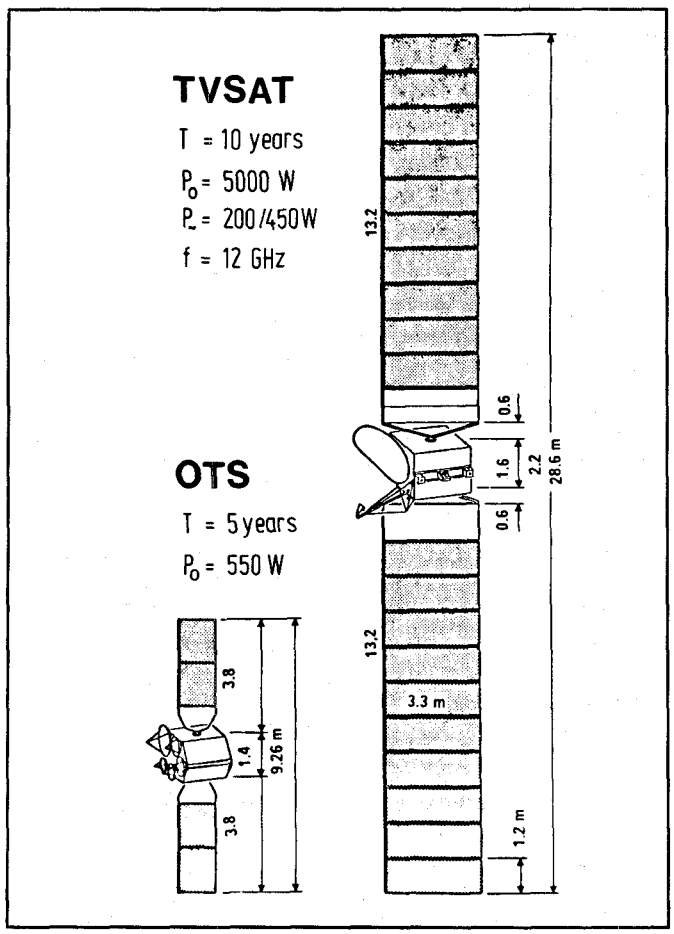

Fig. 1 Model of a national broadcasting satellite TVSAT compared to the regional point-to-point OTS /6/

Microwave Components and Systems for Space Technology and Background Research Activities

During the past two decades, research and development in German industry and in governmental and university laboratories have been stimulated considerably by the new challenge of microwave space applications. A key component in every broadband satcom system is the TWT amplifier in the transmitter stage. Earth station transmitter TWTs in the kilowatt range have been developed by Siemens AG /7/ for the up-link frequency-bands 6 GHz and 14 GHz /8/ as well as for future use at 30 GHz in the Ka-band /9/ and upper Q-band. Medium power (10 - 30 Watt) TWTs for satellite transponders have been built by AEG-Telefunken /10/ and are used at 4 GHz (SYMPHONIE, ANIK B) and 11 GHz (OTS, ECS planned). Further developments concern the TVSAT 12 GHz - 200/450 Watt TWT /11/ and future intersatellite transmitter use at 60 GHz /12/.

A low noise (140 K) PARAMP for 11 GHz and with a 1 dB-bandwidth of 770 MHz was recently reported by Niemeyer /13/ and parametric down-converters for 12 GHz-TV-receivers were investigated by Schau /14/. Small earth stations for mobile use, can be operated with uncooled PARAMPs at 4 GHz and 500 MHz-bandwidth and in a wide ($\pm$ 45° C) temperature range /15/. Developments and investigations in satellite tracking and in telemetry and telecommand problems have been performed by MBB and DFVLR. MBB is also engaged in satellite-borne antennas /16/.

In addition to these specialized space systems developments, there is a broad field of microwave activity in other branches of application, which may be itemized here by some examples: terrestrial radiolinks in analog and digital version up to 40 GHz, microwave ground transport identification and guiding, radar and collision avoidance techniques and navigational system for air-and sea traffic, giant power klystron accelerator, industrial and medical application of microwaves, mm-wave thermography, remote sensing and radioastronomy and finally research on semiconductor- and ferrite-material and related devices.

This background is supplied from microwave research and the education at twelve technical universities (TU). At present there are approximately 2000 young electrical engineers with a university degree, leaving the TU-educational system annually in West Germany. About 100 of them are fairly well qualified in microwave technology and associated fields. They feed the microwave community and are hopefully encouraged enough to accept the technological challenge of the next decade.

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