

# SAR ACTIVITIES AT DORNIER

by

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## ABSTRACT

Radar remote sensing from space was a key element in the German and the European Earth Observation Programmes for more than a decade now. From the beginning, Dornier-System was involved in these activities. It is the prime contractor of the major German and European space projects being concerned with radars. Supported by the German Ministry of Research and Technology (BMFT) and by the "Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt" (DFVLR) Dornier-System has developed important key technologies and extensive system design tools for many spaceborne radars with special emphasis on radars with synthetic aperture (SAR). This paper shows briefly the main space SAR activities in which Dornier was involved and indicates that these demanding programmes again need a creative engagement of innovative industries in future.

## 1. INTRODUCTION

Since that time, when NASA's SEASAT started the area of civil radar imagery from space, Germany initiated an intensive development programme for spaceborne radar instruments and their dedicated technologies. On behalf of the German Ministry of Research and Technology (BMFT) Dornier System has developed the German Microwave Remote Sensing Experiment (MRSE) to be flown on the first SPACELAB mission. This was the first civil radar in space, which has been developed outside the USA. As it happened to SEASAT, the MRSE did not survive the planned mission schedule indicating once again, that high power radar technology for space applications is one of the most critical elements in space radars.

After that, Dornier System overtook the prime contractorship for the first ESA Remote Sensing Satellite (ERS-1) focusing its technological investigations onto the radar subsystems High Power Amplifier (HPA), Synthetic Aperture Radar (SAR) Processing and SAR Antenna.

A growing interest of remote sensing users in multifrequency and multipolarization SAR imagery led to the German/Italian cooperation with NASA/JPL (Jet Propulsion Lab) on a multifrequency/multipolarization SAR facility (SIR-C/X-SAR) to be flown on Shuttle. Dornier System is leading the German/Italian part.

Furthermore, Dornier System is presently using the technological spin off of these space programmes for its development of an airborne dual frequency/dual polarization Synthetic Aperture Radar (DO-SAR), which can be flown on the Dornier-aircraft DO-228.

In parallel to these projects, Dornier System is continuously improving its software tools for design, analysis and simulation of space radars and its capabilities for development of new technologies (see fig. 1).

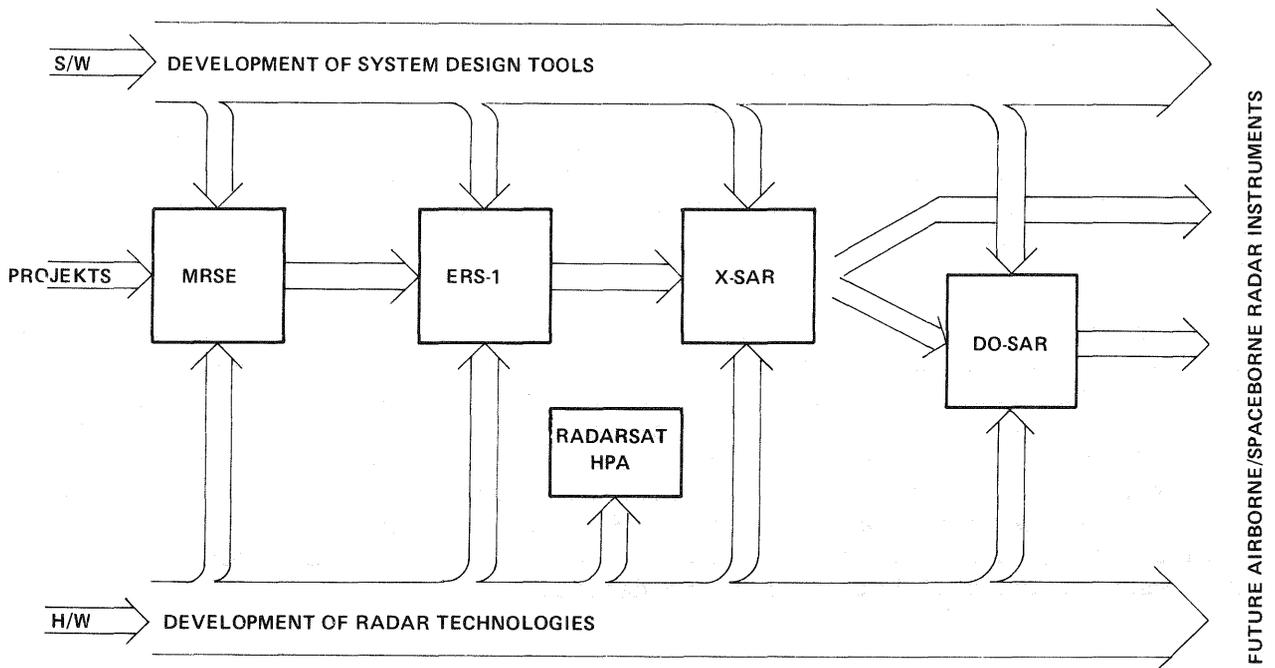


Fig. 1: Programme Overview

## 2. SAR SYSTEM DESIGN

In 1980 Dornier System conducted a study on a multifrequency/dual-polarization spaceborne SAR facility for the German Ministry for Research and Technology (BMFT). After some analysis work along traditional lines it was understood that a task of such proportions could only be coped with by large computer support. More so, as trade-offs between system options were part of the study goal.

Therefore, sets of radar equations and design assumptions were derived that eventually linked more than 100 parameters involved in system design. These may roughly be divided into:

- 1) those derived from user requirements,
- 2) those arising from the technical state-of-the-art and provisional WARC regulations,
- 3) consequential or output parameters of technical nature as subsystem design guide-lines and for final feasibility of user requirements.

A large computer program "SARA" was arranged to work in a synthesis rather than an analysis manner (knowledge based system, KBS). More specifically, after parameters of the first and second category are entered tentatively into the program a range of system solutions is offered by the computer. These are quickly evaluated by the scientific operator. From some kind of "orientation print-out" he has the choice of one or more solutions being nearest to the design goal.

Depending on the mutual compatibility of the initial input values usually two or more of the consequential parameters turned out to be unacceptable or sub-optimal. Typically this procedure had to be iterated twice in order to arrive at a quasi-final system layout. The whole trade-off job illuminating more than a dozen inherently feasible system solutions could be accomplished in about half an hour. Classical trade-off approaches need days in order to derive these results.

This short reaction time of our system synthesis computer program saves time for further system optimization. The system synthesis is followed by an extensive computer aided analysis procedure analysing in detail the performance of each radar subsystem taking all possible error contributions into consideration. Iterations of these analyses allow radar parameter fine tuning. After each system layout and especially after development of radar hardware, we use to improve the performance of our KBS "SARA" by implementing new know-how gained during these analysis and test phases and today we have reached a system synthesis accuracy of better than one decibel.

### 3. MAJOR PROJECTS

The first European spaceborne SAR developed at Dornier was the "Microwave Remote Sensing Experiment" (MRSE). This instrument was flown on the first SPACELAB mission in 1984. It was an X-band radar operating in three modes:

- a SAR mode
- a two frequency scatterometer mode
- a radiometer mode

As shown in figure 2, this instrument was characterized by a mechanically steerable 2 m x 1 m Cassegrain reflector antenna. After successful operation in radiometer and scatterometer mode a HPA failure stopped its operation on Shuttle. Back on Earth, the HPA was operating perfectly again. The problem in orbit had been created by an unexpected high air pressure within the Shuttle cargo bay during the SPACELAB mission.

After MRSE, under leadership of Dornier System on behalf of the European Space Agency, a large industrial team started the development of the first "ESA Remote Sensing Satellite" ERS-1 (see fig. 3). Its mission objectives concentrate on ocean and ice monitoring for scientific as well as for economic purposes. Planned to be launched in 1990, its core payload consists of the following two instruments. The Active Microwave Instrumentation (AMI) is a C-band radar combining a Synthetic Aperture Radar and a Microwave Scatterometer. The Radar Altimeter (RA) is a Ku-band pulse limited altimeter. In line with Dornier's development strategy, Dornier is responsible for the development of the most critical SAR subsystems High Power Amplifier and SAR Antenna.

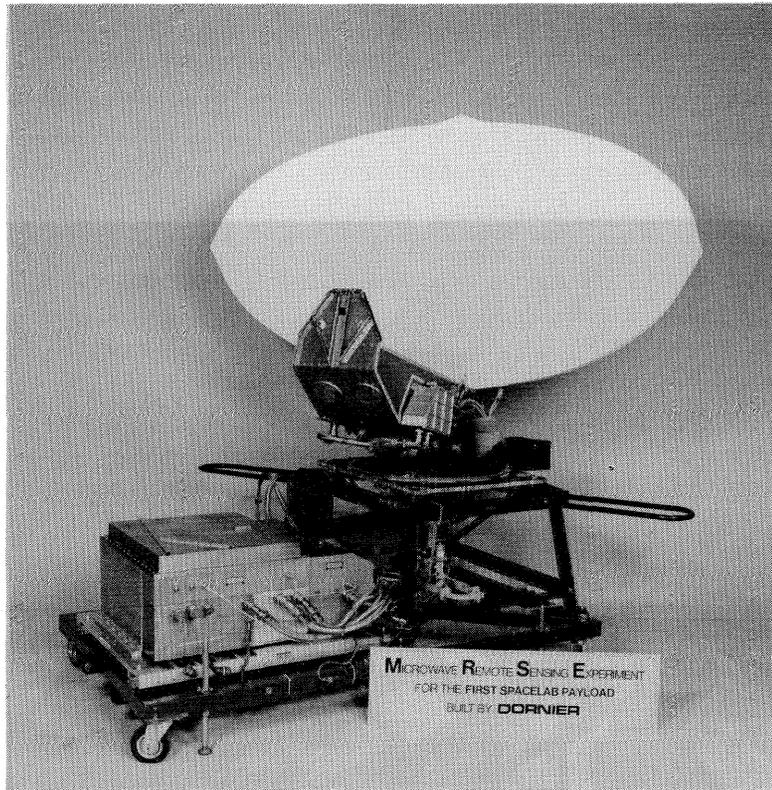


Fig. 2: Microwave Remote Sensing Experiment

In parallel to the ERS-1, Dornier-System started the development of the X-SAR on behalf of the BMFT. The X-SAR (shown in fig. 4) is an "X-Band Synthetic Aperture Radar" planned to be flown in a joint mission with NASA's Shuttle Imaging Radar (SIR-C) which is designed for L- and C-band measurements. The first flight of X-SAR is aimed to be in 1991. Simultaneous observations of ground areas with 3 frequencies (L-band and C-band: SIR-C, and X-band: X-SAR) will provide experimenters radar images with different signatures from the same target scene. Thus, the joint X-SAR/SIR-C experiment will be a new step towards multispectral/dual-polarization SAR measurements from space. The X-SAR is developed in cooperation between Italy and Germany. Italy provides the RF-part and the electrical antenna design. Germany, the system architect, develops the High Power Amplifier, the 12 m long slotted waveguide array antenna made from carbon fibre reinforced plastics, and the onboard data handling. Last but not least, Dornier is developing a realtime SAR processor, which will be located on ground and will provide a quick overview over the amount and the quality of data being collected by the SAR.

#### 4. KEY TECHNOLOGIES

The development of new technologies for spaceborne radar systems is a real challenge for industry. The main areas of involvement of Dornier-System are

- SAR antennas,
- high power amplifiers,
- and realtime SAR processing.

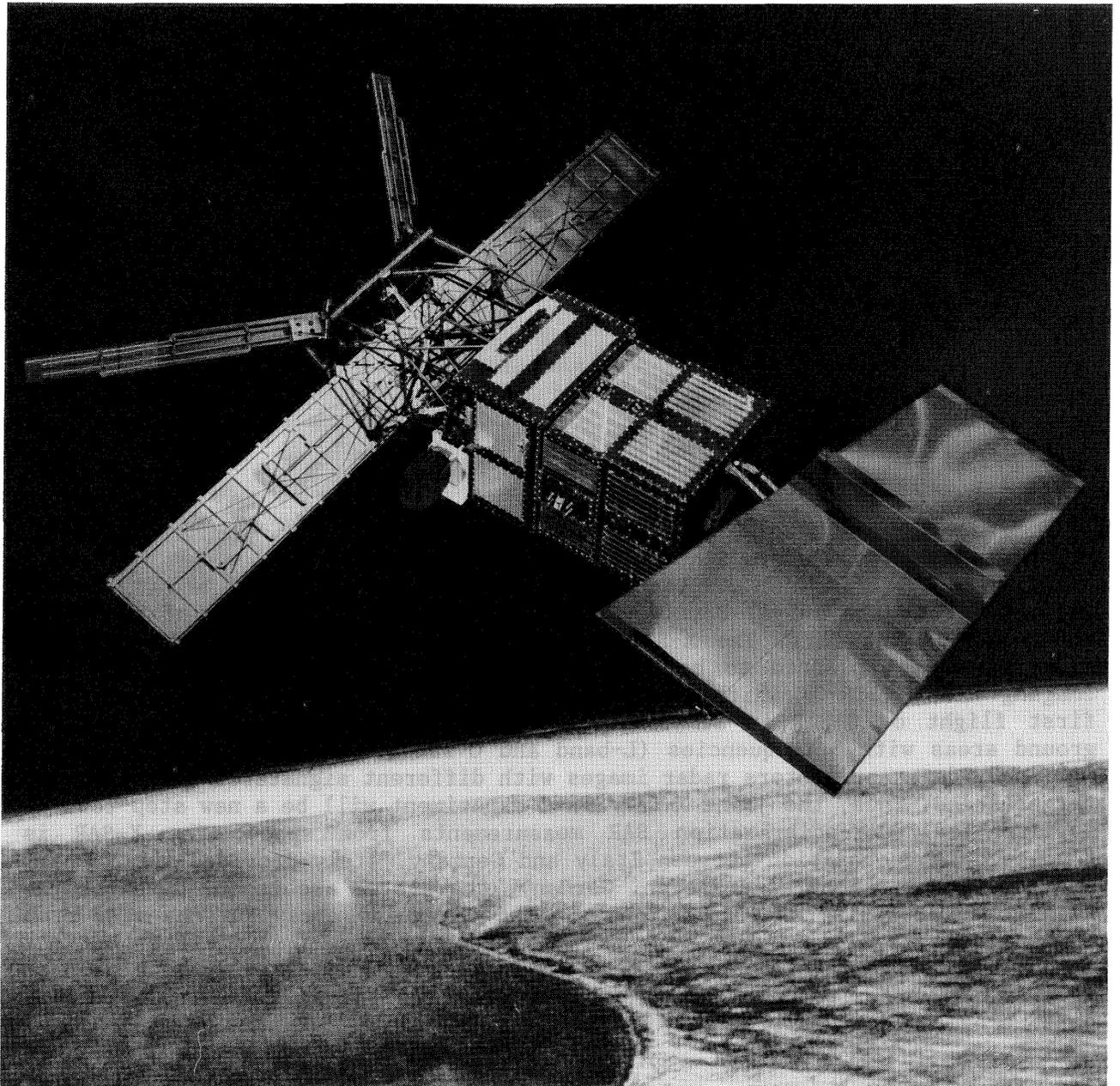


Fig. 3: ESA Remote Sensing Satellite, ERS-1

# Joint Mission with Shuttle Imaging Radar

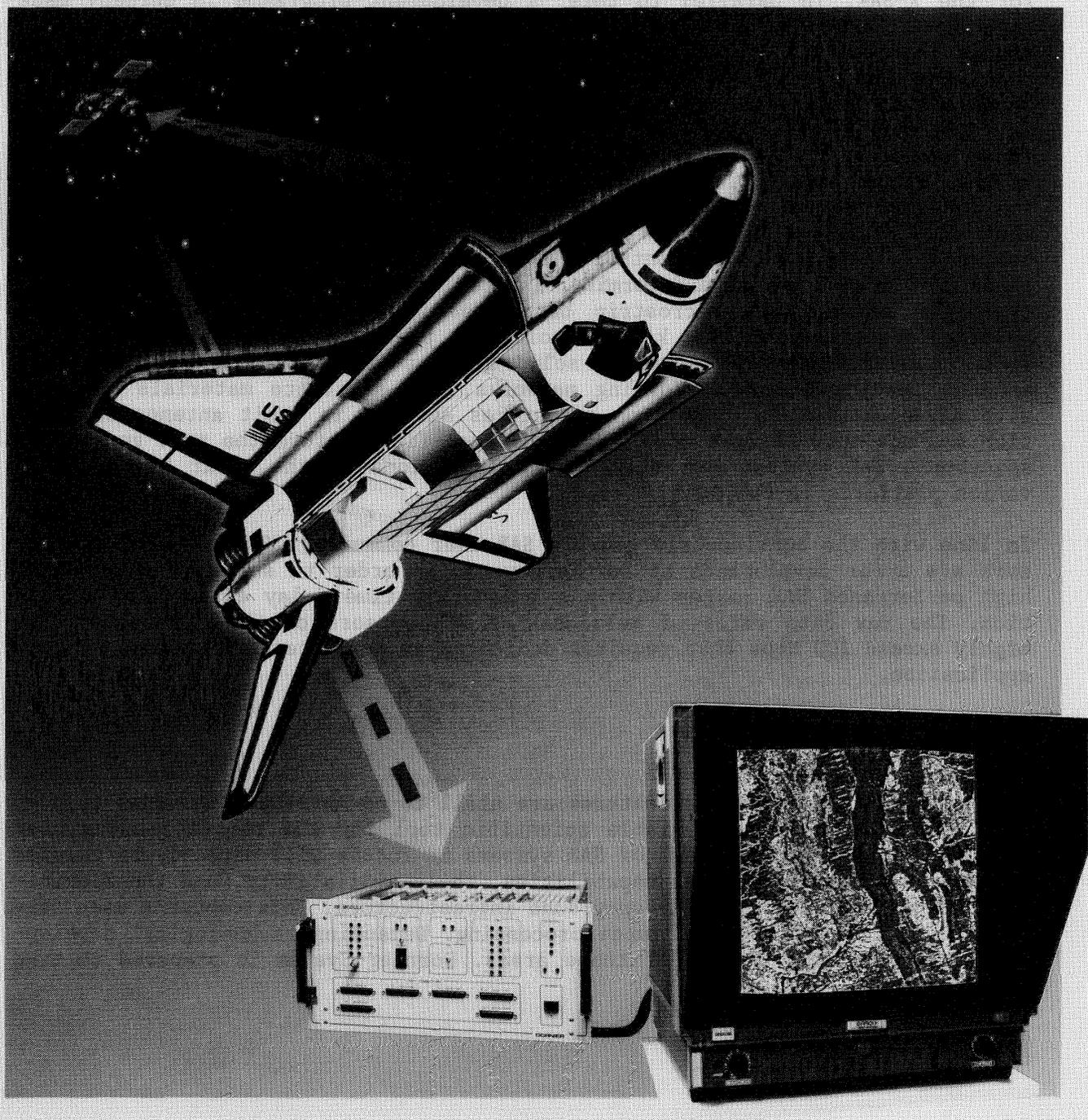


Fig. 4: X-Band Synthetic Aperture Radar, X-SAR

In 1978, Dornier-System initiated the technological research on slotted waveguide array SAR antennas made from carbon fibre reinforced plastics due to the need for large lightweight array antennas with extremely high stiffness and thermal stability. This antenna technology is used today for the ERS-1 SAR and for the X-SAR. In parallel to this, a development programme in Germany made high power travelling wave tube amplifiers available for space radar applications. These amplifiers are presently used in all European space radars which need more than 1 kW peak output power. Their use in the Canadian RADARSAT and in some airborne radars is envisaged.

These two technology areas are presently superseded by the demanding technology of the "Distributed Amplifier Active Array Antennas". Large arrays of this kind can provide very high output power in distributing the amplification task to many amplifiers on the rare side of the antenna. These amplifiers can be designed for remote phase control providing a high antenna beam agility with respect to beam steering and forming. The radiating surface of such antennas is typically realized in microstrip batch technology in order to allow dual polarization operation. The key technological problem of these antennas is the space qualification. Miniaturized solid state power amplifiers, fibre optics antenna feeding and beam forming networks, new substrate materials together with advanced microstrip antenna structures and new in orbit antenna calibration methods must be developed and space qualified, before the next generation spaceborne SAR systems can start their operations on the polar Earth observation platforms in the 90th.

In line with the continuously growing SAR user community, SAR realtime processors are under development at Dornier-System in order to serve the users with high performance SAR images within a reasonable time delay after data collection. The raw data rates of multichannel SAR sensors of the next generation highly exceed 100 Mbps that requires dedicated array processors matched to this application.

## 5. OUTLOOK

Many on-board and on-ground features are still to be developed in order to provide SAR systems being a viable scientific tool for the remote sensing user community. The attractiveness of SAR systems in future will directly be related to their various operational capabilities, their availability, and the flexibility and effectivity of their on-ground infrastructure. This concerns user service, data calibration, and image processing. Demanding technological developments are necessary in all of these areas. Dornier-System is prepared to take this challenge.