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Neuere Untersuchungen für Europäische Erderkundungssatelliten und Erdorientierte Spacelabmissionen

ABSTRAKT

Die derzeitigen Aktivitäten innerhalb des Europäischen und Deutschen Fernerkundungsprogramms sind vorwiegend auf die Entwicklung von Meßinstrumenten zum Einsatz in der Ersten Spacelabmission (Spacelab-1) konzentriert. Die wichtigste Neuentwicklung stellt das Mikrowellenfernerkundungsexperiment (Microwave Remote Sensing Experiment, MRSE) dar. Für die Definition neuer Meßinstrumente zum Einsatz in zukünftigen Shuttle- und Spacelabmissionen in erdorientierten Meßmodes werden Durchführbarkeitsuntersuchungen durchgeführt. Das Instrument mit höchster Priorität ist dabei die sogenannte Synthetik-Apertur-Radar Facility (SAR-Facility). Die Definition der zukünftigen Europäischen Satellitensysteme für die Fernerkundung der Erde wurde mit Durchführbarkeitsuntersuchungen zu den Satelliten und deren Nutzlastinstrumenten begonnen. Die Nutzlasten enthalten sowohl aktive und passive Mikrowellensensoren als auch optische Multispektralabtaster.

RESUME

Les programmes de Télédétection Européens et Allemands sont principalement consacrés, en ce moment, au développement des instruments qui seront embarqués sur la Première Mission Spacelab. Parmi ces expériences l'instrument de Télédétection qui requiert les recherches les plus approfondies est celui qui utilise les détecteurs à Micro-ondes (Microwave Remote Sensing Experiment, ou MRSE). Des études de faisabilité pour la définition et l'élaboration de nouveaux instruments plus performants sont en cours. Ces instruments seront embarqués dans de futurs vols Shuttle-Spacelab pour des missions orientées sur l'étude de la terre. L'appareil qui intéresse au plus haut point les chercheurs Allemands est l'ensemble Radar à Visée Latérale.

La définition d'un futur Système de Satellites de Télédétection Européen a été entreprise avec des études de faisabilité au niveau des satellites et des charges utiles associées. Ces dernières se composeront de senseurs aussi bien actifs que passifs et emporteront des systèmes optiques multispectraux d'imagerie.

ABSTRACT

The present activities within the European and German Remote Sensing Programs are concentrated primarily on the development of instruments for the First Spacelab Mission (Spacelab-1). The most important new development is the Microwave Remote Sensing Experiment (MRSE). Feasibility studies are under way for conceptual design and definition of new more advanced instruments to be additionally included in future Shuttle and Spacelab missions in an earth-oriented measurement mode. The instrument which has strongest interest within the German program is the so-called Synthetic-Aperture-Radar Facility. The definition of the future European Remote Sensing Systellite Systems has been started with feasibility studies on the satellites and their payload instruments. The payload will include both active and passive microwave sensores and optical multispectral imagers.

1. INTRODUCTION

Instead of being only a user of available data from remote sensing satellite systems it is essential for Europe to develop own satellites which are optimized for specific applications. This approach is supported by the member states of the European Space Agency where also own developments have already been started as contributions to the future space systems using the Spaclab/Shuttle system for developing and testing of new measurement methods and instruments. Two complementary sensors, namely the MRSE and the Metric Camera will be flown on the first Spacelab Mission. Reflight and improvement of these instruments as well as new developments as for example the SAR-Facility represent a logical follow-on activity. The basis for automatic satellite systems carrying both microwave and optical instruments is presently being established on system and instrument level through feasibility studies. In addition technology development for components and subsystems is performed.

DORNIER SYSTEM is engaged in a large number of these activities under contracts from the German Ministry for Research and Technology (BMFT) and the European Space Agency (ESA). The following chapters highlight some topics of recent investigations such as development of microwave sensors, studies on earth observation with Spacelab/Shuttle payloads, and investigations on the European Land Applications Satellite System.

2. DEVELOPMENT OF MICROWAVE SENSORS FOR EARTH OBSERVATION

The European approach to remote sensing includes as an element with high priority the development and utilization of imaging microwave instruments. The presently envisaged satellite systems for land and ocean observation include, therefore, both active microwave sensors such as the Synthetic Aperture Radar (SAR) and passive microwave sensors such as the Imaging Microwave Radiometer (IMR). The baseline considers a one-frequency SAR and a multi-frequency IMR which can be implemented on-board the same satellite.

It is expected that in particular for ocean observation the addition of microwave instruments will considerably improve the quality and information content in many aspects, such as near all weather capability and acquisition of information otherwise not obtainable. Furthermore, there is also interest in sspecialized measurement modes as for example the dual-frequency scatterometry which could be used for directional wave spectrum measurement and wind field determination. Feasibility studies for the various satelliteborne microwave instruments have already been performed or are presently being carried out.

The first step for implementation of microwave instrumentation has been taken in Germany, where the Microwave Remote Sensing Experiment (MRSE) is under development since 1977 by Dornier System as a main contractor. The actual development effort is concentrated on integration and testing of all hardware elements; delivery to DFVLR is scheduled for the end of this year. The first flight of MRSE will be on FSLP (Spacelab-1) in 1982.

Figure 1 gives the general characteristics of MRSE. Figure 2 is a photograph of the flight hardware with the antenna mounted on the azimuth and elevation drive unit. The instrument is designed to operate in three different measurement modes:

- two-frequency scatterometer (2FS) for measurement of directional ocean wave spectrum at wavelengths in the 5m to 500 m range
- synthetic aperture radar(SAR) for high resolution imaging of the Earth's surface with a limited swathwidth of 8,5 km
- passive microwave radiometer (PMR) for measurement of emitted microwave radiation

Reflight of MRSE in future earth oriented Shuttle or Spacelab missions is being considered. The addition of a fourth mode for atmospheric limb sounding called MAS (Microwave Atmospheric Sounder) would be an attractive development. Preliminary investigations have shown the feasibility of such a measurement mode which could be implemented with modifications in the antenna system and by addition of radiometer receivers.

The next development step envisaged for spaceborne synthetic aperture radars is an experimental SAR-Facility for flight on earth-oriented Shuttle/Spacelab missions before the mid-eighties. A feasibility study is presently being performed under DFVLR contract by Dornier System. The baseline system is a two frequency version with simultaneous measurement at C-band and X-band. In particular for the X-band SAR there is a good chance of at least partly re-using the technology already developed for MRSE. The C-band system will rely on microwave technology development which has been started for the satellite SAR in the areas of slotted wave guide array antennas and high power amplifier. The block diagram of the SAR-Facility is shown in figure 3, indicating the possibility for implementation of V and H polarisation.

The problem of technology development for future spaceborne microwave instruments has been recognized early and a preparatory program was started for critical areas such as the SAR-antenna, SAR-electronics and the SAR-processing. Dornier is engaged in particular in the antenna development and the SAR-processing. In both areas breadboarding work has been started and is already showing encouraging results.

3. EARTH ORIENTED SHUTTLE/SPACELAB MISSIONS

Investigations on the utilisation of Spacelab for earth-oriented Demonstration Missions were carried out for ESA and for DFVLR. In this approach a complete set of measurement instruments for earth surface observation and atmospheric research was accommodated on a short-module/three pallet Spacelab configuration. Figure 4 shows the configuration of the instruments on Spacelab. Careful analysis of instrument integration timelining and cost estimates led to the conclusion that such a complex mission will most probably not be optimal for the single disciplines. Furthermore the high cost of such a mission will not allow the implementation within the next years.

Therefore in a follow-on investigation a new approach for accommodation of a single discipline package for earth observation was performed. The instruments were the same as used before, except the Metric Camera which was assumed to be installed in a pressurized container. Figure 5 gives the mass, peak power and data transmission requirements of the instrument package. Figure 6 shows the mass and power requirements of the payload package. The payload configuration and the need for supporting subsystems was investigated in more detail. Major constraints came from the deployment of the SAR-antenna and its positioning in operational location above the cargo bay envelope. Since the SAR-antenna is to be about 10 meters in length, an early conclusion with respect to NASA charges was to deploy the antenna across the cargo bay with the final measuring position of the antenna longitudinal-axis parallel to the Shuttle-Y-axis. Figure 7 shows this configuration with the SAR-antenna in measurement position.

4. EUROPEAN REMOTE SENSING SATELLITE SYSTEM FOR LAND APPLICATION

During the preparation of the European Remote Sensing Programme with satellites two major application areas are being considered, namely land applications and monitoring of coastal and open oceans.

The primary mission objective of the Land Applications Satellite System (LASS) is to provide high resolution multispectral imagery of the Earth's land surface, including land water bodies. A variety of applications particularly in the areas of agriculture, land use, and water resources management is envisaged. A large number of these applications will be concerned with the monitoring and study of the temporal variation of diverse surface features. To fulfill the mission objectives the baseline payload of the LASS will include two major instrument types, namely high-resolution multisepctral imagers for the visible and near infrared and a synthetic aperture radar with good radiometric resolution.
The overall system and the payload instruments are being investigated within feasibility studies under contracts from the European Space Agency. Final results can be expected within the next months.

The major characteristics of the LASS paylaod instruments are given in Figure 8 . The present concept of the optical instrument uses charged coupled detector arrays to achieve the required high spatial and photometric resolution. The Synthetic Aperture Radar (SAR) has already been studied previously. Present activities are related to the problem of implementation of different nadir angles. Figure 9 shows the flight configuration of the LASS. It is characterized by the large solar array (2.3 m x 11.63 m) for a power supply of 1800 watt at begin of life and the large SAR antenna (11 m x 1.2 m). As a baseline the spacecraft platform which is presently being developed in France for SPOT is utilized. The payload instruments are mounted on a payload module which houses also the SAR electronics and the data transmission electronics.

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Figure 1 :

• Resolution		
Two Frequency Mode:	1 dB footprint	9 km x 9 km
SAR Mode:	Depression Angle	40 degrees
	Image Width	8.5 km
	Image Length	2500 km
	Ground Resolution	25 m x 25 m
Radiometer Mode:	Surface Temperature Sensitivity	$\pm 1^{o}C$
• Antenna – Paraboloid Section with Cassegrain Feed	Dimensions	1 m x 2 m
	Frequency	9.6 GHz
	Field of View	$1.6^{o} \times 3.1^{o}$
• Antenna Pedestal	Elevation Angle	32^{o} to 55^{o}
	Azimuth	$+34^{o}$ to -34^{o}

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GENERAL CHARACTERISTICS OF THE MICROWAVE REMOTE SENSING EXPERIMENT

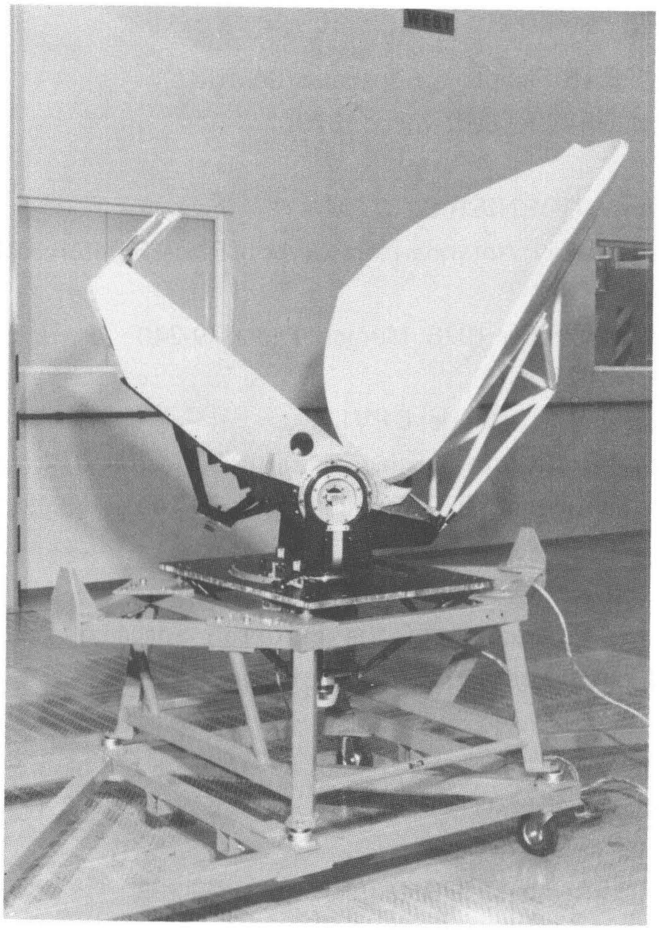

Figure 2 :

PHOTOGRAPH OF MRSE FLIGHT HARDWARE

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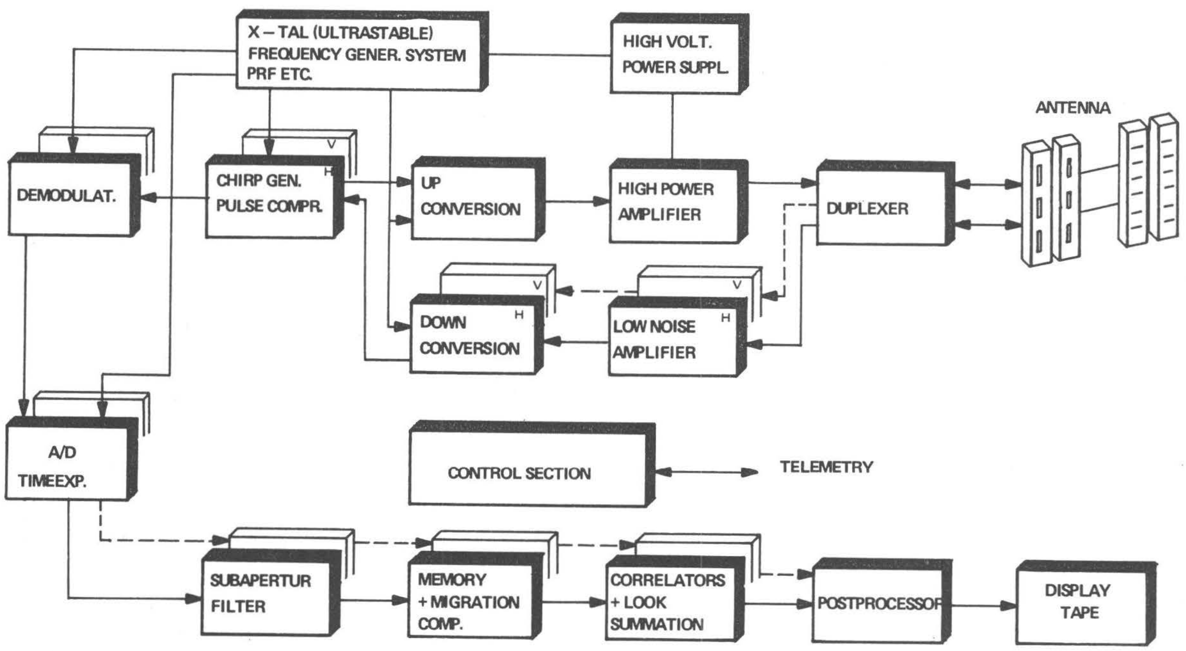

Figure 3 :

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BLOCKDIAGRAM OF THE SAR – FACILITY

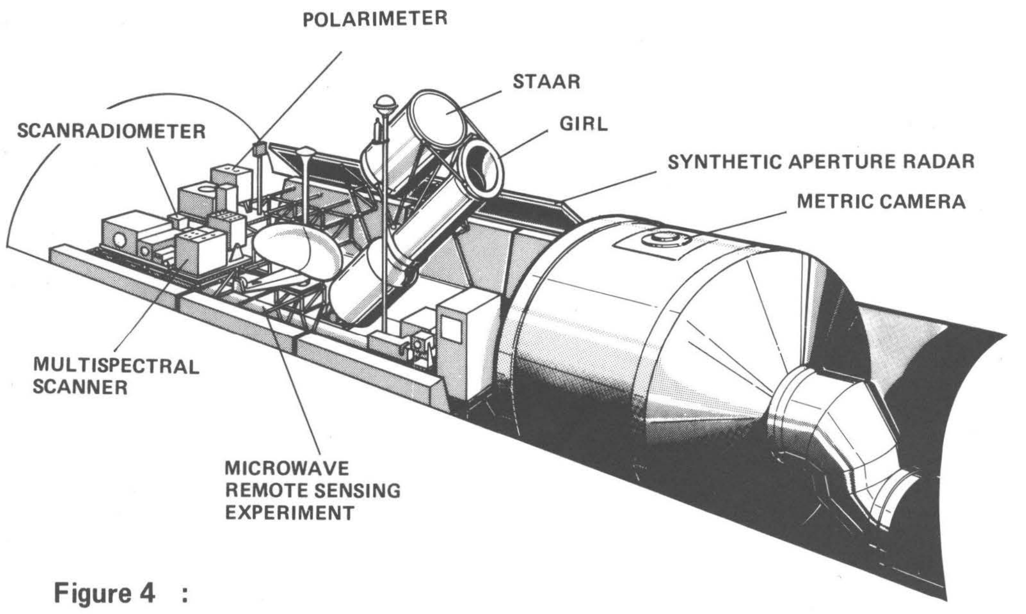

Figure 4 :

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CONFIGURATION OF THE EARTH ORIENTED SPACELAB MISSION

Instrument	Mass (kg)	Peak Power (w)	Peak Data Rate (Mbit/sec)	Remarks
METRIC CAMERA + Aux. Equipment	310	300	–	Reflight from FSLP in pressurized container
MICROWAVE REMOTE SENSING EXPERIMENT (including MAS)	190	876 for 2FS 100 for MAS	0,377 0,010	Reflight from FSLP including MAS – mode
SAR – FACILITY (2 Frequencies)	430	2000	200	New Development
MULTISPECTRAL SCANNER (2 Channels)	110	90 for 2	40	New Development

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REMOTE SENSING INSTRUMENTS WITHIN DEMONSTRATION MISSIONS

Figure 5 :

Mass Budget

	Shuttle Missions	Spacelab Missions
Instruments	1040 kg	1040 kg
Auxiliary Subsystems	396.6 kg	371 kg
Supporting Structure	500 kg	80 kg
Total Mass	1936.6 kg	1491 kg

Power Budget

Power Requirement: 1.7 kW

– SAR Peak Power Provided from Batteries!

Total Energy Required for a 10 Day Mission: 34 kWh

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Figure 6 : MASS AND POWER BUDGETS FOR AN EARTH OBSERVATION PACKAGE

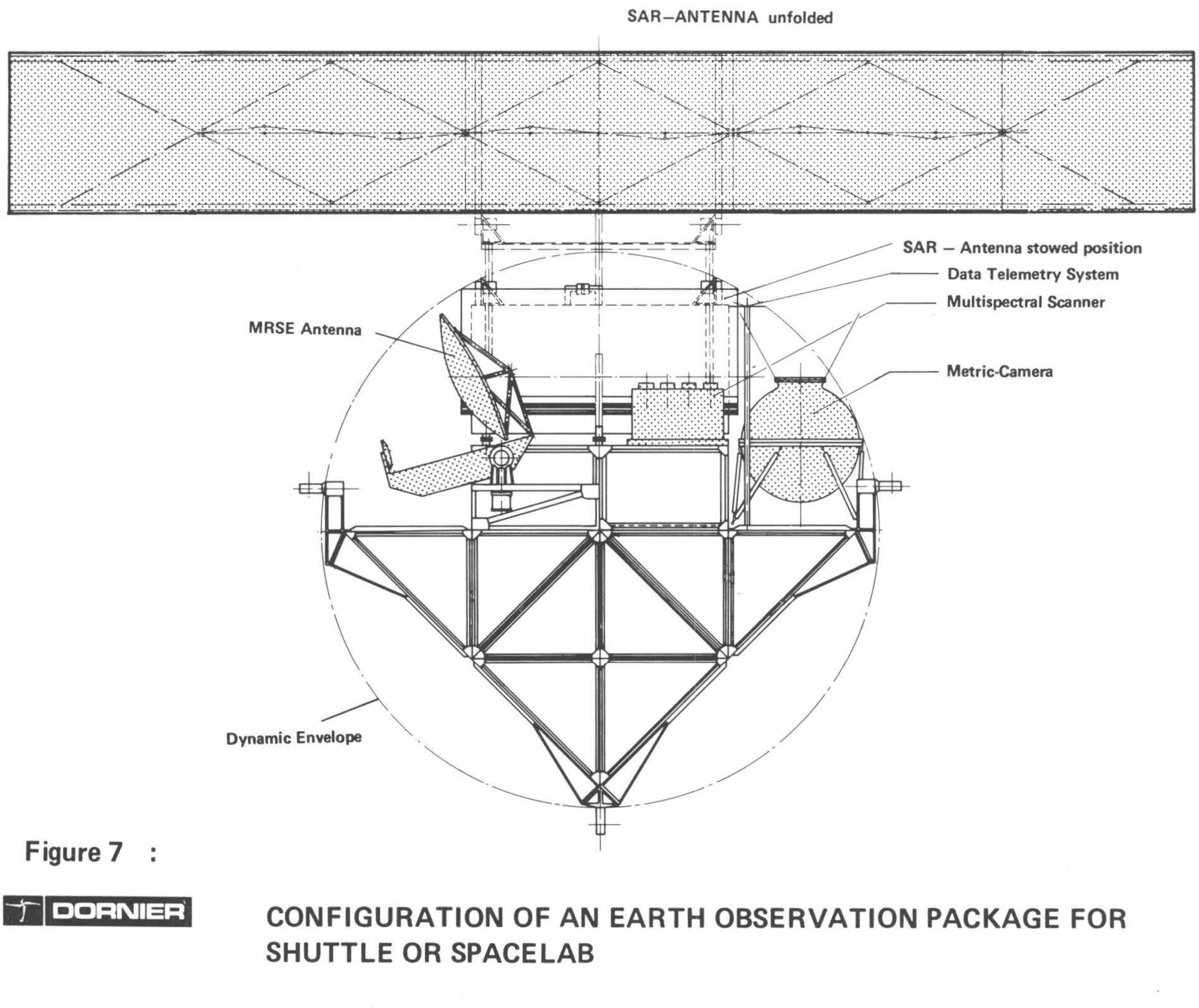

Figure 7 :

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CONFIGURATION OF AN EARTH OBSERVATION PACKAGE FOR SHUTTLE OR SPACELAB

OPTICAL IMAGING INSTRUMENT (OII)

6 SPECTRAL CHANNELS:

0.52 – 0.60 μm	0.64 – 0.69 μm	0.75 – 0.80 μm
0.80 – 0.90 μm	1.55 – 1.75 μm	2.08 – 2.35 μm

SPATIAL RESOLUTION : 30 km
SWATHWIDTH : 190 km

SYNTHETIC APERTURE RADAR (SAR)

MEASUREMENT FREQUENCY:	5.3 GHZ
POLARISATION:	HH
OFF NADIR ANGLE:	20^{o} nominal
SPATIAL RESOLUTION:	30 m
SWATHWIDTH:	100 km

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Figure 8 : PAYLOAD INSTRUMENT CHARACTERISTICS FOR THE LAND APPLICATIONS SATELLITE

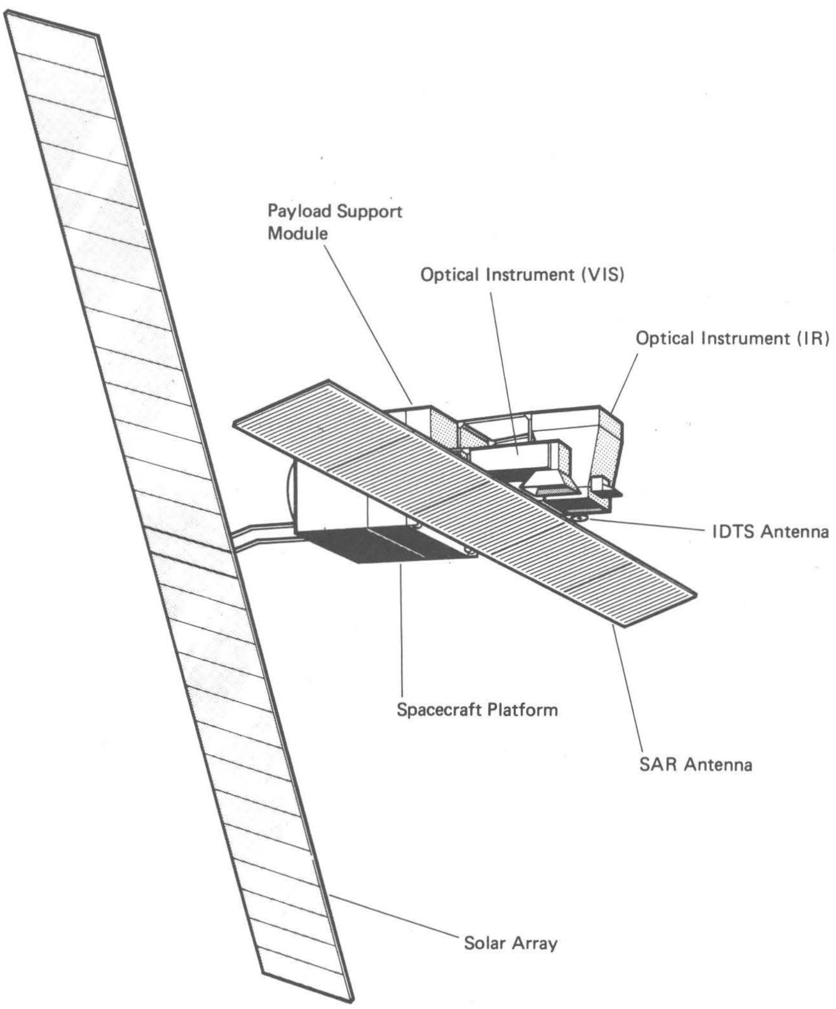

Figure 9 :

FLIGHT CONFIGURATION OF THE EUROPEAN LAND APPLICATIONS SATELLITE

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