ENVISAT-1

Mission & System Summary

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Introduction

The impacts of mankind's activities on the Earth's environment is one of the major challenges facing the human race at the start of the third millennium.

The ecological consequences of human activities is of major concern, affecting all parts of the globe. Within less than a century, induced climate changes may be bigger than what those faced by humanity over the last 10000 years. The 'greenhouse effect', acid rain, the hole in the ozone layer, the systematic destruction of forests are all triggering passionate debates.

This new awareness of the environmental and climatic changes that may be affecting our entire planet has considerably increased scientific and political awareness of the need to analyse and understand the complex interactions between the Earth's atmosphere, oceans, polar and land surfaces.

The perspective being able to make global observations by satellite of the Earth has fostered the development of a number of space-based remote sensing techniques. With its two ERS satellites, ESA has played a key role in the development of these techniques for a wide range of scientific and application oriented observations.

In 1988, an ESA overall 'Strategy for Earth Observation' was presented to the ESA member states. This proposed a series of complementary polar-orbiting and geostationary satellites to study the Earth's environment and resources, to continue and improve meteorological observations.

Based on this scenario, two ESA councils at ministerial level, held in Munich in November 1991 and Granada in November 1992, established a programme composed of two missions: the ENVISAT-1 mission and the METOP-1 mission preparatory programme.

While METOP-1 is primarily an operational meteorological satellite, ENVISAT-1 is a satellite dedicated to the study of the Earth and its environment.

With its launch planned for the end of the decade, ENVISAT-1 is a multidisciplinary mission having science and application objectives, continuing and extending the ERS-1/2 mission objectives and contributing to a coherent European Earth Observation Programme.

The ENVISAT-1 mission constists of three main elements:

- the Polar Platform (PPF);
- the ENVISAT-1 Payload;
- the ENVISAT-1 Ground Segment.

The PPF development was initiated in 1989 as a multimission platform; the ENVISAT-1 payload complement was approved in 1992 with the final decision concerning the industrial consortium being taken in March 1994. The ENVISAT-1 Ground Concept was approved in September 1994.

These decisions resulted in three parallel industrial developments, together producing the overall ENVISAT-1 system.

The development, integration and test of the various elements are proceeding leading to a launch of the ENVISAT-1 satellite planned for the end of this decade. The satellite is designed for an in-orbit mission lifetime of 5 years.

This document provides a brief description of the ENVISAT-1 mission objectives and the underlying system design concept including all its major constituents and its relation to the operation strategy. It also describes the status of the design and development of the system elements.

Mission

To monitor and study our environment at global scale, polar orbiting remote sensing satellites offer unique features:

- complete Earth coverage;
- high revisiting rate;
- continuity of measurements over the seasons and years;
- stability and highly repeatable measurements.

However, due to the limited lifetime (a few years) of each satellite, the continuity of the measurements, which is of paramount importance to monitor the evolution of our environment and potential climate change, can only be ensured by flying a succession of polar orbit satellite missions.

In this context, the main objective of the ENVISAT-1 programme is to endow Europe with an enhanced capability for the remote sensing of the Earth from space, with the aim of further increasing the capacity of participating states to take part in the study and monitoring of the Earth and its environment. Its primary objectives are:

- to provide for the continuity of the observations started with the ERS satellites, including those obtained using radar-based observations;
- to provide for the enhancement of the ERS-1 mission, notably its ocean and ice missions;
- to extend the range of parameters observed to meet the need to increase knowledge of the factors determining the environment;
- to make a significant contribution to environmental studies, notably in the areas of atmospheric chemistry and ocean studies (including marine biology);

coupled with two linked secondary objectives:

- to allow more effective monitoring and management of the Earth's resources;
- to better understand solid Earth processes.

These objectives will be achieved by developing:

- a package of instruments aimed at meeting the need to observe the Earth and its atmosphere from space in a synergetic fashion, addressing such matters as global warming, climate change, ozone depletion and ocean and ice monitoring;
- a ground segment including a flight operations segment, dedicated to spacecraft and mission control and operations; a payload data segment, ensuring payload operations planning, data acquisition and processing, data distribution and archiving, and user services; taking into account the existing ESA ground infrastructure and those of participating states.

The mission is intended to continue and improve upon measurements initiated by ERS-1 and ERS-2, and taking into account the requirements related to the global study and monitoring of the Earth and its environment as expressed by international cooperative programmes such as the International Geosphere and Biosphere Programme and the World Climate Research Programme. The mission is an essential element in ensuring the long term provision of continuous data sets, essential for addressing environmental and climatological issues. The mission will at the same time further promote the gradual transfer of applications of remote sensing data from experimental to pre-operational and operational exploitation.

The ENVISAT-1 satellite comprises a set of ESA developed instruments (EDI's) complemented by Announcement of Opportunity Instruments (AOI's) embarked on the Polar Platform:

ESA Developed Instruments (EDI's)

MERIS
(Medium Resolution Imaging Spectrometer)

MIPAS
(Michelson Interferometric Passive Atmospheric Sounder)

ASAR
(Advanced Synthetic Aperture Radar)

GOMOS
(Global Ozone Monitoring by Occultation of Stars)

RA2
(Radar Altimeter 2)

MWR
(Microwave Radiometer)

LRR
(Laser Retro Reflector)

Announcement of Opportunity Instruments (AOI's)

SCIAMACHY
(Scanning Imaging Absorption Spectrometer for Atmospheric Chartography)

AATSR
(Advanced Along Track Scanning Radiometer)

DORIS
(Doppler Orbitography and Radiopositioning Integrated by Satellite)

Disciplines (Parameters) \ Instruments	ASAR	GOMOS	RA-2	MERIS	MIPAS	MWR	LR	SCIAMACHY	DORIS	AATSR
Atmosphere										
Clouds				■				■		■
Humidity						■				
Radiative Fluxes				■						■
Temperature					■			■		
Trace Gases		■			■			■		
Aerosols		■		■	■			■		■
Land										
Surface Temperature										■
Vegetation Characteristics	■			■						■
Surface Elevation	■		■				■		■	
Ocean										
Ocean Colour				■						
Sea Surface Temperature										■
Surface Topography			■				■			
Turbidity				■						
Wave Characteristics	■		■							
Marine Geoid			■							
Ice										
Extent	■			■						■
Snow Cover	■			■						■
Topography	■		■				■			
Temperature										■

Instrument Contributions to ENVISAT-1 Mission Objectives

Part of the payload is focussed on ensuring the continuity of the ERS-1/2 missions: ASAR, AATSR, MERIS, RA-2 with its supporting instrumentation (MWR, DORIS and LRR).

The observation of the ocean and coastal waters is the primary objective of the MERIS instrument.

The ability to observe the atmosphere, following on from the GOME instrument on ERS-2, is significantly enhanced by 3 instruments on ENVISAT-1 which offer complementary measurement capabilitites:

- observation of a large quantity of atmospheric species by analysis of the absorption lines through the atmosphere;
- characterisation of the atmospheric layers as well as total column content by complementary limb and nadir observations.

These instruments operate over a wide range of the electromagnetic spectrum, from centimetre waves to ultraviolet.

The ENVISAT-1 mission includes both global and regional mission objectives with the corresponding need to provide data to both scientific and application users.

Global Requirements

Continuous and coherent global data sets are needed by the scientific and application community to better understand climatic processes and to improve climate models.

Some of the global objectives require products available in an off-line mode (days to weeks from sensing). Specific examples include quantitative monitoring of:

- radiative processes
- ocean-atmosphere heat and momentum exchange
- interaction between atmosphere and land or ice surfaces
- composition of the atmosphere and associated chemical processes
- ocean dynamics and variability
- ice sheet characteristics and sea-ice distribution and dynamics
- large scale vegetation processes in correlation with surface energy and water distribution
- primary productivity of oceans
- natural and man-made pollution over the oceans

as well as support to large international scientific programmes (GCOS, IGBP, GEWEX, JGOFS, etc.).

However, some global applications require near-real time data delivery (from a few hours to one day from sensing). Specific examples include:

- forecasting of sea state conditions at various scales
- monitoring of sea surface temperature
- monitoring of some atmospheric species (e.g. ozone for warning purposes)
- monitoring of some atmospheric variables (e.g. temperature, pressure and water vapour, cloud top height, earth radiation budget, etc.)
- monitoring of ocean colour for supporting fisheries and pollution monitoring (complementing the regional mission).

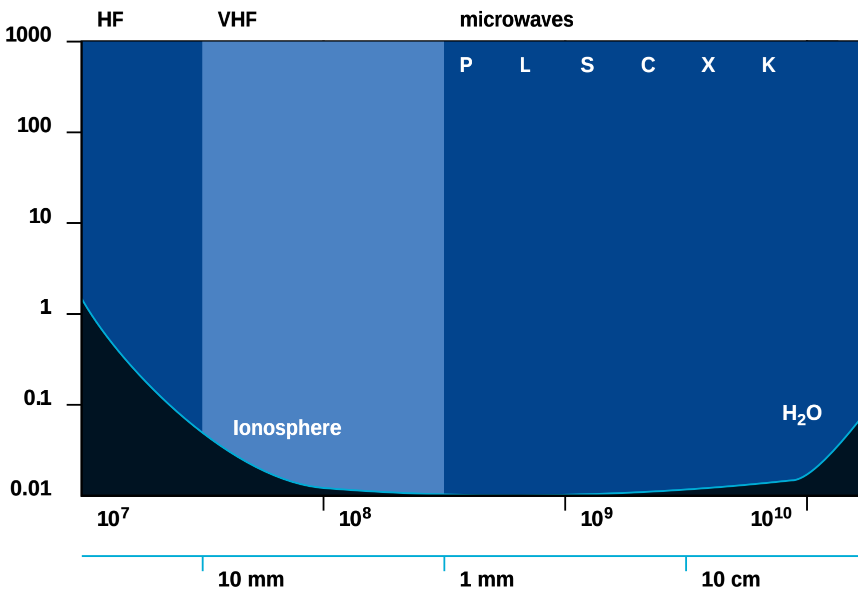
Regional Requirements

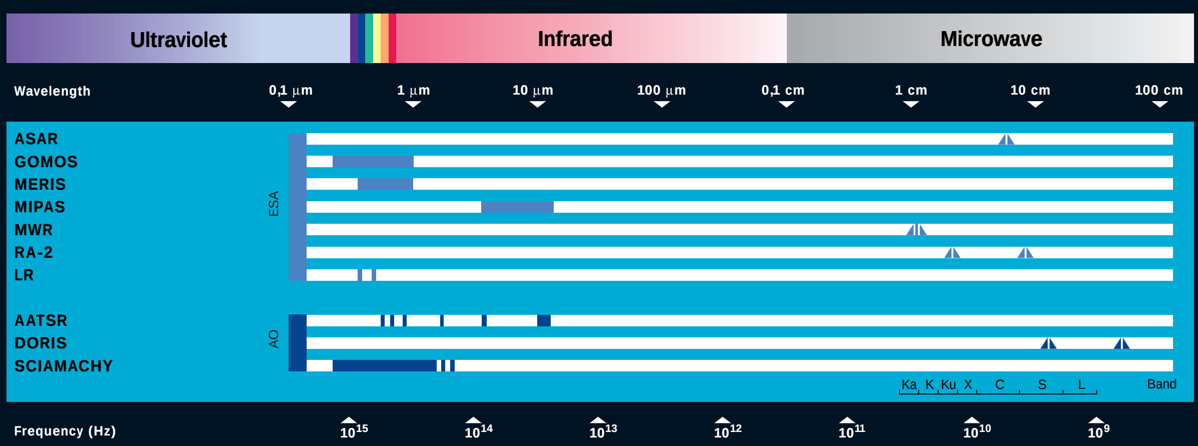
Regional data sets are needed by the scientific and application user community for a variety of objectives such as:

- sea ice tactical and strategic off-shore applications
- snow and ice detection and mapping
- coastal processes and pollution monitoring
- ship traffic monitoring
- agriculture and forestry monitoring (including tropical zones)
- soil moisture monitoring and large scale vegetation processes
- geological features and mineral resources
- applications linked to SAR interferometry (DTM generation, hazard monitoring, etc.)
- hydrological research and applications
- support to fisheries in coastal waters.

Some of the regional objectives (e.g. sea ice applications, marine pollution, maritime traffic, hazard monitoring, etc.) require near real time data products (within a few hours from sensing) generated according to user requests. Some of the other objectives (e.g. agriculture, soil moisture, etc.) require fast turnaround data services (a few days). The remainder would be satisfied with off-line (few weeks) data delivery.

Measurement Spectrum of ENVISAT-1 Instruments




Ultraviolet
Infrared
Microwave
Wavelength
0,1 µm
1 µm
10 µm
100 µm
0,1 cm
1 cm
10 cm
100 cm
ASAR
GOMOS
MERIS
MIPAS
MWR
RA-2
LR
ESA
AATSR
DORIS
SCIAMACHY
AO
Ka K Ku X C S L
Band
Frequency (Hz)
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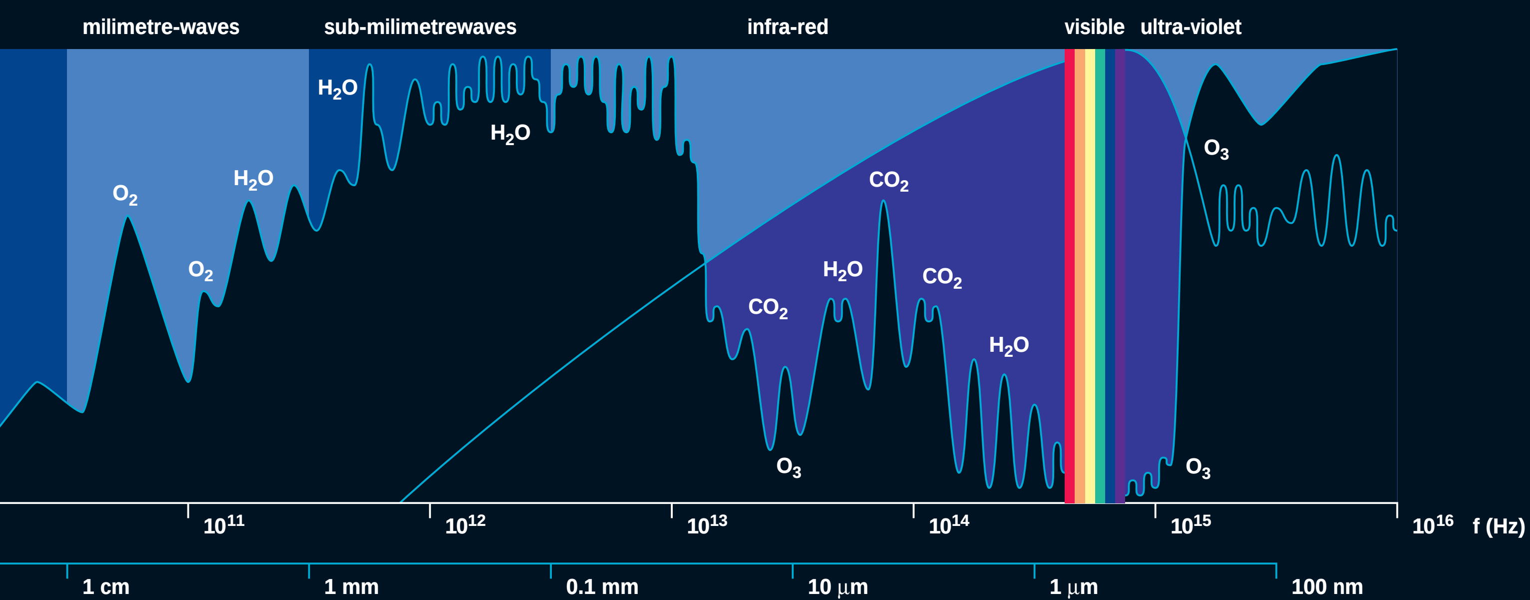
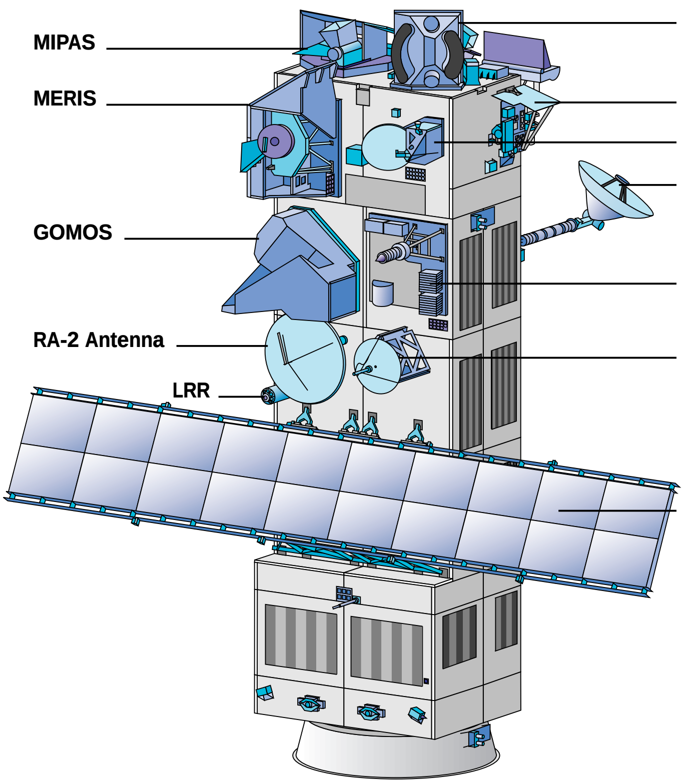

milimetre-waves
sub-milimetrewaves
infra-red
visible
ultra-violet
O_2
O_2
H_2O
H_2O
H_2O
CO_2
CO_2
H_2O
CO_2
H_2O
O_3
O_3
O_3
10^{11}
10^{12}
10^{13}
10^{14}
10^{15}
10^{16}
f (Hz)
1 cm
1 mm
0.1 mm
10 µm
1 µm
100 nm

System



The system needed to achieve the ENVISAT-1 mission objectives consists of two main building blocks:

- the Satellite
- the Ground Segment.

Furthermore, it will also utilise the ARTEMIS Data Relay Satellite for instrument data recovery to complement the ENVISAT-1 direct to ground X-band links.

The satellite will be launched from the Kourou Space Centre in French Guyana by an Ariane 5 launch vehicle.

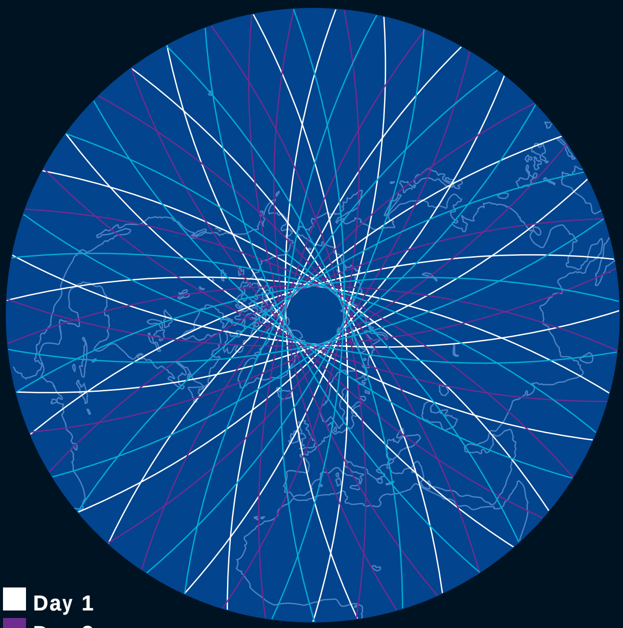
The ENVISAT-1 Satellite is composed of the payload complement embarked on the Polar Platform.

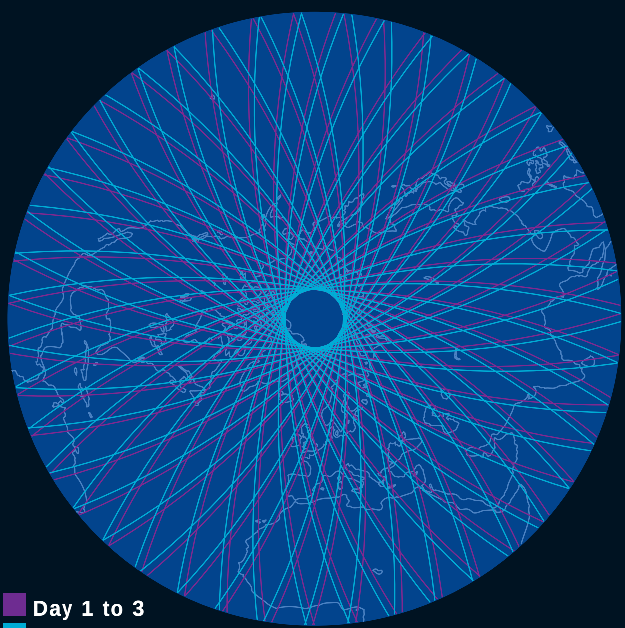
The Payload comprises a set of seven ESA Developed Instruments (EDI's), complemented by three Announcement of Opportunity Instruments (AOI's), listed earlier.

The Polar Platform is constituted of two major assemblies

- the Service Module (SM) which accommodates most of the satellite support subsystems such as
  - power generation, storage and distribution,
  - Attitude and Orbit Control System (AOCS),
  - communication on S-band,
  - support structure and launcher interface,

- the Payload Module (PLM) carrying the instruments and the payload dedicated support subsystems
  - instrument control and data handling,
  - communication on X- and Ka-band,
  - power distribution,
  - support structure.





Orbits per day	14 11/35
Repeat cycle (days)	35
Orbit period (min)	100.59
Mean local time at descending node	10:00
Inclination (deg.)	98.55
Orbit radius (km)	7159.5
Orbit velocity (km/sec)	7.45
Mean altitude (km)	799.8

Orbit

To fulfil its mission objectives, the orbit selected for the ENVISAT-1 satellite is sun synchronous, with a mean altitude of 800 km and a descending node mean local solar time of 10:00 am.

This orbit will be maintained such to ensure that the deviation of the actual ground track is kept within 1 km of the reference orbit track and the mean local solar time is maintained within 1 minute.

The maintenance of the orbit require two types of manoeuvres:

- along track fine orbit control manoeuvres which will not interrupt payload operation but will degrade temporarily pointing performance. The time interval between these manoeuvres depends on the solar activity. It can be as small as one week in case of maximum solar activity.
- orbit inclination control manoeuvres, which will be performed at intervals of a few months, and which will interrupt payload operation. These manoeuvres will be performed in eclipse to avoid optical sensors be forced to view the sun directly.

The selected orbit provides a 35 day repeat cycle (as for the ERS-2 mission). This orbit also provides various coverage subcycles, building up orbit track grids with a fixed longitudinal drift from one subcycle to the next which are of direct relevance to the realisation of the mission objectives. The one-day and three-day orbit subcycles provide a global sampling of the Earth which, for the instruments contributing to the global mission, is well matched to the objective of data assimilation in global meteo or climate models. The 17 day subcycle is directly relevant to the radar altimeter. The 35 day cycle provides a good repeat grid for the altimeter, building up the equivalent of two interleaved 17 day grids; it also offers potential coverage access, with the ASAR high resolution imaging mode, to any part of the world. Since the orbit track spacing varies with latitude (the orbit track spacing at 60° latitude is half of the equator one) the density of observations and/or the revisiting rate is significantly higher at high latitudes than at the equator.

The **Ground Segment** will provide the means and resources to manage and control the mission, to receive and process the data produced by the instruments and to disseminate and archive the generated products. Furthermore, it will provide a single interface to the users to allow optimum utilization of the system resources in line with user needs.

The Ground Segment can be split into two major elements;

- the Flight Operation Segment (FOS) and
- the Payload Data Segment (PDS).

The **FOS** is composed of the Flight Operations Control Centre (FOCC), located at ESOC Darmstadt (Germany), and the associated command and control stations. It provides control of the satellite through all mission phases:

- satellite operation planning based upon the observation plans prepared at the PDCC
- mission planning interface with ARTEMIS
- command and control of the satellite, up-loading of operation schedules on a daily basis via the TT&C station at Kiruna-Salmijarvi (north Sweden).

Furthermore the FOCC will support:

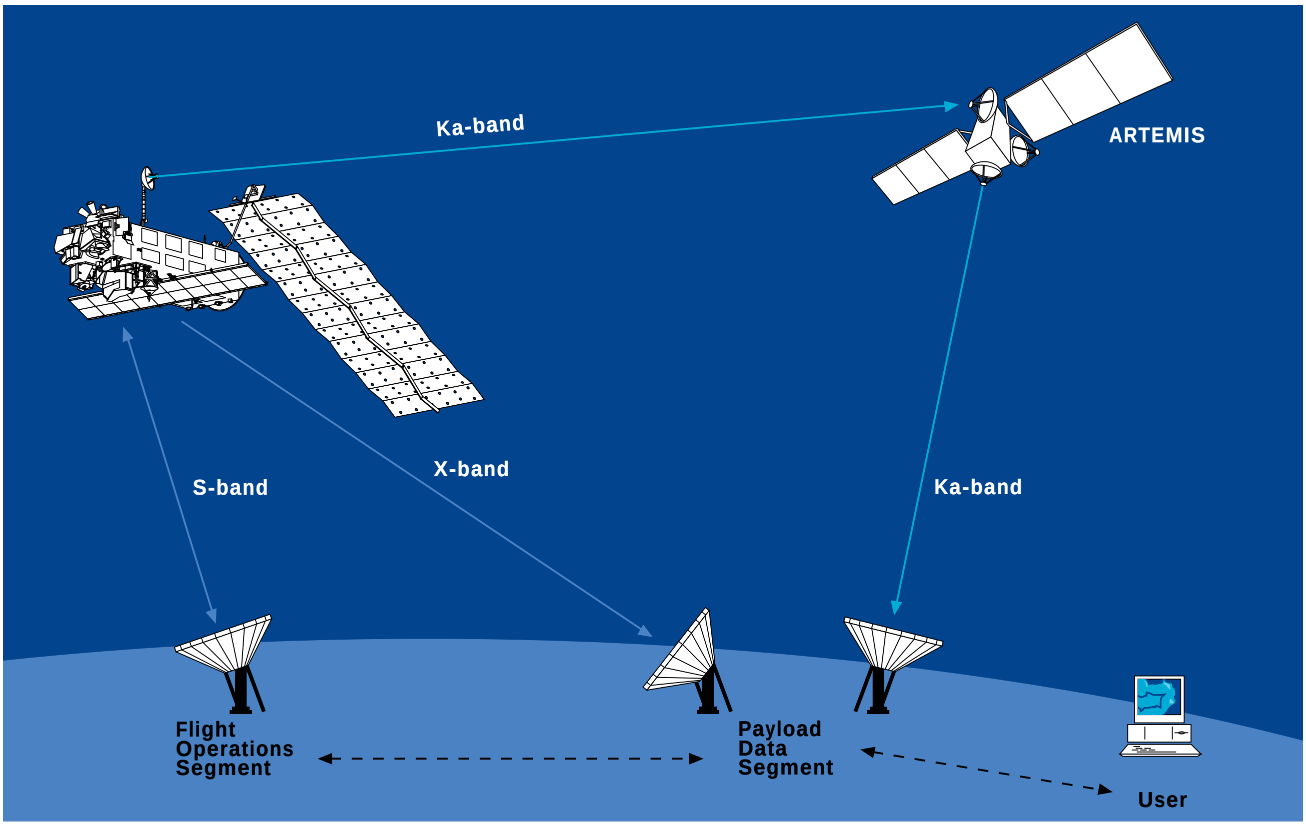
- satellite configuration and performance monitoring
- software maintenance for PPF and payload elements
- orbit prediction, restitution and maintenance.

Satellite command and control will nominally be performed using S-band via the Kiruna Ground Station. During Launch and Early Orbit Phase, the Kiruna Station will be complemented by an LEOP TT&C station network providing coverage of critical events.

The **PDS** comprises all those elements which are related to payload data acquisition, processing, archiving as well as those concerning the user interfaces and services. The PDS will thus provide:

- all payload data acquisition for the global mission
- all regional data acquisition performed by ESA stations
- processing in Near Real Time and dissemination of ESA Fast Delivery Products
- data archiving, processing and delivery of ESA off-line products with support of Processing and Archiving Centres (PAC's)
- interfaces with national and foreign stations acquiring regional data
- interfaces to the users from order handling to product delivery.

The PDS centres and stations will be coordinated by the Payload Data Control Centre (PDCC) located at ESRIN Frascati (Italy). The PDCC will interface with the FOCC for all mission planning activities.
The PDS ESA stations include a Payload Data Handling Station (PDHS-K) providing X-band data reception and located at Kiruna salmijarvi, a Payload Data handling Station (PDHS-E) located at ESRIN and receiving via an User Earth Terminal (UET) the data relayed via ARTEMIS in Ka-band, a Payload Data Acquisition Station (PDAS) receiving X-band data and located in Fucino (Italy).



Mission Operation & Data Recovery scenarii

The Instrument Data Transmission System

The satellite offers a programming capability which permits the operation schedule to be uplinked on a daily basis. The instrument scheduling is directly derived from the global and regional mission objectives.

All instruments contributing to the global mission deliver data at rates compatible with the on-board tape recorder capability. These low data rate instruments add up to a composite date rate of 4.6 Mbit/s. Use of on-board tape recorders, having each a capacity of 30 Gbits, allows full orbit recording. Therefore, for the low rate global data, the nominal strategy is to perform one tape dump per orbit via either the ARTEMIS link (with data reception at the UET of ESRIN) or a direct X-band link with data reception at Kiruna. In both cases, the tape dump is performed at 50 Mbit/s and completed in less than 10 minutes. This strategy will permit the distribution to users of global Near Real Time (NRT) products within less than 3 hours of observation.

The regional mission includes the imaging modes of the ASAR (single swath or Scansar wide swath), and MERIS, in its 250 m Full Resolution mode. ASAR high rate operation will be possible up to 30 minutes per orbit. MERIS operation is constrained, by the required solar illumination of the observed scene, to maximum 43 minutes per orbit.

Operation of the imaging modes of ASAR induces a data rate of 100 Mbit/s. Operation of MERIS Full Resolution, multiplexed with the low rate instruments real time telemetry, induces a data rate of 50 Mbit/s. These data, acquired on a regional basis, can be either recorded on-board using the Solid State Recorder (SSR), offering a total capacity of 60 Gbits, or transmitted directly via the X-band and/or Ka-band data down links

The ENVISAT-1 satellite is capable of transmitting two data streams at 100 Mbit/s each. Each 100 Mbit/s data streams occupies a full X-band or Ka-band radio frequency channel. MERIS Full Resolution real time data transmission can be performed in parallel with on-board recorder tape dump using one single down link channel at 100 Mbit/s. The SSR data can be down linked at either 50 Mbit/s or 100 Mbit/s

The satellite is capable of providing simultaneous operation of the X-band and Ka-band channels. For the regional mission, the simultaneous operation of the X-band and Ka-band channels may also be of interest to permit data acquisition by an X-band regional station in parallel with Ka-band operation via ARTEMIS and reception at the ESA UET.

Mission Planning

The planning of the two missions will be performed accordingly:

- The Global mission operation is provided in a Reference Operation Plan (ROP) which defines an operation strategy valid for several months in advance, including the data recording segments on an orbit basis and the corresponding tape dump sequence via ARTEMIS or Kiruna direct link.
- The Regional mission is mainly driven by the user requests received via the PDS User Services.
A complementary background observation plan can be defined in the ROP.

Whenever a request for regional mission operation is requested, the mission management control system will plan both the corresponding instrument operation and the corresponding data recovery (direct data down link or on-board data recording with deferred playback). The strategy selected for data recovery will take into account the location of the observation, the location of the user and the type of service requested. This could imply, in particular cases, direct X-band data transmission in visibility of a national or foreign station, having an agreement with ESA for the reception of the data, in parellel with data recovery by ESA via on-board recording or direct Ka-band data transmission.

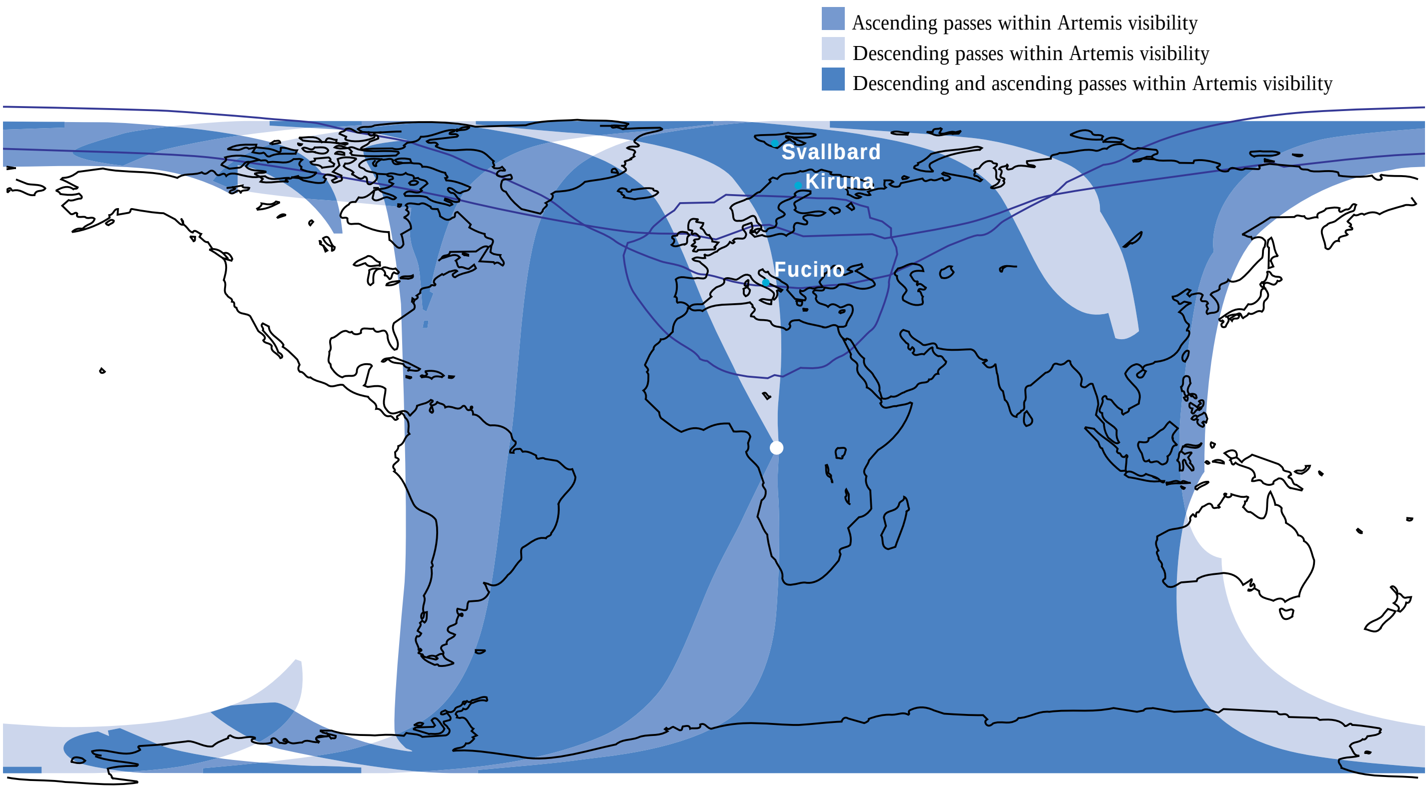
Mission Scenarii

Various scenarii have been defined and analysed for recovery of the Global Mission:

- The nominal scenario is based on equal workload sharing between the Kiruna station and the ESRIN UET. Both Payload Data Handling Stations (PDHS-K and PDHS-E) will receive daily a sequence of about seven consecutive orbits. All received data will be systematically processed in Near Real Time (NRT) and the corresponding products disseminated to the users.
- In case of temporary unavailability of the ARTEMIS link, the Kiruna station will receive up to 10 consecutive orbits per day. The remaining data, up to 5 orbits out of any Kiruna visibility, will be recorded on-board using the four recorders in cascade (3 tape recorders and the SSR). The data will be dumped (in deferred time) within less than a day, using the Fucino station. The corresponding data will be further routed and processed at the PDHS-E. So, the NRT service will not be provided for four of these orbits per day.
- In case of permanent unavailability of ARTEMIS, a high latitude X-band receiving station, in Svalbard, will be equipped with PDHS processing equipment, removed from the PDHS-E, to complement Kiruna and restore the nominal NRT service to the users for all the orbits, the Svalbard station acquiring and processing all orbits out of Kiruna visibility.

For the regional mission, the nominal scenario is to downlink the data in X-band to the two ESA stations of Kiruna and Fucino for data reception within their coverage (european coverage). Data outside this coverage will be acquired using the ssr or via the ARTEMIS link, within ARTEMIS coverage limit. Direct X-band down link will be planned when requested by duly authorised national or foreign stations. In case of ARTEMIS unavailibility, the Regional Mission direct data recovery will be limited to the zones under coverage of ESA, national or foreign stations. Outside these direct coverage zones, data will be recorded on-board and dumped under ESA X-band station coverage.

Station visibility masks and Artemis coverage



The Instrument Derived Data Products

A comprehensive list of ESA products has been established and approved as part of the Ground Segment concept. This list includes the following type of products:

- Level 0 products, time ordered Instrument Source Packets formatted as PDS products;
- Level 1B products, geolocated engineering products;
- Level 2 products, geolocated geophysical products.

To ensure coherency of data product definitions and formatting through all the PDS, as well as to define an approach valid for both Near Real Time and Offline products, the Agency has established precise product guidelines and organised a clear distinction between:

- the product definition and processing algorithm development assigned to a set of Expert Support laboratories (ESL's) and supporting industries;
- the PDS Instrument Processor implementation assigned to the PDS consortium and based on product and algorithm detailed definition documents provided by the ESLS and supporting industries.

This approach, coordinated by the Agency, has been so far very successful:

- Commonality between NRT and Offline algorithms has been confirmed, the product formats and processing algorithms are identical, the main difference is in the quality of the auxiliary data available at processing time;
- The Instrument Processors being implemented in the PDS are compatible with both NRT and Offline product generation.
- The same processors will be used in all PDS centres and stations, ensuring constant product quality for users, coordinated upgrades and configuration control throughout the operation lifetime of the mission.

The User Services

The main objective of the ENVISAT-1 System is to provide the required products to the users.
The PDS will provide, via its User Services accessible on Internet, an interface to the user community, registering data requests and organising the acquisition, processing and delivery of the corresponding products.

The ground segment concept and architecture will provide a unified service to the users with access, once the user is registered, to the full range of services provided by the PDS centres and stations offering ESA services.

From the user's point of view, the services offered will provide:

- a decentralised system offering an homogeneous and consistent suite of services accessible via Internet in a transparent way (without the need to know where the data inventory nor the data are physically located);
- on line ordering of the products available and their delivery via electronic links or physical media according to size of product and network capabilities available;
- satellite links for systematic dissemination of NRT global data and for on request dissemination of NRT high resolution regional products;
- Offline product distribution on physical media;
- ordering of products implying satellite data acquisitions to be planned by the PDCC;
- support of the Help Desk and Order Desk located at the PDCC.

System Coherence

The complex contractual and engineering environment of the overall ENVISAT-1 system, with its three independent contracts, requires on the one hand an unambiguous and comprehensive definition of the split of responsibilities between the various parties involved and on the other hand close cooperation between these parties to ensure the well coordinated coherent development of an homogeneous system fulfilling the system requirements.

With respect to the PPF and ENVISAT-1 Mission/System programmes this cooperation is well established in all areas relevant to the programme.

The baseline for the cooperation is recorded in a set of documents defining the split of managerial and technical responsibilities as well as providing a clear technical baseline for the interfaces between the payload instruments and the PPF:

- PPF/ ENVISAT-1 Contractor Mutual Responsibility Definition (MuReD),
- ENVISAT-1 Reference Accommodation,
- Payload Applicability Matrix to the PPF SRD for ENVISAT-1,
- Mission Specific Annexes to PPF Support Specifications,
- Avionics Interface Specification,
- Common Interface Control Document (CICD),
- Instrument Specific Interface Control Documents (ISICD's), one per instrument,
- PPF EGSE to IEGSE ICD,
- Satellite Reference Database to Payload Macrocommand and Telemetry Data Definition Database ICD.

All these documents have been agreed between the Agency and the two Prime Contractors (Dornier and MMS-B) as well as, where applicable, with the Instrument Contractors.

Concerning the interface between the satellite and the Ground Segment, a clear document baseline is established:

- Satellite to G/S ICD,
- Payload to G/S ICD,
- Mission Prime Assumptions on G/S
- Flight Operation Manuals for the PPF and all payload elements.
- Satellite Reference Database (telecommand and telemetry) for the PPF and all payload elements.

The Interface of the ENVISAT-1 satellite and ground Segment with ARTEMIS is established:

- Interface Control Document Between The Data Relay System and the ENVISAT-1 System.

The interface with ARIANE 5 is controlled via the:

- Launch System/Spacecraft Interface control File DCI

Numerous Ground Segment documents have been established to control the interfaces, in particular:

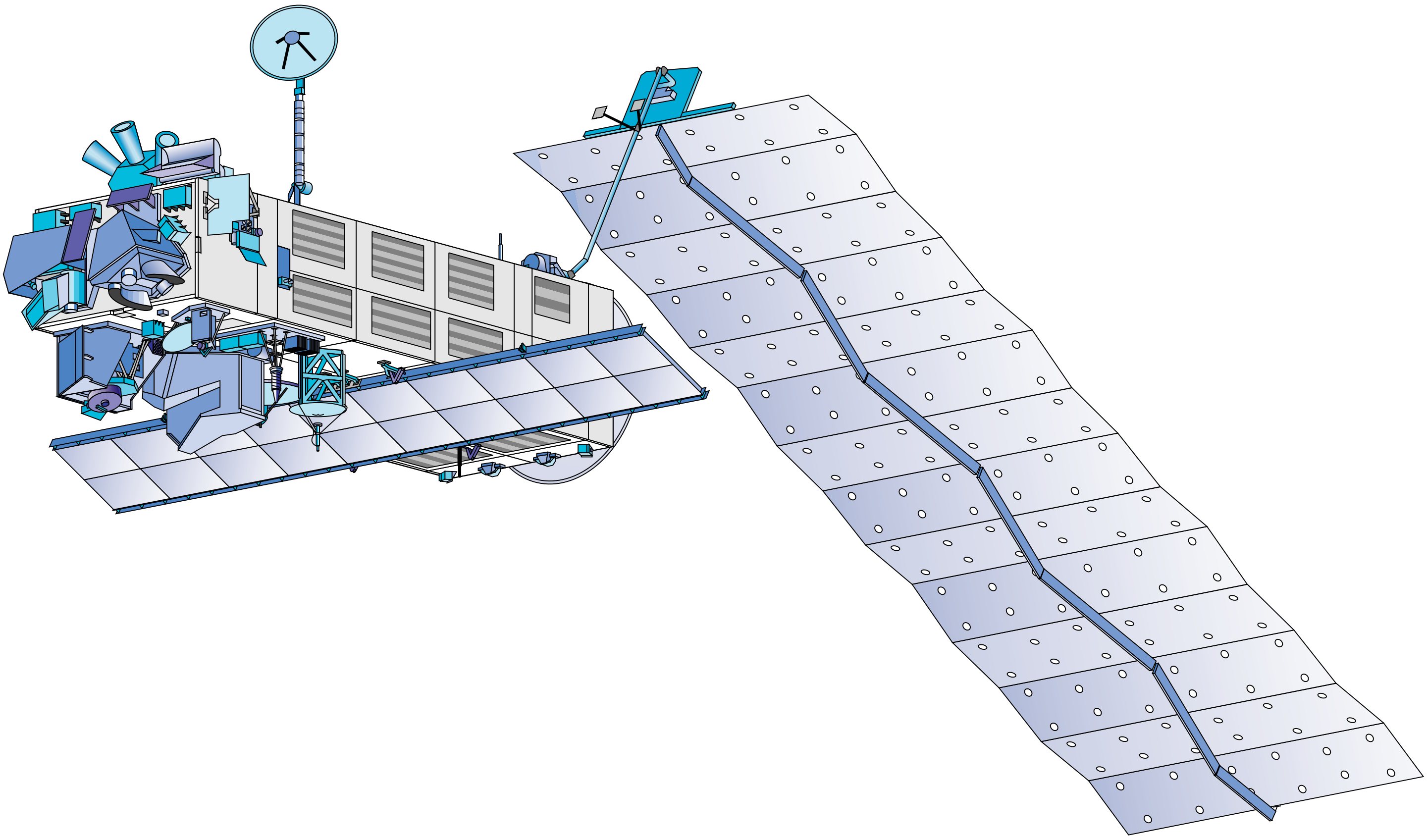
- FOS to PDS interface;
- FOS to AOI provider interfaces;
- PDS to AOI provider interfaces;
- PDS to EMM (ENVISAT-1 Mission Management Interface including Reference Operation Plan and Instrument Calibration tables)

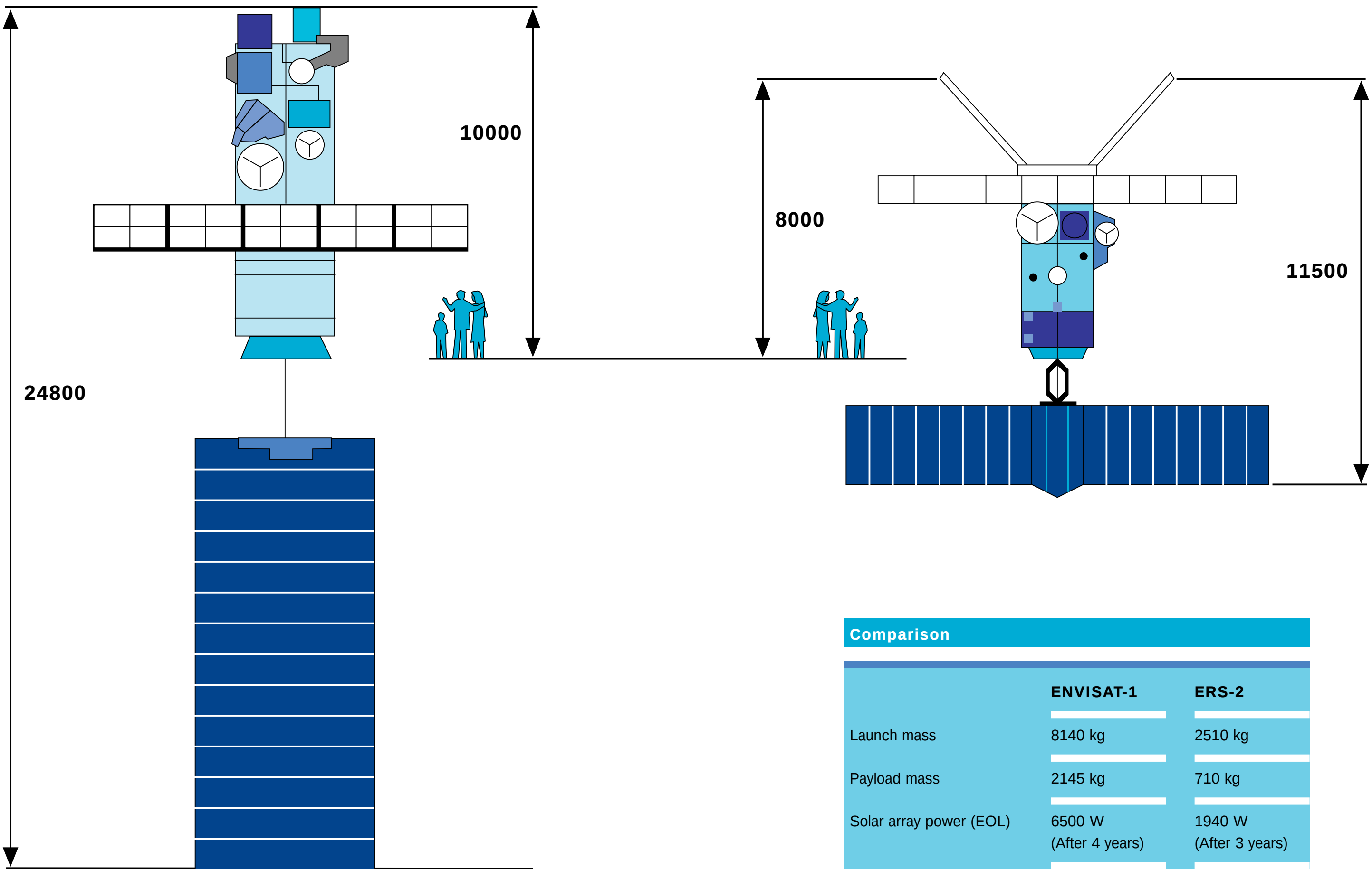
The transfer of information from the ESLS (products and algorithm definition) to the PDS consortium is governed by two documents for each instrument:

- The IODD (Input Output Detailed Definition)
- The DPM (Data Processing Model).

Preparation of the Commissioning Phase, including the instrument in-orbit calibration and the level 2 product validation, is the responsibilty of the ESA Project Team.

The overall ENVISAT-1 system coherency remains the responsibility of the Agency via its Project Team.
A System Overall Verification Plan has been established to ensure that all requirements, as specified in the Mission requirements Document, are properly verified.
A Ground Segment Overall Verification is planned to be performed prior to the Ground Segment Readiness Review. Verification of all ENVISAT-1 Ground Segment external interfaces will be performed, including the Satellite, the interfaces between all the Ground segment elements as well as the capability of the total Ground Segment to support a sustained operation test.



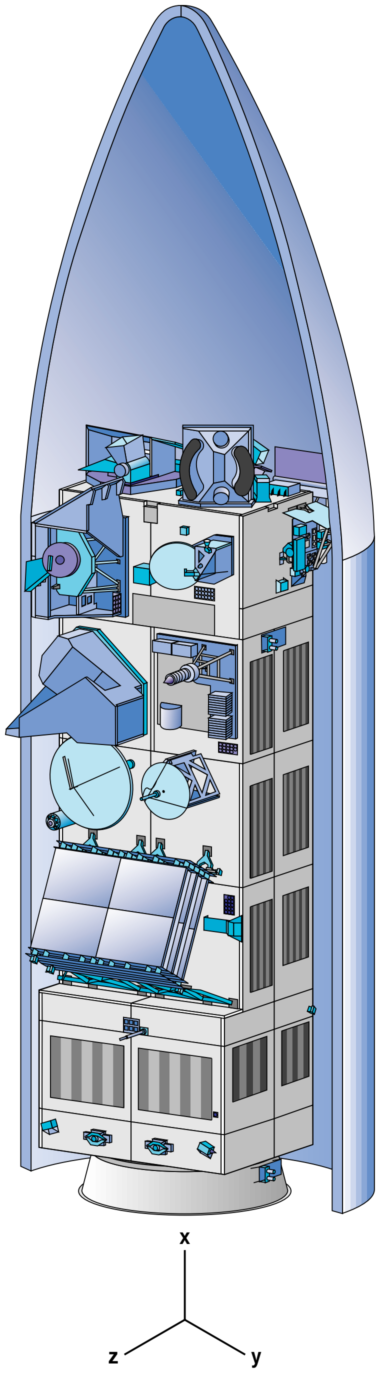


Comparison

	ENVISAT-1	ERS-2
Launch mass	8140 kg	2510 kg
Payload mass	2145 kg	710 kg
Solar array power (EOL)	6500 W (After 4 years)	1940 W (After 3 years)
Instruments	10	5

Satellite

ENVISAT-1 will be the largest free flying satellite built in Europe. Ten instruments, accommodated on the Polar Platform, compose its payload.



PPF/ENVISAT-1
Satellite Launch and Inflight Configuration

Overall Configuration

The major driver for the ENVISAT-1 satellite configuration has been the need to maximise the payload instrument mounting area and to meet viewing requirements whilst staying within the constraints of the Ariane 5 fairing and interfaces.

The most demanding instrument in terms of mass, volume and power resources is the ASAR with an antenna of circa 700 kg but 6 other large instruments also share the satellite resources with mass ranging between 100 kg and more than 300 kg.

In addition, the configuration has been driven by the re-use of the SPOT Mk II Service Module design concept and ERS payload accommodation experience.

This configuration concept provides a large, modular construction, with sufficient Earth facing mounting surface for payload instruments and an anti-sun face, free of occultation by satellite subsystem equipment. In-flight, the spacecraft longitudinal axis (the X-axis) is normal to the orbit plane, the Y-axis is closely aligned to the velocity vector and the Z-axis is Earth pointing.

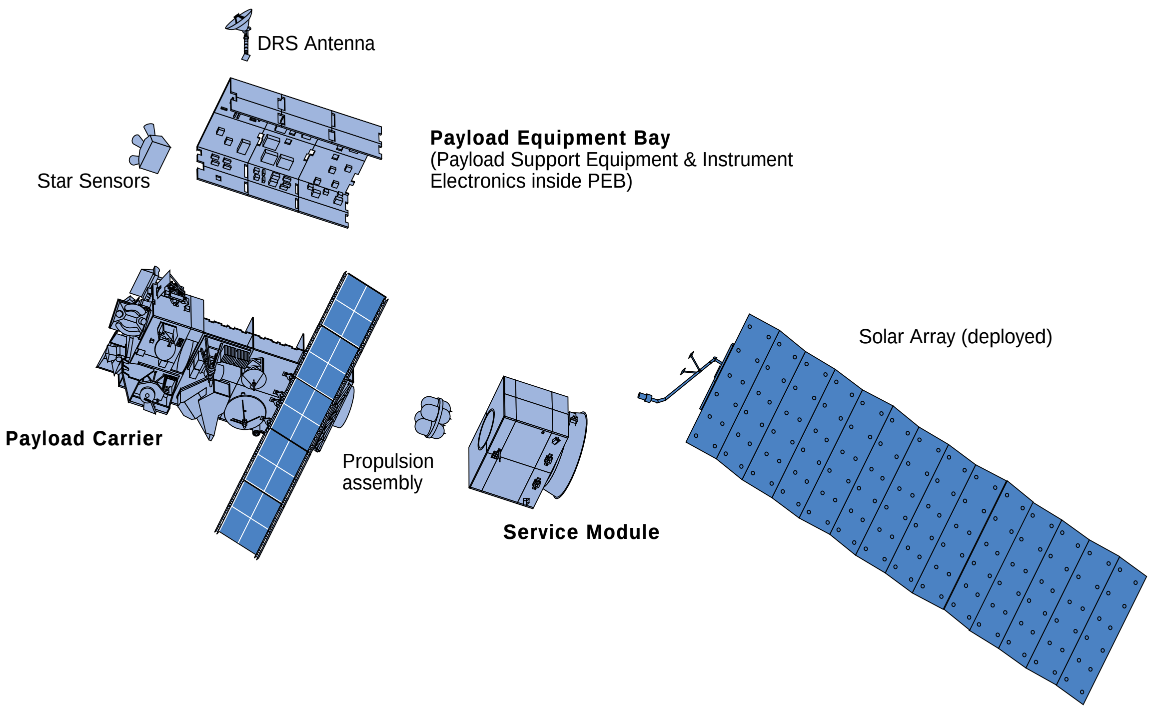
The satellite comprises two major assemblies:

- The Service Module (SM) which provides the main satellite support functions
- The Payload Module (PLM) on which the payload instruments are mounted

The Payload Module itself is composed of three major subassemblies:

- The instruments either externally mounted or partly accommodated in the Polar Platform
- The Payload Equipment Bay (PEB) which accommodates payload support subsystems and some instrument electronics
- The Payload Carrier (PLC) which provides the main structural support for externally mounted instruments and antennas.

This split provides the basis for a convenient physical and functional separation between the Service Module subsystems and equipment which is needed for every mission and those in the Payload Module which are mission specific and therefore dedicated only to the needs of the particular payload complement being flown. In addition, the interface, decoupling at module level, facilitates parallel development and integration of Service and Payload Modules and allows for an efficient satellite AIT programme where only a minimum of system level activity is needed for final verification.



PPF/ENVISAT-1 Functional Split

- PPF / ENVISAT-1 Satellite
  - Payload Module **PLM**
    - Payload Carrier **PLC**
      - ENVISAT-1 Instruments (externally mounted)
        - Instrument antennas (ASAR, RA-2)
        - MERIS, MIPAS, GOMOS optical assembly, SCIAMACHY, MMR, DORIS
      - Support subsystems
        - Mechanical support to instruments and PEB Equipment
        - PLM interface with the SM
        - Mechanical support for AOCS sensors and thrusters
    - Payload Equipment Bay **PEB**
      - ENVISAT-1 Instrument electronics (internally mounted)
        - ASAR, RA-2, GOMOS
      - Support subsystems
        - Payload data management and multiplexing
        - Payload data communications in X- and Ka-band
        - Power distribution for instruments
        - Thermal control for instruments
        - Electrical interface to instruments
  - Service Module **SM**
    - Launcher interface and Payload Module support
    - Power generation, storage and distribution
    - Attitude and orbit control
    - Telemetry, tracking and command
    - Monitoring and control of on-board operations

Design Description

The Service Module (SM) developed by MMS-F, is based on the concept and design of the SPOT Mk II Service Module with a number of important new developments particularly in the area of mechanical design. These include:

- An enlarged Service Equipment Module consisting of a box shaped structure made in aluminium honeycomb panels fabricated around a central CFRP cone which constitutes the SM primary structure. The majority of the subsystem equipment, including additional AOCS actuators to cope with the increased size of ENVISAT-1 compared to SPOT, are located inside this module. At the lower end of the module, the cone provides an increased diameter of 2.6 m for interfacing with the ARIANE 5 launch vehicle adaptor. The upper end of the cone provides the interface to the Propulsion Module and in turn the PLM central cylinder.
- An enlarged Battery Compartment, which comprises the lower 600 mm of the SM central cone attached to an aluminium alloy battery plate, allows installation of 8 batteries.
- A Propulsion Module, which comprises an aluminium alloy machined plate, interfaces to the central cone upper ring. This supports 4 propellant tanks which are attached to the plate through equatorial rings and provide ENVISAT-1 with a fuel capacity of 300 kg of hydrazine.

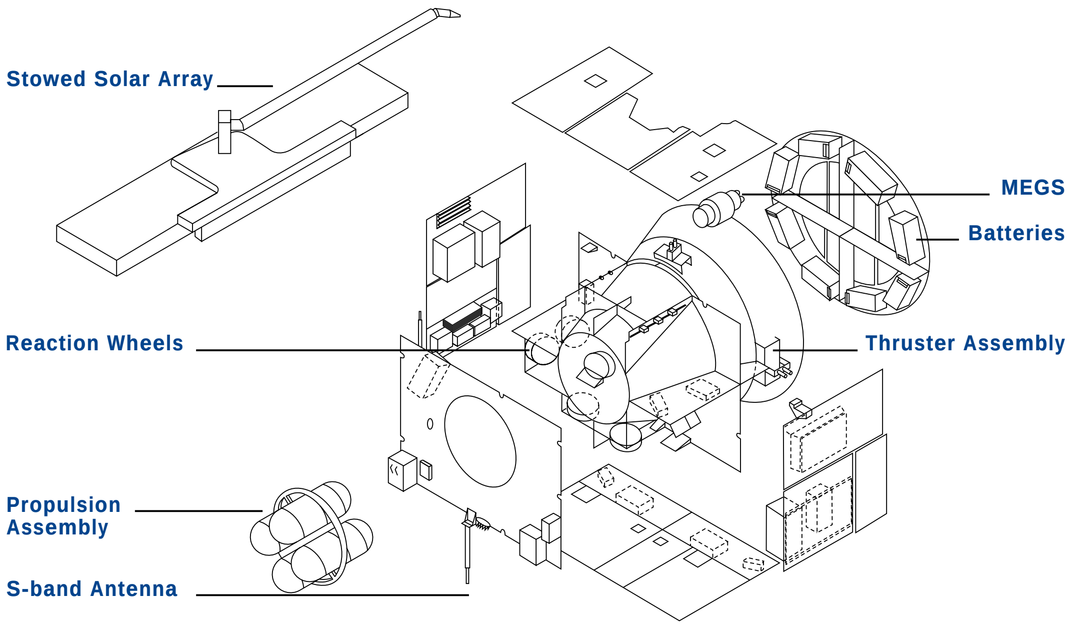
The attitude and orbit control, the reaction control, the power distribution and storage and data handling systems are extensively re-using SPOT developed hardware, either unmodified or with minor modification. In addition, the SM on-board and ground check-out softwares are re-used with only limited modification.

New developments have been carried out in several areas (Structure, Solar Array, S-band Transponder) where no existing design was available to fulfil the requirements. The single wing Solar Array is a new development. The array comprises a primary deployment mechanism and arm plus a set of 14 deployable rigid panels. This array is based on the rigid panel technology developed by ESA and already flown on EURECA. In the launch configuration the array is stowed folded against the zenith faces of the SM and PLM. Once deployed the solar array is rotated to point continuously towards the sun using a solar array drive mechanism which is attached to the base of the SM central cone. The Dual Mode Transponder is another new development compared to SPOT-4. It provides a 2000 bit/s forward and a 4096 bit/s return S-band link capability. Ranging and range rate measurements are performed by ground stations on the range signals transmitted by the transponders in either coherent or non coherent modes.

The Payload Carrier (PLC) provides the main structural support for the PEB and the externally mounted instruments and antennas. In addition the PLC provides accommodation for certain equipment which are functionally part of the PPF Service Module but located on the PLM. These are:

- star sensor optical assembly mounted on zenith face near the forward end of the PLC to allow unobstructed field of view, star sensor electronics, located inside the upper PLC section,
- gyro mechanical assemblies located close to the star sensor optical assembly to minimise misalignment.
- propulsion subsystem thrusters distributed on PLC to provide equalisation of control torques and forces about the satellite centre of mass.

The Polar Platform ProtoFlight Service Module during thermal tests in the ESTEC Large Space Simulator (LSS) View from the top.
Service Module is upside down with Battery Compartment on top and visible on picture.



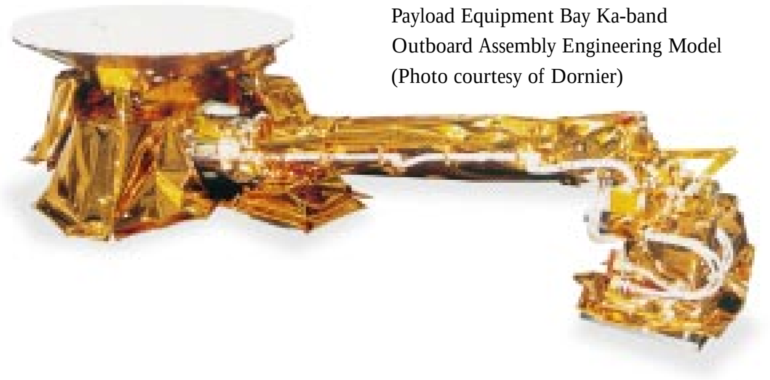
Service Module Design Concept

The Development Model of the Solar Array (fully deployed configuration) (Photo courtesy of Fokker)

The Payload Equipment Bay (PEB) provides all necessary functions to support and control the payload instruments as well as all functions required to handle the scientific data. The U-shaped configuration, consisting of the zenith and side panels of the lower three sections of the Payload Module (PM), houses the following entities:

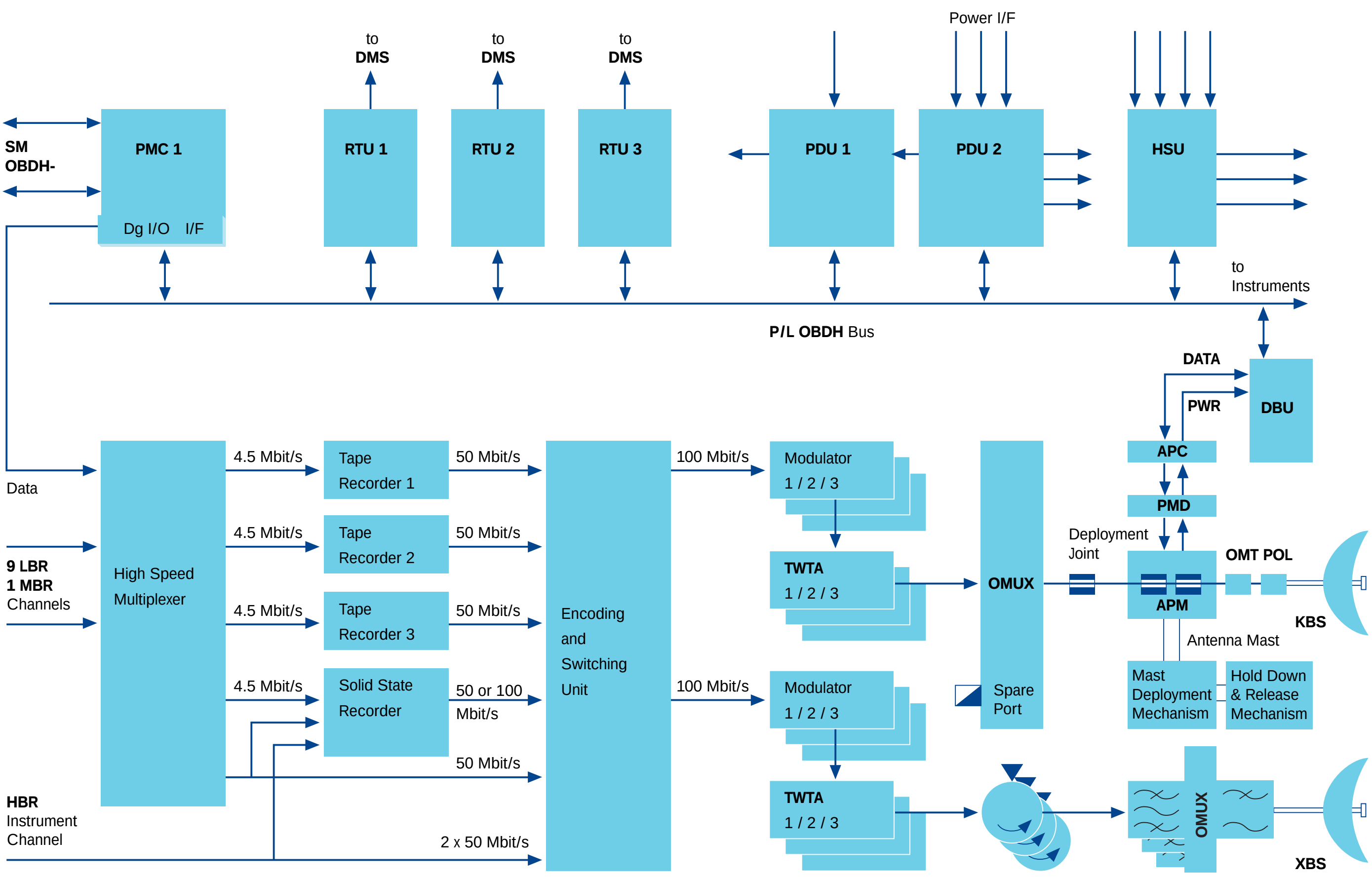
- The Payload Management Assembly comprising the Payload Management Computer (PMC) with its mission specific application software, which controls and monitors via three Remote Terminal Units (RTU's) all PEB functions and via dedicated Digital Bus Units (DBU's) the payload instruments. The RTUS and the DBUS are connected by the On-Board Data Handling (OBDH)-Bus to the PMC.

- The data handling subsystem including:
  - the High Speed Multiplexer (HSM), which can select and assemble the instrument data into a continuous data stream,
  - four 30 Gbit tape recorders, allowing for intermediate storage of HSM output data during periods without direct ground station coverage, and
  - the Encoding and Switching Unit (ESU), to encode and switch hsm, tape recorder play-back or payload high rate data to different downlink channels.
- The X-band transmission subsystem, with three 100 Mbit/s links for direct transmission to ground, comprising the modulators, the Travelling Wave Tubes (TWT) and their power conditioners for signal amplification, the Output Multiplexer (OMUX), which combines the three links prior transmission, and the fixed X-band antenna located on the Payload Module Earth face.
- The Ka-band transmission subsystem, providing three 100 Mbit/s links for data transmission to ground via the Agency's ARTEMIS Satellite. It uses similar modulation and amplification hardware as the X-band subsystem, but requires on the zenith panel an outboard assembly consisting of a deployable mast carrying the Antenna Pointing Mechanism (APM), which controls the antenna pointing to the Data Relay Satellite according to a defined trajectory.
- The power subsystem, comprising two Power Distribution Units (PDU's), one for the PEB and the other for the Instruments and the Heater Switching Unit (HSU) which provides switching to Payload Module heaters under control of the Payload Management Computer.



Payload Equipment Bay Ka-band Outboard Assembly Engineering Model (Photo courtesy of Dornier)

Payload Equipment Bay Functional Block Diagram



Satellite Budgets

A summary of the overall ENVISAT-1 satellite budget figures for mass, power and data rate is given in the table below.

A comparison between the instrument budget figures and the Polar Platform capabilities results in actual margins of around 4,5% for mass and also for power, where the margin depends on the envisaged operation timeline.

These margins are considered adequate at this stage of the development and sufficient to cope with modifications which might be required for the instrument flight models.

The data rate capabilities of the Polar Platform and the demands of the instruments are compatible with each other and the margins are considered sufficient.

The total mass of the satellite is well compatible with the ARIANE 5 capability which is around 10 tons for the ENVISAT-1 orbit.

Satellite Budget Summary

	Mass (kg)	Average Power (W)*		Data Rate (Kbit/s)		
		Sun	Eclipse	Real Time	Low rate Recording	High Rate
Instruments						
EDIs	1657	1432	1488	34838	3371	100000
AOIs	390	264	264	2509	1042	
Formatting Overhead				755	96	
Total instruments	2047	1696	1752	38102	4509	100000
Payload Module (- Instruments)	3099	750	466			
Service Module	2673	827	651	4	4	
(Hydrazine)	319					
Total satellite	8138	3273	2869	38106	4513	100000

*) Reference operation profile applied
Note: No Payload nor PPF level margins or contingencies added.

Platform Capabilities

Payload Mass	2145 kg including attachment hardware
Payload Power	sunlight and eclipse average 1.9 kW peak power 3.0 kW
Payload Data Transmission	2 Ka-band channels, each 50/100 Mbit/s 2 X-band channels, each 50/100 Mbit/s
Payload Data Interfaces	3 Tape Recorders, capacity > 30 Gbit each; recording rate 4.6 Mbit/s; replay rate 50 Mbit/s 1 Solid State Recorder, 60 Gbits capacity, recording ASAR High rate or MERIS Full Resolution, replay rate 50 or 100 Mbit/s 1 high rate channel, 100 Mbit/s 10 low/medium rate channels: 1 channel 0 - 32 Mbit/s 9 channels 0 -10 Mbit/s each

Polar Platform Development Status

The development of the Polar Platform is well advanced. Following the preliminary design phase completed by early 1994 and reviewed by the Agency in the frame of the EMS Preliminary Design Review, held in mid 94, the detailed design has been completed and the manufacturing of electronics units initiated.

During this phase, technology critical equipment and subsystems have been the object of intensive development and breadboarding (ie. 1/3 scaled model solar array, Ka-band Antenna Pointing Mechanism, CFRP structural element, Tape Recorder, etc.). Furthermore, two satellite-level models (configuration model and RFC mock-up) were used for the early verification of the design. An impressive set of Mechanical Ground Support Equipment (Transport containers, integration stands) have been developed as well as basic Electrical Ground Support Equipment able to control and operate the Service Module and Payload Module.

Engineering Model of Polar Platform Payload Module in integration at MMS(B) (GOMOS BB Integrated, RA-2 IEGSE in foreground) (Photo courtesy of MMS(B))

The manufacturing of the structure and structural elements, started in 1994, was the basis for the Structural Model (SM) Polar Platform which, after assembly by MMS(B), was shipped to ESTEC in April 96 to perform the mechanical qualification tests.
For some of the tests mechanically representative models were mounted on the Polar Platform (ASAR antenna, MERIS, MIPAS, SCIAMACHY and AATSR).
The mechanical test programme is now basically complete with the completion of the vibration tests in January / February 1997.

By mid 1996 the Engineering Model (EM) of the Payload Electronics Bay (PEB) has been delivered by DORNIER to MMS(B) for integration into the Engineering Model Payload Carrier to become the Engineering Model (EM) payload module.
The integration of instruments engineering or reduced models has been already completed, allowing to proceed with the satellite EM test programme.

The Flight Model (FM) units of the PEB have been manufactured and integrated into the PEB Flight Model in DORNIER .

The Service Module (SM) is a Proto-Flight Model as most of its electronics units are re-used from the SPOT-4 design. The PPF flight units were manufactured in the time frame end 1994 to mid 1996 and the integration of this module has now been completed.

Interfaces with all the major elements have been finalised. This applies in particular to the launcher and the ARTEMIS system. Detailed interfaces with the instruments which are internal to the satellite have been defined and formalised.

From a contractual viewpoint, the Polar Platform development contract was signed by the Agency and MMS in July 1995 while the ARIANE 5 Launcher contract was signed with ARIANESPACE in November 1996.

ARIANE 5 interface

The ENVISAT satellite will be launched on an ARIANE 5 launch vehicle and separated in-orbit about 24 minutes after launch. The satellite is bolted to an interface ring, which itself provides the interface with the launcher vehicle adaptor separation system.

The interfaces with the ARIANE 5 launcher have been detailed and agreed with ARIANESPACE, the launch authorities. Preliminary definition of the launch activities in Kourou has permitted problem areas to be explored and the major optional services needed from ARIANESPACE defined.

ARTEMIS interfaces (inter-orbit link aspect only)

The ENVISAT Satellite interfaces with ARTEMIS have been worked out in close coordination with the ARTEMIS Project. In 1994, an Agency internal review (Inter Orbit Link Review) was held to review the definition and the status of the interfaces between the two satellites.
All in-orbit and on-ground interfaces are well defined and no problem was encountered during this review.

The Polar Platform and satellite development programme

The development approach used in the European Polar Platform program includes several measures intended to reduce development risks and costs:

- The platform comprises two major functional elements: the Service Module and the Payload Module. Their physical and functional autonomy allows them to be developed, integrated, and tested in parallel.
- The payload instruments, which also have maximum functional autonomy from the polar platform, can be developed and verified separately and integrated with the platform relatively late in the assembly phase for final mechanical, electrical and functional checks.
- In view of the reuse of SPOT-4 equipment in the Service Module, most of its electrical units use designs that have already been qualified. This allows the development of this module to be based on a protoflight approach.

The model philosophy incorporates all these measures. Satellite qualification and acceptance will be achieved by using three basic major satellite models: the Structural Model (STM), Engineering Model (EM), and the actual Flight Model (FM).

In addition, during the development phase, two satellite level models have been used: The Configuration Model, which is a full scale mock-up of the ENVISAT satellite, was used to study accommodation as well as access and compatibility with major AIT activities. The RF Mock-Up (RFMU) spacecraft model is a hardware RF development tool used in support of the overall satellite RF analyses.

- The Structural Model Satellite consists of a fully representative structural model of the PPF and structural models for some of the instruments and mass dummies for others. Its objectives are to achieve mechanical qualification of the structure, verification of mechanical ground support equipment and facility interfaces, and verification of handling procedures.
- The Engineering Model Satellite consists of the Protoflight Service Module assembled with the Engineering Model Payload Module integrated with electrically representative models of the instruments. The objectives are to verify the electrical design and to validate assembly integration and test procedures and aspects related to the satellite's operation.
- The Flight Model Satellite comprises the protoflight Service Module and the flight model Payload Module equipped with the ENVISAT provided instruments. The Flight Model undergoes a complete flight acceptance program and is used for verification of the Payload Module's thermal control system.

The ENVISAT-1
Structual Model during acoustic
testing in the ESTEC LEAF
(Large European Acoustic Facility)


Polar Platform

Payload Instruments

Monitoring a complex system like the Earth's environment clearly demands a specific set of multidisciplinary payload instruments which complement each other. The translation of the mission objectives into the physical and engineering parameters, which finally have to be measured, results in a Payload Complement comprising 10 individual instruments, even using strong selection criteria governed by available financial budget and physical system constraints.
The comprehensive measurement requirements with respect to

- atmosphere,
- biosphere,
- hydrosphere, and
- geosphere

the corresponding distinct physical quantities

- spatial resolution (global and regional data),
- spectral range and resolution, and
- radiometric resolution

will be met by the unique set of two Radar instruments, three spectrometers of different types and measurement characteristics, two different radiometers, broad and narrow band, the first high-resolution spaceborne interferometer for long term observation and two instruments for range measurements.

The Payload Complement embarked on-board the PPF is composed of two categories of instruments reflecting the responsibilities for their development and procurement

- the ESA Development Instruments (EDI's), developed within the ENVISAT-1 programme and
- the Announcement of Opportunity Instruments (AOI's) which will be provided by national or multinational institutions.

ENVISAT-1 Payload Characteristics

	Instruments	**Mass**[1] (kg)	**Power**[1,2] (W)	**Data Rate** (Mbit/s)	**Duty Cycle**	**Geometrical Resolution**	**Wavelength/Frequency Range**	
EDIS	**ASAR**	830	Image: 1365 Wave: 647 ECL: 839 SUN: 751	Image: 100 Wave: 0.9 Global: 0.9	continuously, Image: 30 min Global monit. or wave: rest	Image: 30m x 30m Wide Swath: 150m x 150m Global: 1 km x 1 km	C-band	5.331 GHz
	GOMOS	163	146	0.222	continuously	1.7 km vertical resolution	UV, visible, near IR	250 nm - 952 nm
	LR	2	-	-		-	visible	532 nm 694 nm
	MERIS	207	ECL: 124 SUN: 157	Full res.: 24.0 Red. res.: 1.6	Sun light (43 min.)	Full: 250 m x 250 m Red.: 1 km x 1 km	visible, near IR	390 nm - 1040 nm
	MIPAS	320	195	recorded: 0.53 real time: 8.0	continuously	3 km vertical resolution	mid IR	4.2 µm - 14.6 µm
	MWR	25	23	0.017	continuously	20 km spot beam diameter	K-, Ka-band	23.8 GHz 36.5 GHz
	RA-2	110	161	0.1	continuously		S-, Ku-band	3.2 GHz 13.575 GHz
AOIS	**AATSR**	101	100	0.625	continuously	1 km x 1 km	visible, near IR, mid IR	0.555 µm; 0.67 µm; 0.865 µm; 1.6 µm; 3.7 µm; 10.85 µm; 12 µm
	DORIS	91	42	0.017	continuously	orbit: 10 m radial, 25 m others	S-band	2.03625 GHz; 401.25 MHz
	SCIAMACHY	198	122	recorded: 0.4 real time: 1.867	continuously	3 km vertical resolution	UV, visible near IR	240 nm - 2380 nm
	Total	2047	ECL: 1752 SUN: 1696					

[1] Budget data
[2] Average Values for Reference Operation Profile

Advanced Synthetic Aperture Radar (ASAR)

The Advanced Synthetic Aperture Radar is a high-resolution, wide-swath imaging radar instrument that can be used for site specific investigations as well as land, sea ice and ocean monitoring and surveillance.

Its main objective is to monitor the Earth's environment and to collect information on

- ocean wave characteristics,
- ocean mesoscale features,
- sea ice extent and motion,
- snow and ice sheet extent,
- surface topography,
- land surface properties,
- surface soil moisture and wetland extent,
- deforestation and extent of desert areas,
- disaster monitoring (flooding, earthquake, oil spills, ...).

The major advantage of using a SAR instrument for these Earth observation tasks is its capability to obtain images independent of weather conditions, cloud coverage and sun illumination. Considering in particular observations of disaster like floods or hurricanes which usually happen in adverse weather conditions, this weather independence is of vital importance.

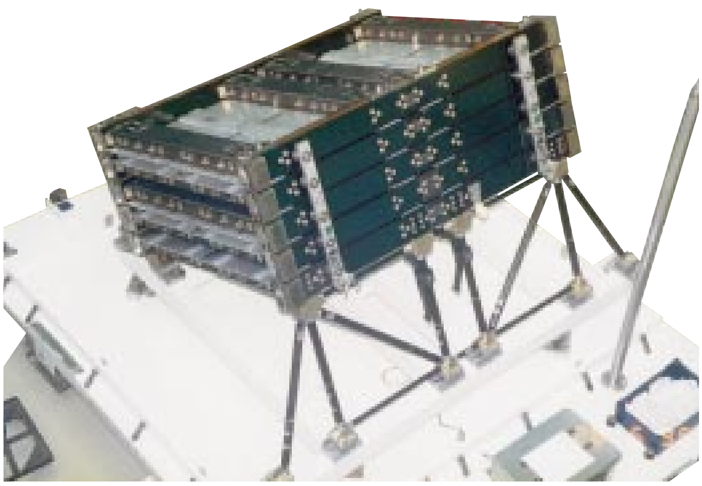
Compared to the ERS-1/2 Active Microwave Instrument (AMI) the ASAR is a significantly advanced instrument employing a number of new technological developments, where the replacement of the passive radiator array of the AMI by an active phased array antenna system using distributed elements is the most challenging one. The resulting attractive improvements are the capability to provide more than 400 km wide swath coverage using ScanSAR techniques and the alternating polarization feature allowing scenes to be imaged simultaneously in vertical (V) and horizontal (H) polarization or a combination of both.

In nominal operation a radar antenna beam illuminates the ground to one side of the satellite. Due to the satellite motion and the along-track (azimuth) beamwidth of the antenna, each target element stays inside the illumination beam for a while.

As part of the on-ground signal processing the complex echo signals received during that time will be added coherently. In this way a long antenna is synthesized with the Synthetic Aperture length being equal to the distance the satellite travelled during the integration time.

The along-track resolution obtainable with the SAR principle is about half the real antenna length. However, to enhance the radiometric resolution multilook azimuth processing will be employed and consequently the along-track resolution will be reduced by a factor equal to the look number.

The across-track or range resolution is a function of the transmitted radar pulse bandwidth. Pulse compression techniques are used to improve ASAR performance taking into account the instrument peak power capability.

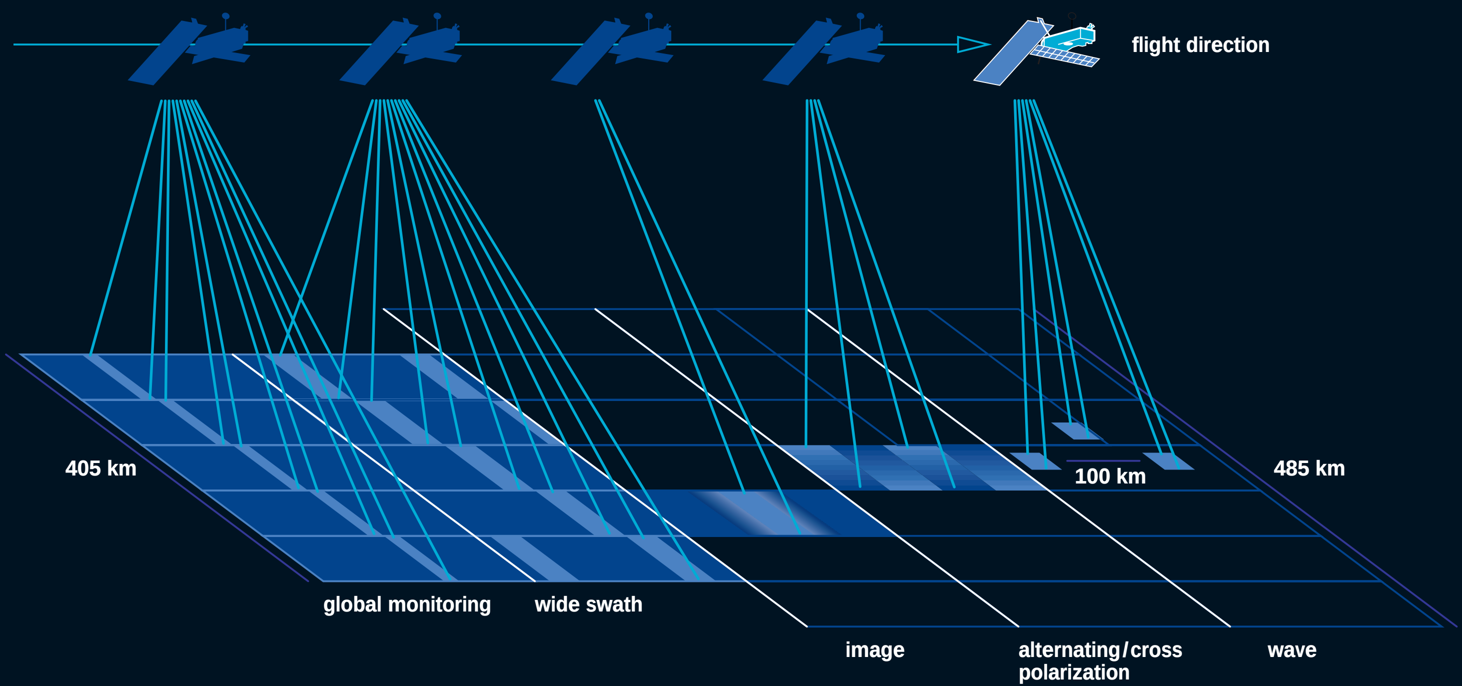


ASAR STM Antenna in Stowed Configuration (Photo courtesy of Oerlikon Contraves)

Instrument Parameters

	Image	Wide Swath	Alternating/ Cross Polarization	Wave	Global Monitoring
Polarization	VV or HH	VV or HH	VV/HH, VV/VH or HH/HV	VV or HH	VV or HH
Spatial Resolution					
along-track	≤ 30 m	≤ 150 m	≤ 30 m	≤ 10 m	≤ 1000 m
across-track	≤ 30 m (~4 looks)	≤ 150 m (~12 looks)	≤ 30 m (~2 looks)	≤ 10 m (single look)	≤ 1000 m (>7 looks)
Radiometric Resolution	≤ 2.5 dB	≤ 2.0 dB	≤ 3.6 dB	≤ 2.3 dB	≤ 1.6 dB
Swath Width	up to 100 km	≥ 400 km	up to 100 km	5 km vignette	≥ 400 km
Ambiguity Ratio (Point)					
along-track	≥ 27 dB	≥ 24 dB	≥ 21 dB	≥ 27 dB	≥ 26 dB
across-track	≥ 30 dB	≥ 24 dB	≥ 25 dB	≥ 30 dB	≥ 24 dB
Ambiguity Ratio (Distrib.)					
along-track	≥ 23 dB	≥ 22 dB	≥ 20 dB	≥ 23 dB	≥ 23 dB
across-track	≥ 13 dB	≥ 13 dB	≥ 13 dB	≥ 17 dB	≥ 13 dB
Radiometric Accuracy (36)	≤ 1.6 dB	≤ 1.5 dB	≤ 2.0 dB	≤ 2.2 dB	≤ 1.8 dB
Centre Frequency			5.331 GHz		
Pulse Repet. Frequ.			1650 to 2100 Hz		
Chirp Bandwidth			up to 16 MHz		
Antenna Size			10 m x 1.3 m		
Operation		up to 30 min/orbit			Rest of orbit
Data Rate	≤ 100 Mbit/s	≤ 100 Mbit/s	≤ 100 Mbit/s	0.9 Mbit/s	0.9 Mbit/s
Mass			830 kg		
Power	1365 W	1200 W	1395 W	647 W	713 W

* except for one far swath



The instrument is designed to operate in the following principal operating modes

- image,
- wide swath,
- alternating polarization mode,
- wave, and
- global monitoring.

In image mode the ASAR gathers data from relatively narrow swaths (100 km within a viewing area of appr. 485 km) with high spatial resolution (30 m), whereas in wide swath mode using SCANSAR techniques a much wider stripe (≈400 km) is imaged with lower spatial resolution (150 m). The alternating/cross polarization mode provides imaging in VV/HH, HH/HV and VV/VH polarization of the same scene with a spatial resolution equal to image mode but reduced radiometric resolution. In wave mode, ASAR measures the change in radar backscatter from the sea surface due to ocean surface waves. In this mode images of 5 km x 5 km are taken over the ocean at a distance of 100 km. In global monitoring mode a wide swath (≈400 km) is imaged with low spatial resolution (1 km).

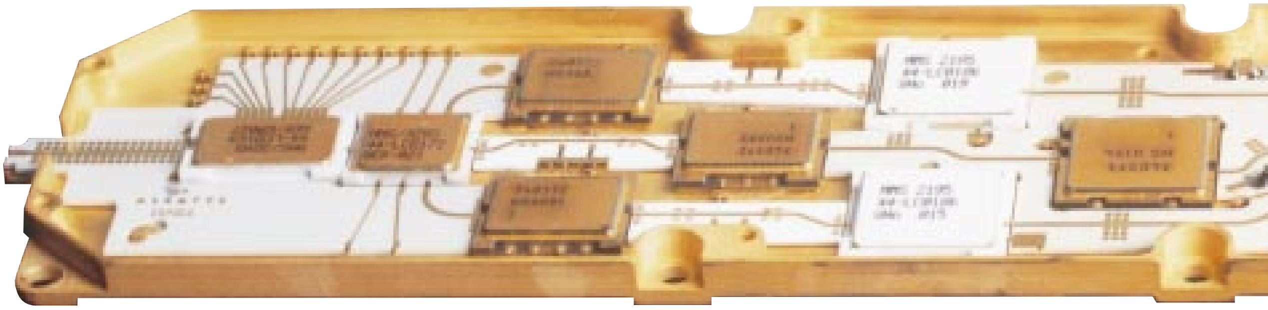
Low data rates are systematically recorded on-board the satellite and high data rates can also be recorded (up to 10 minutes per orbit), thus the operation of the instrument is independent of the availability of direct ground station or ARTEMIS contact. Recorded data will be dumped every orbit via X- or Ka-band link in visibility of an ESA ground station.

The range of products, generated by on-ground processing of the ASAR data, will cover images from land surfaces, arctic and coastal regions, and ocean wave spectra.

In order to obtain comparable measurement results independent of, for example, varying operation scenarii, environmental conditions, or instrument life time, both internal and external calibration will be possible. External calibration can be made by observing a reference target on the ground for each mode, swath, and polarization state. Internal calibration is intended to compensate for changes in the overall gain of the instrument. This is achieved by regular calibration loop measurements including both the central electronics and the transmit/receive (T/R)-modules housed in the antenna.

The ASAR instrument is a phased array radar with T/R-modules arranged across the antenna, such that by adjusting individual module phase and gain, the transmit and receive beams may be steered and configured.

The instrument comprises two major functional groups, the Antenna Subassembly (ASA) and the Central Electronics Subassembly (CESA) with subsystems as shown in the functional blockdiagram. The active antenna contains 20 tiles with 16 T/R-modules each.
The ASAR Instrument is controlled by its Instrument Control Equipment (ICE), which provides the command and control interface to the satellite. Macrocommands are transferred from the Payload Module Controller to the ICE where they are expanded and queued. The ICE maintains and manages the distribution of a database of operational parameters such as transmit pulse and beam characteristics for each swath of each mode and timing characteristics such as pulse repetition frequencies and window timings.
The ICE downloads parameters from the database during transition to the operation mode. The ICE provides the operational control of the ASAR equipment including the control of power and telemetry monitoring.



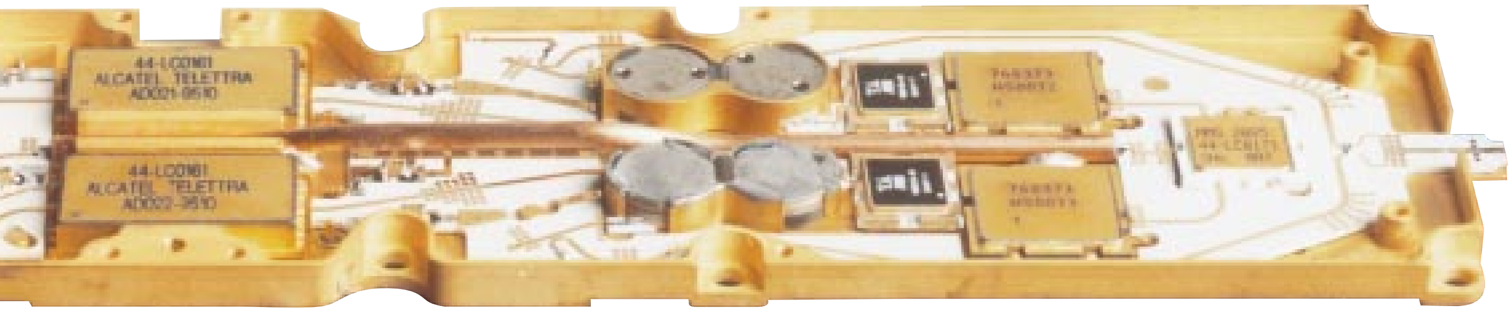
ASAR EM Transmit/Receive Module
(Photo courtesy of Alcatel Espace)

The transmit pulse characteristics are set within the Data Handling Equipment by coefficients in a Digital Chirp Generator which supplies In-phase (I) and Quadrature (Q) components. The output of the Data Subsystem is a composite up-chirp centred at the IF carrier frequency.

The signal is then passed to the RF Subsystem where it is mixed with the local oscillator frequency to generate the RF signal centred on 5.331 GHz. The upconverted signal is routed via the Calibration/Switch Equipment to the antenna signal feed waveguide. At the antenna the signal is distributed by the RF Panel Feed waveguide network to the tile subsystems. The T/R Modules apply phase and gain changes to the signal in accordance with the beamforming characteristics which have been given by the Tile Control I/F Unit (TCIU), taking into account compensation for temperature effects. The signal is then power amplified and passed via one of two feeds (V or H) to the Tile Radiator Panel.
Echo signals are received through the same antenna array, passing to the T/R Modules for low noise amplification and phase and gain changes which determine the receive beam shape. The outputs from each module are routed at RF via the corporate feed and antenna RF distribution system which acts as a combiner, effectively adding signal inputs coherently and noise inputs incoherently.

Coherent RF/IF conversion of the RF echo signals is performed in the Downconverter. This section of the RF Subsystem also includes a selectable, alternative IF path for On-Board Range Compression purposes.
I/Q detection of the IF echo signal is accomplished in the Demodulator of the Data Subsystem. The resulting baseband I/Q signals are further processed in the Data Handling Equipment, which performs digitalization, compression and filtering of this data. After buffering and packetizing, the echo data is transmitted to the measurement date interface.

ASAR is developed under leadership of MMS UK.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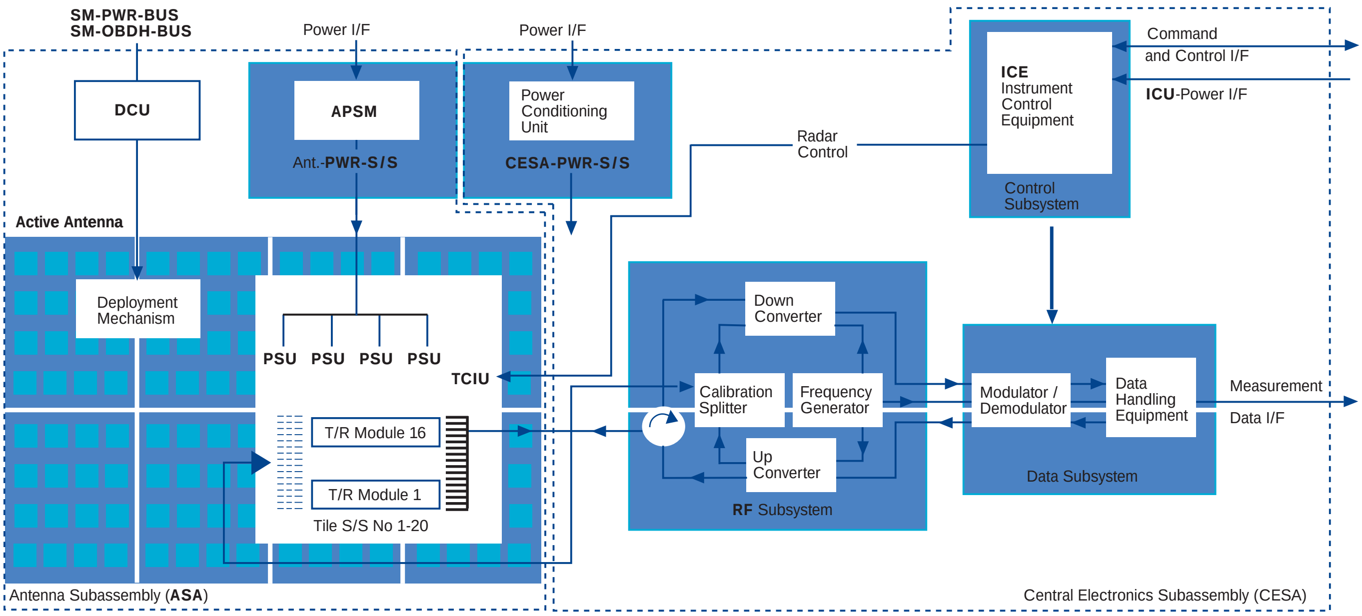

SM-PWR-BUS
SM-OBDH-BUS
Power I/F
Power I/F
DCU
APSM
Ant.-PWR-S/S
Power Conditioning Unit
CESA-PWR-S/S
Command and Control I/F
ICE Instrument Control Equipment
ICU-Power I/F
Radar Control
Control Subsystem
Active Antenna
Deployment Mechanism
PSU PSU PSU PSU
TCIU
T/R Module 16
T/R Module 1
Tile S/S No 1-20
Down Converter
Calibration Splitter
Frequency Generator
Up Converter
RF Subsystem
Modulator / Demodulator
Data Handling Equipment
Measurement Data I/F
Data Subsystem
Antenna Subassembly (ASA)
Central Electronics Subassembly (CESA)

Global Ozone Monitoring by Occultation of Stars (GOMOS)

Ozone depletion in the stratosphere has been recognized as a very critical factor affecting our environment. Accurate means to monitor and consequently understand the relevant chemical processes in the Earth's atmosphere are urgently required.
The GOMOS instrument has therefore been proposed for the ENVISAT-1 Mission. The instrument enables simultaneous monitoring of ozone and other trace gases as well as aerosol and temperature distributions in the stratosphere. Furthermore, it supports analysis of atmospheric turbulences. The overall instrument performance (coverage, spatial and spectral resolution and accuracy) is far superior to previous systems such as SAGE I/II and will therefore improve significantly global monitoring of stratospheric ozone.

The GOMOS instrument has been designed to measure trace gas concentrations and other atmospheric parameters in the altitude range between 20 and 100 km.

The instrument accommodates a UV-visible and a near-infrared spectrometer fed by a telescope which has its line of sight orientated towards the target star by means of a steerable mirror. The instrument then tracks the star and observes its setting behind the atmosphere. Additional measurements provided by two fast photometers allow to correct the spectral data from the high frequency component introduced by the atmospheric scintillations.

The 930 nm band of the near-infrared spectrometer allows to derive vertical profiles of water vapour, which is an important stratospheric constituent. From the 760 nm band of this spectrometer, the vertical temperature profile can be retrieved which adds usefull data for the extraction of the ozone concentration profile and for its long term trend monitoring.

About 25 stars brighter than MV=2 can routinely be observed at different longitudes from each orbit. With 14.3 orbits/day, the GOMOS instrument will produce as much data as a global network of 360 ground stations. The instrument is typically commanded to observe a sequence of up to 50 stars which are repeatedly observed on sequential orbits.

From the spectral analysis, spatial as well as seasonal and long-term temporal information can be derived. As a result detailed maps and trends for various atmospheric constituents and parameters under investigation can be obtained.

The excellent performance of the GOMOS instrument stems from

- the self-calibrating measuring scheme by detecting a star's spectrum outside and through the atmosphere,
- the drift and background compensating measurement algorithms introduced by the use of two-dimensional array detectors, which allow stellar and background spectra to be recorded simultaneously.

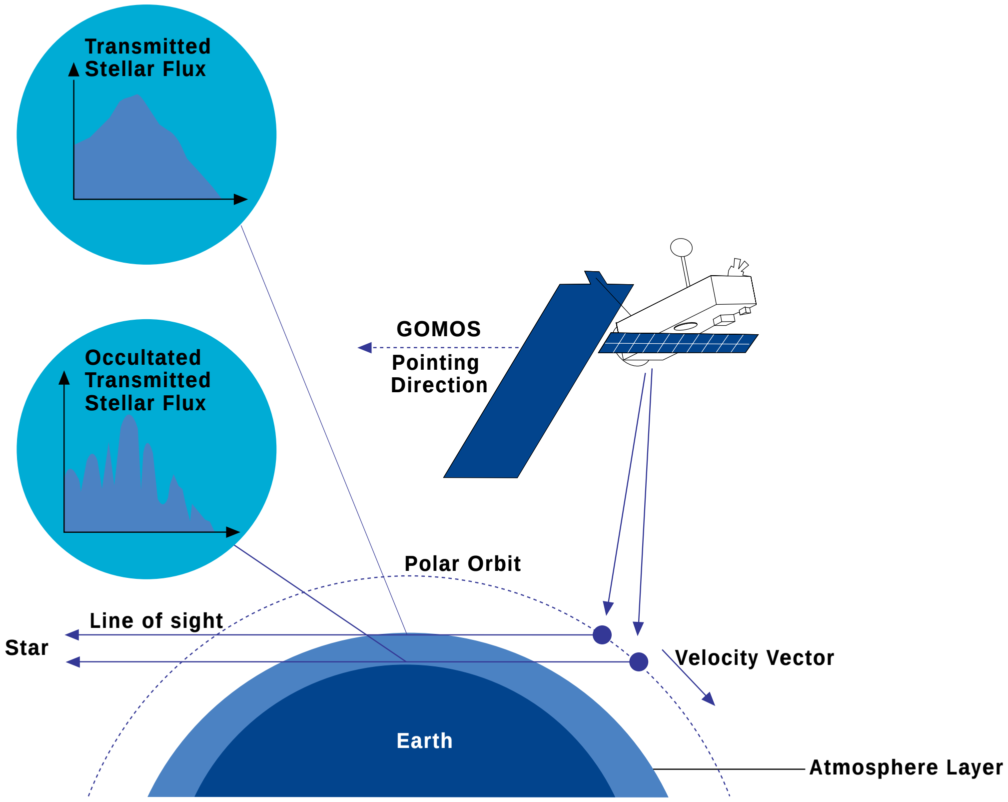
As a result, the spectra are therefore easily corrected for background or straylight and detector dark current contributions. Successive recordings of stellar spectra outside and through the atmosphere allow any long-term changes in spectral emission characteristics as well as drifts in sensor spectral sensitivity to be compensated.

Thus, from simple relative measurements, high stability is obtained. Over a 5 year mission period, ozone level changes as low as 0.05% per year can be detected, far below the actual depletion rate.

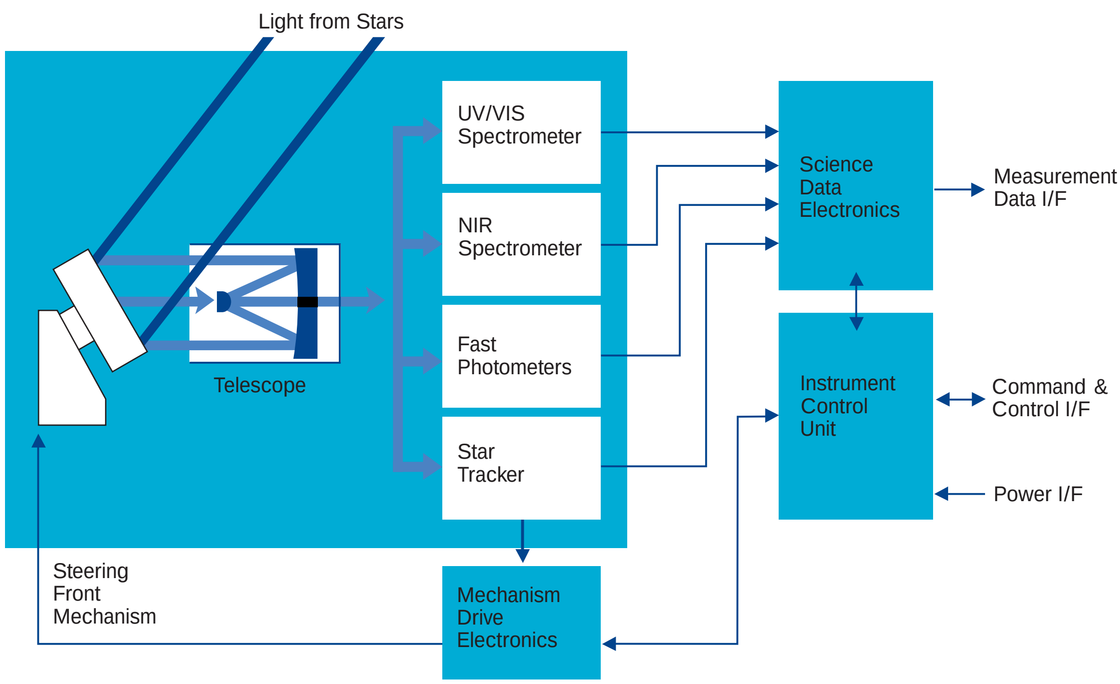
The GOMOS instrument combines two basic functions:

- an optical measurement function, to acquire, record and transmit spectral data of the observed star, and
- a pointing function required to successively point to preselected stars and to accurately maintain the instrument line of sight towards the star setting behind the horizon.

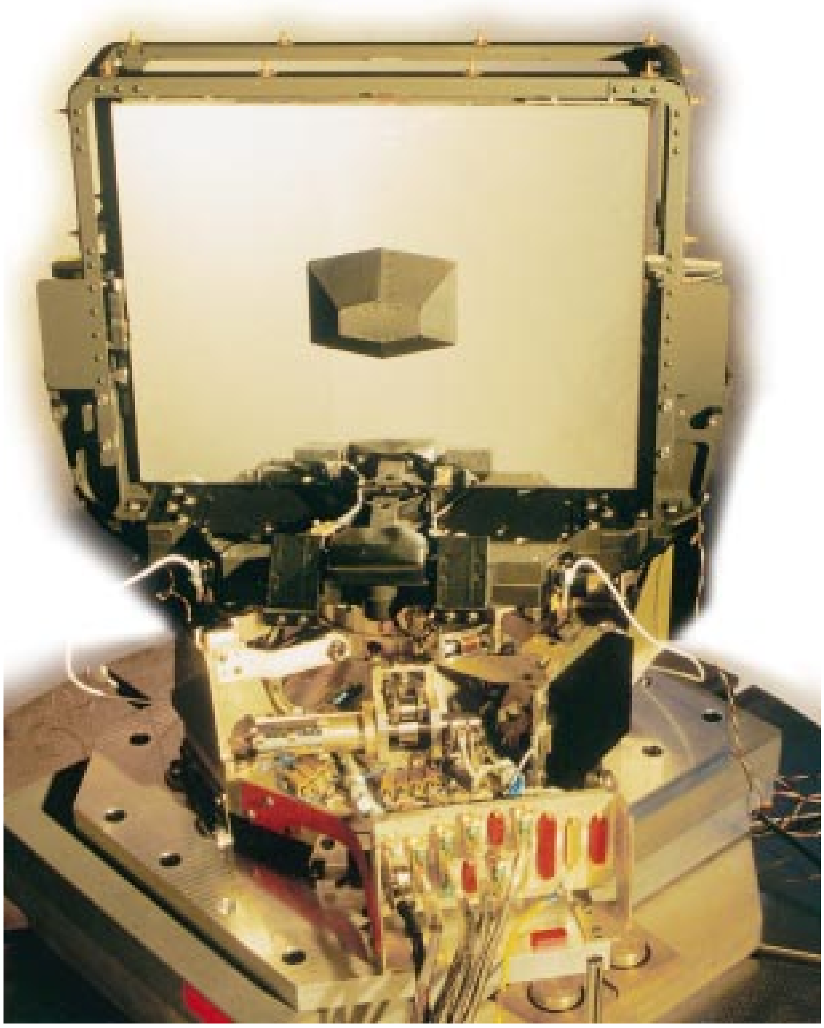
The instrument optical design is based on a single telescope concept: the telescope simultaneously feeds, through an optical beam dispatcher placed at its focal plane, a UV-visible medium resolution spectrometer -for signal measurements in the Huggins and Chappuis bands (250-675 nm) - and a near IR high resolution spectrometer - for O_2 (around 760 nm) and H_2O (around 930 nm) observations. Back illuminated CCD's, operating in Multi-Pin-Phase (MPP) mode, serve as the primary detectors.



GOMOS Functional Block Diagram



GOMOS EM Main Structure
(Photo courtesy of ORS)



GOMOS EM Steering
Front Mechanism
(Photo courtesy of MMS-B)

A redundant CCD based star tracker, which may operate either in dark limb or in bright limb conditions, shares the same focal plane. It provides the pointing and tracking accuracy required to maintain the star image at the centre of the spectrometer's entrance slit during the observation. A fast photometer, equipped with 2 spectral channels, receives part of the telescope signal for a high frequency monitoring (1 kHz sampling rate) of the input signal scintillations.

The single telescope concept has been selected for spectrometers and star tracker co-alignment considerations. The proposed telescope focal plane arrangement allows a common slit for both spectrometers, close to the star tracker detector, and thus avoids the need of any additional alignment correction mechanism.

All the spectrometers, fast photometers and star tracker optics and detection modules are implemented on a thermally controlled CFRP optical bench. This optical bench and the telescope are mounted together and fixed on the instrument interface plate via 3-point attachment.

The Steering Front Assembly (SFA) is made of one flat mirror (300 mm x 400 mm size) mounted on a two stage mechanism. The first stage is the orientator. it is used to move the instrument line of sight towards the target star. This motion is an open loop tracking ending with the star entering the star tracker field of view. The second stage is the tracking device, mounted on top of the orientator. It is operated during the occultation phase, i.e. over a reduced field of view (8° in azimuth and 6° in elevation) and provides the fine centering of the star image within the spectrometers entrance slit. This accurate tracking function is performed by a closed control loop using the star tracker data. The Steering Front Assembly is directly mounted on the instrument interface plate, just in front of the telescope.

An opto-mechanical cover is put around both optical and steering front assemblies to provide the adequate straylight suppression and thermal insulation. It is fixed on the instrument interface plate.

Major electronics subassemblies are the detection Modules, the Science Data Electronics (SDE) which processes the detector signals and outputs the data to the measurement data interface, the Instrument Control Unit (ICU) which performs pointing loop control (using data from the star tracker) and overall instrument management, and finally the Mechanism Drive Electronics which regulates the mirror steering mechanism under the control of the ICU. These electronic boxes are directly mounted on a Payload Equipment Bay panel.

GOMOS is developed under leadership of MMS-F.

Instrument Parameters

	Channel	Spectral Range	Spectral Resolution
Optical Performance Parameters	UV-VIS	250 - 675 nm	1.2 nm
	IR 1	756 - 773 nm	0.2 nm
	IR 2	926 - 952 nm	0.2 nm
	PHOT 1	650 - 700 nm	broadband
	PHOT 2	470 - 520 nm	broadband
Altitude Range	20 km - 100 km		
Vertical Resolution	1.7 km		
Operation	continuously over full orbit		
Data Rate	222 kb/s		
Mass	163 kg		
Power	146 W		

GOMOS Performance Parameter and Budget Data

Medium Resolution Imaging Spectrometer (MERIS)

The Medium Resolution Imaging Spectrometer addresses the needs of three disciplines, primarily oceanographic and secondarily atmospheric and land observations. The main applications are listed below. MERIS, complemented by the RA-2 and AATSR provides a unique synergistic mission for bio/geophysical characterization of the oceans, coastal zones and land leading to application in climate and global environmental studies.

MERIS is a 'push-broom' instrument and measures the solar reflected radiation from the Earth's surface and from clouds through the atmosphere in the visible and near infrared range during daytime. The 1150 km wide swath is divided into 5 segments covered by 5 identical cameras having corresponding fields of view with a slight overlap between adjacent cameras. Each camera images an across-track stripe of the Earth's surface onto the entrance slit of an imaging optical grating spectrometer.

This entrance slit is imaged through the spectrometer onto a two-dimensional CCD array, thus providing spatial and spectral information simultaneously.

The spatial information along-track is determined by the push-broom principle via successive read-outs of the CCD-array. Full spatial resolution data, i.e. 250 m at nadir, will be transmitted over coastal zones and land surfaces as part of the Regional Mission. Reduced spatial resolution data, achieved by on-board combination of 4x4 adjacent pixels across-track and along-track resulting in a resolution of approximately 1000 m at nadir, will be generated continuously and recorded on-board.

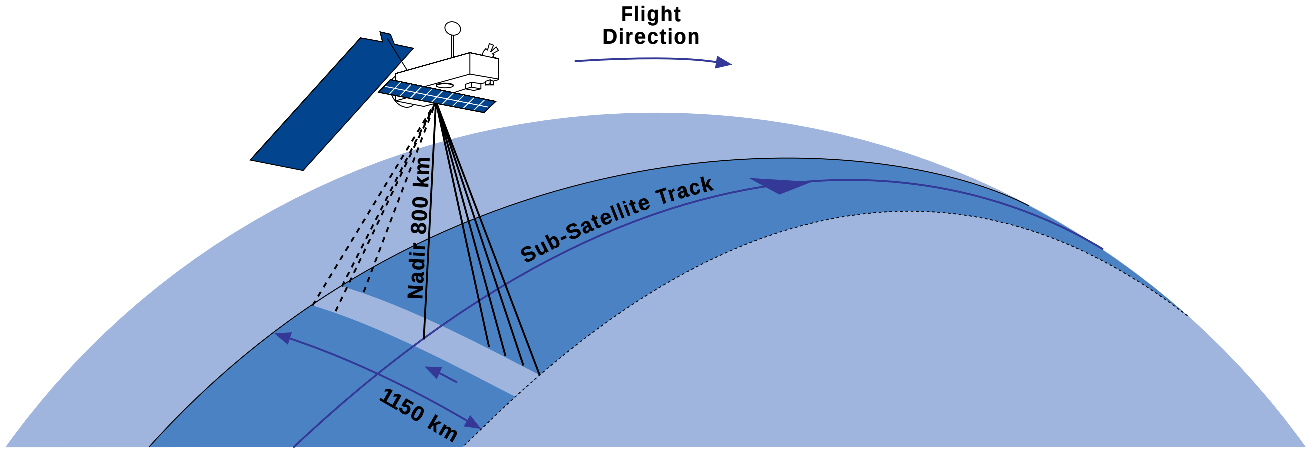
These data will be pre-processed in-flight and further on ground to provide spectral images of the Earth, corrected for the influence of the atmosphere. The data will be used for the generation of large scale maps, for

- ocean pigment concentrations
- clouds and water vapour,
- vegetation status and distribution.

The instrument is optimised for absolute and relative radiometric performances, featuring regular updating of calibration parameters applied on-board via dedicated calibration hardware to achieve long-term stability. In addition, fully programmable on-board processing allows the selection of spectral bands and spectral bandwidths.

Instrument Parameters

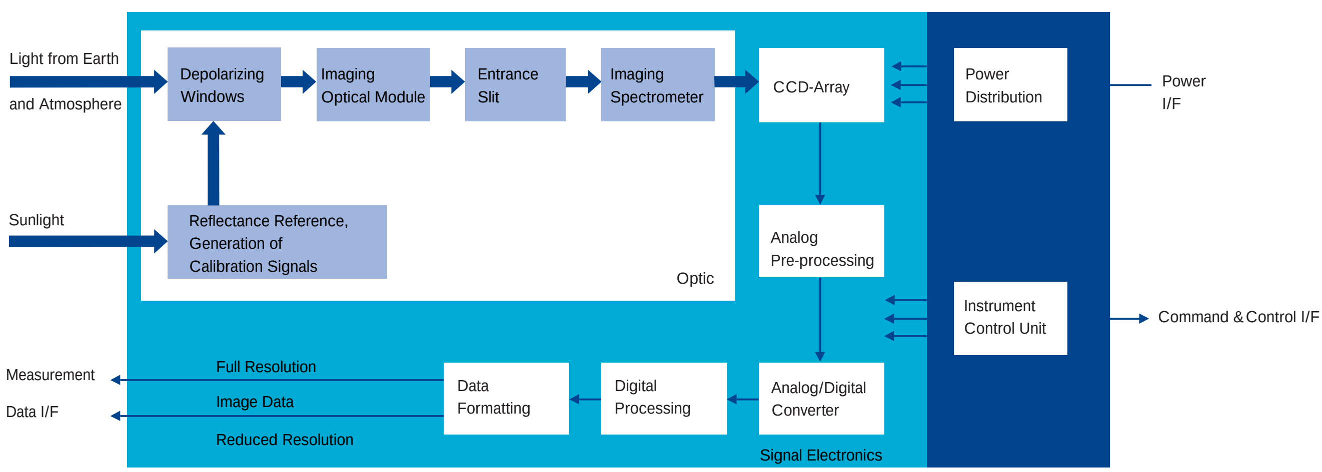
Spectral Range	390...1040 nm
Spectral Sampling Interval	1.25 nm
Spectral Bands	15, centre frequencies programmable
Spectral Bandwidth	1.25...25 nm, programmable
Instrument Field of View	68.5°, equivalent 1150 km swath
Absolute Localisation Accuracy	< 2000 m
Solar Reflectance abs. Accuracy	< 2%
Measurement Modes	full resolution: 0.25 km x 0.25 km at nadir reduced resolution: 1 km x 1 km at nadir
Polarization Sensitivity	< 0.5%
Error of Spectral Position	< 1 nm
Radiometric Resolution	15 µW/ (m2 . sr . nm) at 865 nm (10 nm bandwith, reduced resolution)
Dynamic Range	~ 40 dB
Operation	during day time
Data Rate	24 Mb/s full resolution, 1.6 Mb/s reduced resolution
Mass	207 kg
Power	148 W average



MERIS Observation Parameters

	Ocean	Atmosphere	Land
Monitoring	- chlorophyll - yellow substance - suspended matter	- cloud distribution - cloud top pressure - water vapour column content - aerosols	- vegetation/ biomass - inland water - agriculture/forestry - top pressure
Observation and mapping	- sea pollution - coastal erosion - sea ice		- snow and ice distribution - vegetation stress/calamities (fire)

MERIS Functional Block Diagram



The MERIS optical imaging system is composed of five cameras, each receiving a 14° section of the total instrument field of view.

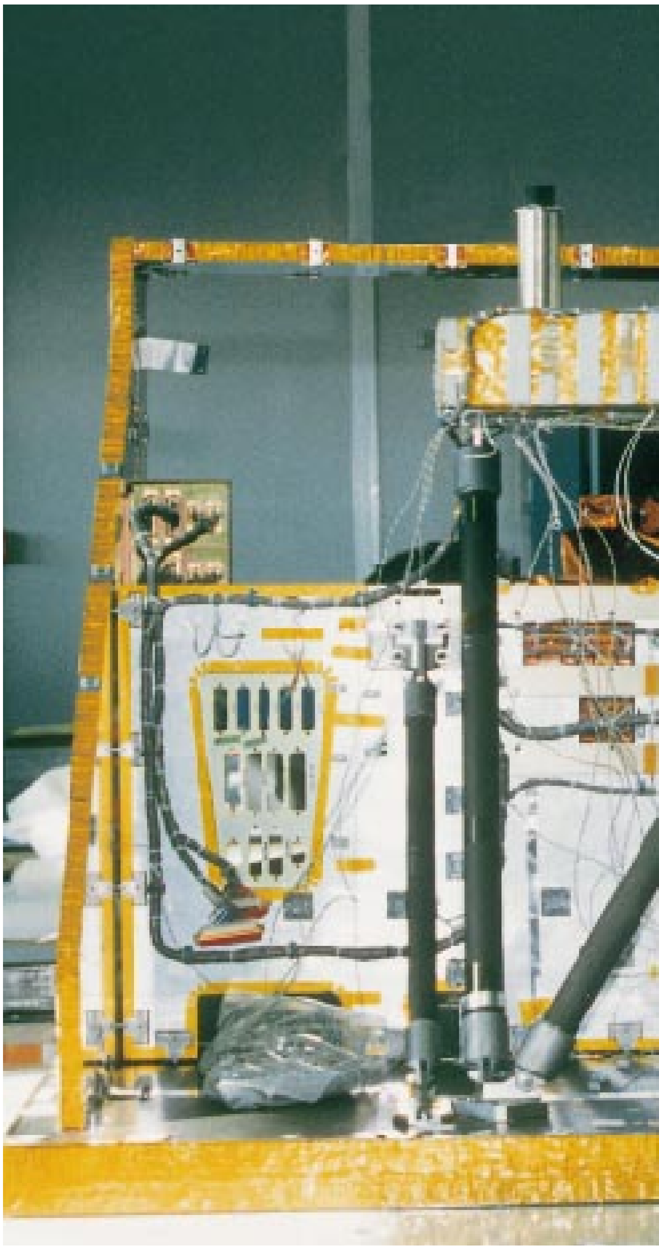
The camera modules receive light from the Earth's surface and the atmosphere or, alternatively from the calibration hardware when illuminated by the sun. Light then passes through the depolarizing windows and is deflected in the along-track direction by a folding mirror located between the windows and the cameras. Each camera comprises of an imaging module and a grating spectrometer. The light is imaged by the optical modules onto the entrance slit of the imaging spectrometers.

In the imaging spectrometer, the light is dispersed and imaged onto the CCD-arrays. The useful image area is 740 spatial pixels (column) by 520 spectral pixels (line). The element size is 22.5 µm x 22.5 µm.

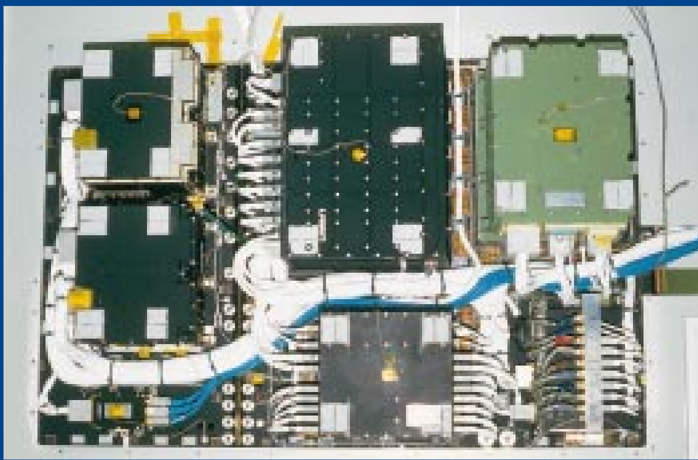
The CCD is coupled to a Peltier cooler stabilizing the CCD temperature to -22°C. After high performance analog pre-processing and digital conversion, data can be corrected by the application of calibration coefficients to the raw data in 15 spectral bands. Each band is selectable in position and width by ground command. On-board data correction is fully flexible allowing uplink and downlink of all calibration parameters as well as programmable bypassing of the correction functions. The MERIS instrument delivers in parallel full and reduced resolution data.

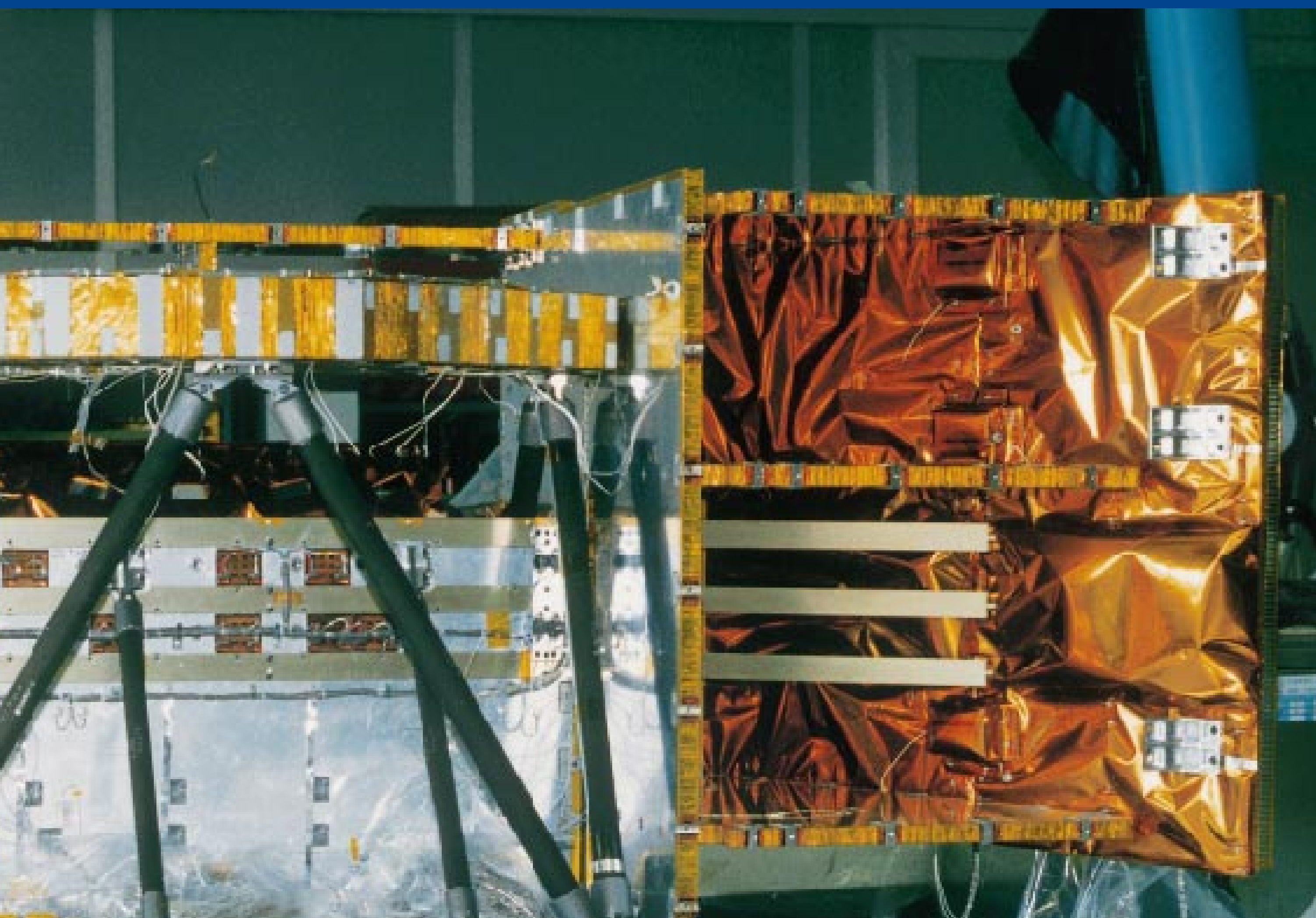
MERIS is developed under leadership of **AEROSPATIALE**.

MERIS EM Electronics
(Photo courtesy of AEROSPATIALE)



MERIS Engineering Model
(Photo courtesy of AEROSPATIALE)





Michelson Interferometer for Passive Atmospheric Sounding (MIPAS)

MIPAS is a high-resolution Fourier Transform Infrared spectrometer which is designed to measure concentration profiles of various atmospheric constituents on a global scale. It will observe the atmospheric emissions from the Earth horizon (limb) in the mid infrared region (4.15 µm - 14.6 µm) providing global observations of photochemically interrelated trace gases in the middle atmosphere, in the tropopause and in the upper troposphere. These data will contribute to the development of a better understanding in the following research areas:

- Stratospheric Chemistry: Global ozone problem, polar stratospheric chemistry,
- Global Climatology: Global distribution of climate relevant constituents,
- Atmospheric Dynamics: transport exchange between troposphere and stratosphere,
- Upper Tropospheric Chemistry: Correlation of gas distribution with human activities.

The instrument is designed to allow the simultaneous measurement of more than 20 relevant trace gases, including the complete NO_y family and several CFCs. The atmospheric temperature as well as the distribution of aerosol particles, tropospheric cirrus clouds and stratospheric ice clouds (including Polar Stratospheric Clouds) are further important parameters which can be derived from MIPAS observations.

The data are obtained with complete global coverage, for all seasons and independent on illumination conditions, allowing measurement of the diurnal variation of trace species.

The atmospheric emissions will be measured at the horizon of the Earth (limb) over a height range of 5 to 150 km. This observation geometry allows the maximum measurement sensitivity and a good profiling capability to be achieved.

The MIPAS data products are calibrated high-resolution spectra which are derived on ground from the transmitted interferograms. From these spectra, geophysical parameters such as trace gas concentrations, temperature profiles, mixing ratios, are retrieved permitted to establish global maps of atmospheric constituents in geophysical coordinates.

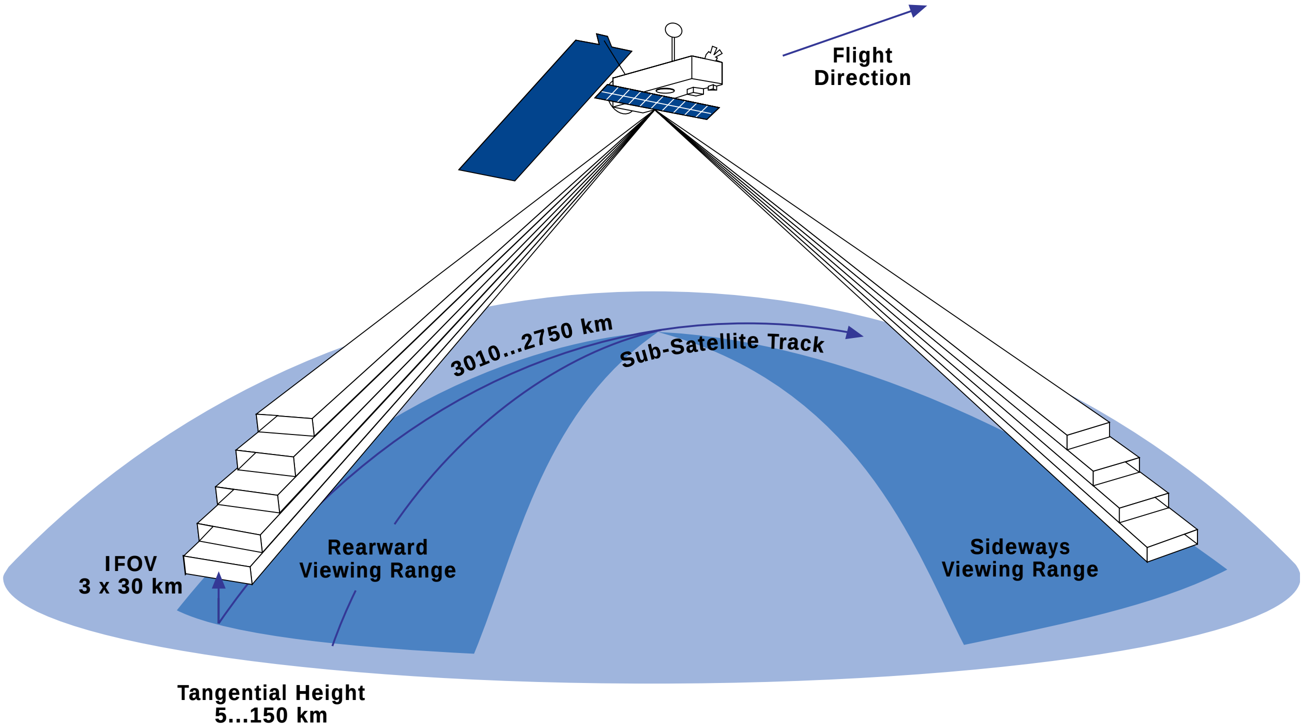
MIPAS will perform measurements in either of two pointing regimes: rearwards within a 35° wide viewing range in the anti-flight direction and sideways within a 30° wide range on the anti-sun side. The rearward viewing range will be used for most measurements, since it provides a good Earth coverage including the polar regions. The sideways range is important for observations of special events, like volcano eruptions, trace gas concentrations above major traffic routes or concentration gradients across the dawn/dusk border.

In nominal measurement mode, MIPAS will perform series of measurements at different tangent heights by performing elevation scan sequences with a duration of 75s in the rearward viewing range. Such an elevation scan sequence comprises typically 16 interferometers sweeps.
For special event observations, viewing elevation scans sequences in the sideways range can be commanded.

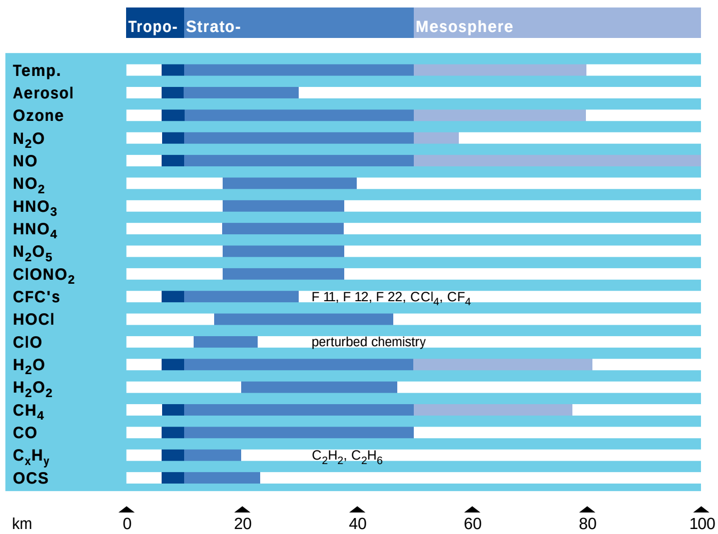
Radiometric calibration will be performed using two measurements:

- gain calibration approximately once per week, applying a two-point calibration method, where radiances from deep space and an internal blackbody are recorded in sequence,
- offset calibration, prior to every elevation scan sequence, in order to correct for the instrument self-emission.

Another calibration mode will be required for the in-flight determination of the line-of-sight pointing direction, which is based on the observation of stars crossing the instrument field of view and subsequent correlation of the actual with the predicted time of star crossing.



MIPAS Measurement Species



Instrument Parameters

Instrument NESR$_0$	between 50 nW $cm^{-2}sr^{-1}/cm^{-1}$ at 685 cm^{-1} and 4.2 nW $cm^{-2}sr^{-1}/cm^{-1}$ at 2410 cm^{-1}
Radiometric Accuracy	2 . NESR$_0$ + 2 % to 5 % of source radiance depending on wavelength
Spectral Coverage	685 cm^{-1} to 2410 cm^{-1}
Spectral Resolution	< 0.035 cm^{-1}
Spectral Stability Goal	< 0.001 cm^{-1} over 1 day
Elevation Scan Range	between 5 km to 150 km tangential height
Azimuth Scan Range	between 80° - 110° and 160° - 195° w.r.t. flight direction
Line of Sight Pointing Knowledge	< 1.8 km in tangential height
Line of Sight Stability	< 500 m/4 s in tangential height
Detectors Oper. Temperature	65 K - 75 K
Operation	continuously over full orbit
Data Rate	533 kb/s; Raw Data Mode 8 Mb/s
Mass	320 kg
Power	195 W

MIPAS Performance Parameter and Budget Data

The MIPAS blockdiagram depicts the functional elements and their relationship. The radiation emitted from the observed scene will enter MIPAS through the Front-End Optics comprising an azimuth scan mirror, an elevation scan mirror and a telescope. The radiation propagates through a dual slide, dual port Michelson-type interferometer, which is designed to provide an unapodized spectral resolution of better than 0.035 cm^{-1} throughout the observed spectral range.

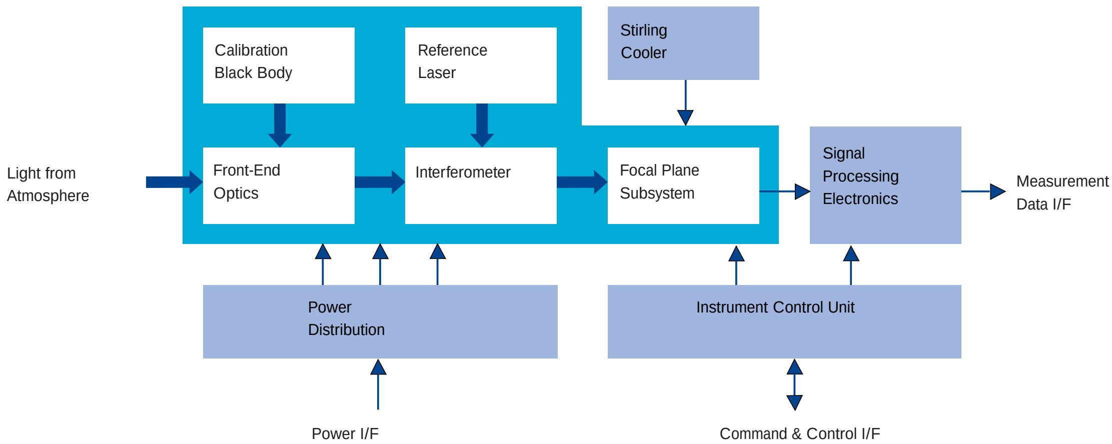
The input signals are divided at the beamsplitter inside the interferometer and directed to cube corners moving at a constant velocity of 25 mm/s along a path of 100 mm. Hence one spectrum is typically recorded within 4 s. From the cube corners the IR beam is reflected to the beam recombiner and then directed to the output ports.

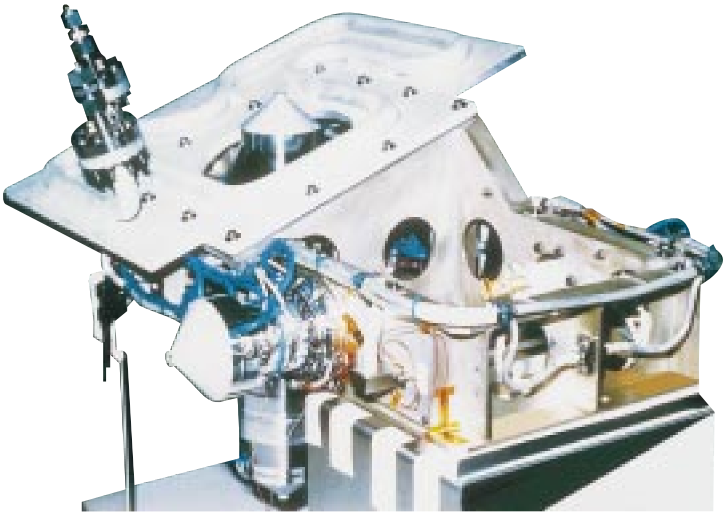
Depending on the optical path difference in the two interferometer arms, the recombined signal is an intensity modulated interferogram. The optical path difference signal for the interferogram sampling is derived from a reference laser the interferogram.
The output signal enters the Focal Plane Subsystem where beam size matching, beam splitting and optical filtering is performed.

After optical filtering the input spectrum is separated into eight narrow spectral bands for detection by eight Hg:Cd:Te-detectors operating at about 70 K.
After pre-amplification, the eight signals are amplified, lowpass filtered and digitized by the analogue processing part of the Signal Processing Electronics. Its digital part separates the spectral range of interest by complex filtering, undersamples the input sequences individually and equalizes channels to be combined. Word length truncation is then performed to reduce the data rate for downlink budget reasons. In a final processing step, measurement data is multiplexed and formatted to source packets. On ground, the incoming source packets are sorted according to measurement/calibration data and the interferograms are converted into calibrated spectra.

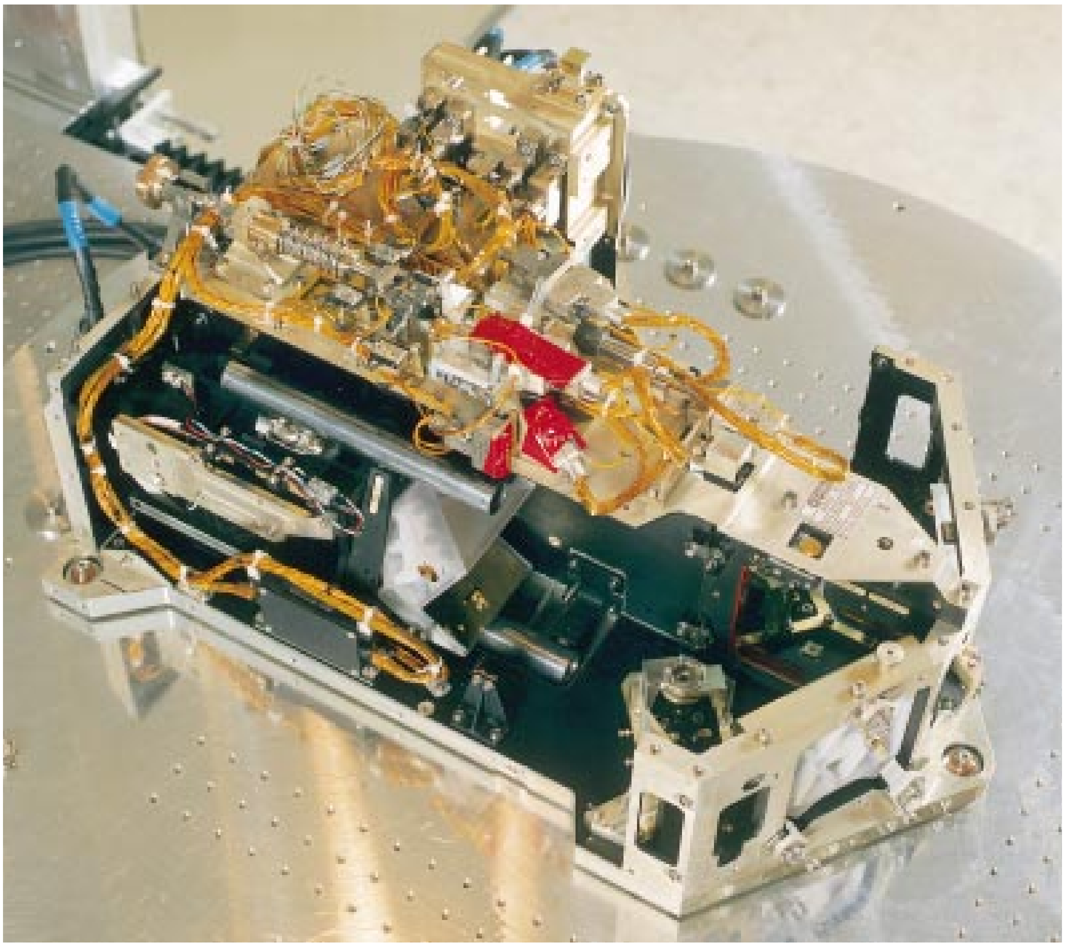
MIPAS is developed under leadership of Dornier Satellitensysteme GmbH.

MIPAS Functional Block Diagram





MIPAS EM Cooler with Radiator
(Photo courtesy of Dornier)



MIPAS Interferometer
Engineering Model
(Photo courtesy of Dornier)

Radar Altimeter 2 (RA-2)

The Radar Altimeter 2 is a dual-frequency (Ku-band, S-band) altimeter derived from the ERS-1/2 Radar Altimeters, providing improved measurement performance and new capabilities.

The main objectives of the RA-2 are the high-precision measurements of the time delay, the power and the shape of the reflected radar pulses for the determination of the satellite height and the Earth surface characteristics.

RA-2 transmits radio frequency pulses which propagate at approximately the speed of light. The time elapsed from the transmission of a pulse to the reception of its echo, reflected from the Earth's surface, is proportional to the satellite's altitude. The magnitude and shape of the echoes contain information on the characteristics of the surface which caused the reflection.

On-board the satellite, RA-2 measures, with respect to transmission, the power level and time position of the samples of the earliest part of the echoes from ocean, ice and land surfaces. This result is achieved by one of the new features on RA-2: a model-free tracker in the on-board signal processor keeps the radar echoes within the sampling window. Window position and resolution are controlled by algorithms developed to suit the tracking conditions.

Operating over oceans, these measurements are used to determine the ocean surface topography, thus supporting studies of ocean circulation, bathymetry, gravity anomalies and marine geoid characteristics.

The on ground processing of the radar echo power and shape enables the determination of wind speed and significant wave height in the observed sea area, contributing to weather and sea state forecasting.

Furthermore, the RA-2 is able to map and monitor sea ice and polar ice sheets.

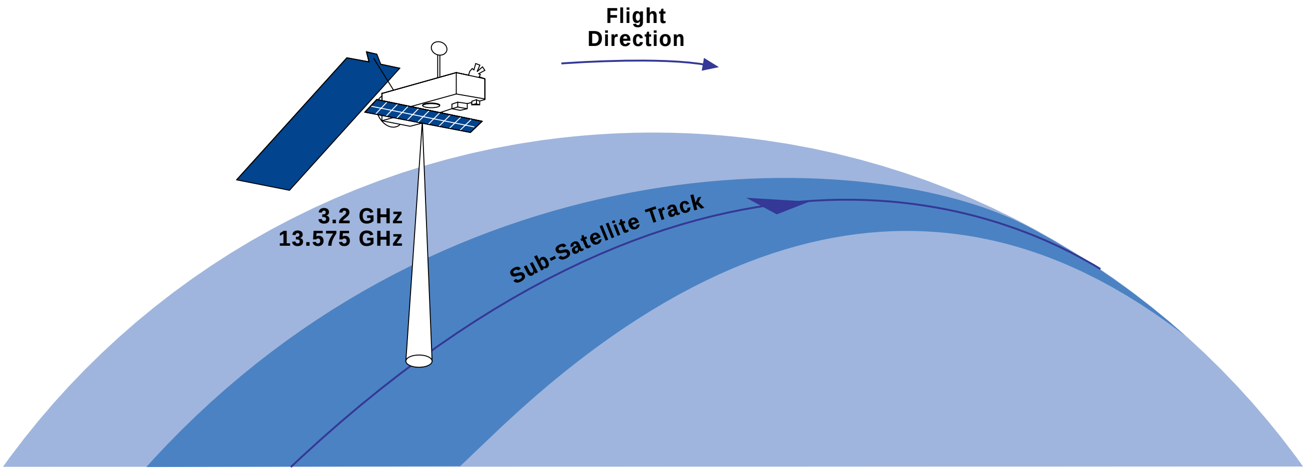
The new features of RA-2 enable it to extend its measurements of altitude and reflectivity over land. The measurements will be used for the determination of Earth surface elevation, geological structure and surface characteristics.

Adaptive height resolution operation is implemented by selecting the bandwidth of the transmitted pulses. As a result, measurements over ocean are carried out with improved accuracy at the highest resolution. Over land or ice or during transitions from one kind of surface to another, the tracking is maintained accepting sometimes a certain degradation of the height resolution.

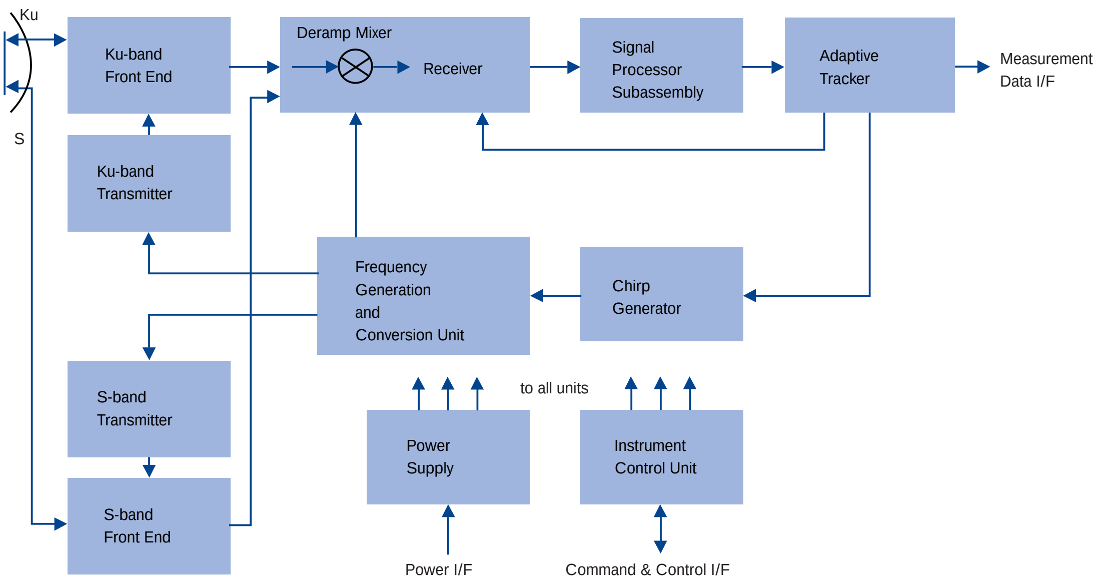
Accurate altitude measurements over the ocean carried out by RA-2 at the main frequency of 13.575 GHz are affected by fluctuations in ionospheric characteristics. Measurements at a second frequency channel of 3.2 GHz enable corrections for this error.

Instrument Parameters

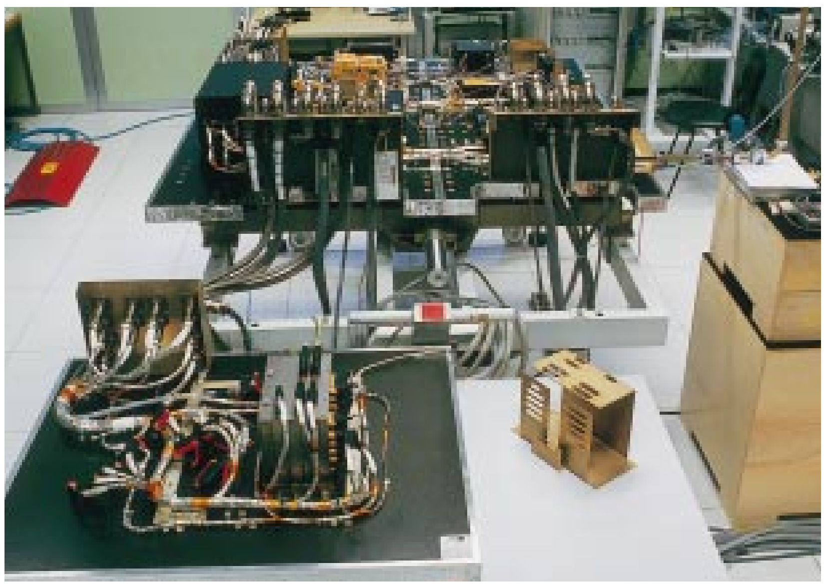
	Range	Accuracy
Altitude	764 km to 825 km	< 4.5 cm (highest res.)
Backscatter Coefficient	-10 dB to +50 dB	< 0.4 dB (bias) < 0.2 dB (residual)
Waveheight	0.5 m to 20 m	< 5 % or 0.25 m
Measurement Datation	+/- 100 µs wrt. UTC	
Operating Frequency	13.575 GHz (Ku-band) 3.2 GHz (S-band)	
Bandwidth	320 MHz & 80 MHz & 20 MHz & CW (Ku-band) 160 MHz (S-band)	
Pulse Repetition Frequency	1795.33 Hz (for Ku-band) 448.83 Hz (for S-band) interleaved operation	
Pulse Width	20 ms	
IF Bandwidth	6.4 MHz	
Operation	continuously over full orbit	
Data Rate	100 kb/s	
Mass	110 kg	
Power	161 W	



RA-2 Functional Block Diagram



RA-2 EM Antenna
(Photo courtesy of Alenia Aerospazio)



RA-2 EM Electronics
(Photo courtesy of Alenia Aerospazio)

Echo samples are processed on ground to account for correction and calibration data. On-ground algorithms allow extraction of precise satellite altitude, wind speed and significant wave height over the oceans.

RA-2 is a nadir-pointing pulse limited radar altimeter which transmits frequency modulated pulses.
The transmit pulses are generated in the Chirp Generator by means of Surface Acoustic Wave (SAW) devices, up converted in the Frequency Generation and Conversion Unit and finally amplified by the High Power Amplifier (HPA) or the S-band Transmitter (STX), depending on the transmit carrier frequency.
The HPA uses a travelling wave tube whilst the STX applies solid state technology. The Ku-band Front End Electronics (KFEE) or the S-band Front End Electronics (SFEE) feed the signals to be transmitted from the HPA or the STX respectively to the antenna which is designed as a dual frequency parabolic antenna.

The radar echo is received by the antenna and led via the KFEE or the SFEE to the Microwave Receiver.
Then each echo signal is mixed with a replica of the transmitted chirp (deramping chirp) to map the echo signal from time into frequency domain.
The resulting signal is filtered, amplified and down-converted. A phase detector produces the base band in phase and quadrature components. These signals are fed to the Signal Processing Subassembly (SPSA) where they are sampled and analog-to-digital converted. Then, a 128-point complex fast Fourier transform, square-modulus extraction and averaging are applied to the samples to produce an averaged signal power spectrum.

A software implemented robust tracking algorithm keeps the leading part of the echo spectrums independent of their shapes within the sampling window by appropriate positioning of the deramping chirps such that they will coincide with the echo signals and, if necessary, by appropriate adaptation of the chirp bandwidth and thereby of the sampling window resolution.

There are three chirp bandwidths available: 320 MHz, 80 MHz and 20 MHz. In general, the tracking is performed with the highest possible resolution corresponding to 320 MHz. A second tracking algorithm controls the receiver gain.

For the initialization of the tracking and after loss of tracking an acquisition routine detects the radar echoes and presets the tracking parameters in order to allow the start of the tracking. The indication of loss of track with the following acquisition and transitions between acquisition and tracking are performed autonomously.
The acquisition uses unmodulated radar pulses.
The echo detection is performed from the end to the beginning of the receive window in order to avoid rain detection.

Simultaneously to the tracking, the RA-2 performs periodically internal calibration measurements. For this the transmit pulse is coupled into the receiver by means of a calibration coupler (-100 dB) within the KFEE/SFEE.
The signal is amplified, deramped, filtered etc. as the normal radar echo signals are. The power spectrum of this signal which is extracted by the SPSA represents the point target response of the instrument thus indicating all residual errors and distortions in the transmit/receive path of the instrument (except the antenna and the antenna feeders which have to be characterized separately on-ground).

All measured data, the radar echo spectrum samples, the point target response spectrum samples, etc. together with auxiliary data which are necessary for the evaluation of the measured data, e.g. the instrument parameter settings, measurement datation data and other are sent to ground for further processing. On command, the RA-2 is able to transmit also bursts of single radar echo samples (ADC outputs) to ground.

The RA-2 is developed under leadership of Alenia Aerospazio.

Microwave Radiometer (MWR)

The main objective of the Microwave Radiometer is the measurement of atmospheric humidity as supplementary information for tropospheric path correction of the Radar Altimeter signal, which is influenced both by the integrated atmospheric water vapour content and by liquid water. In addition, MWR measurement data are useful for the determination of surface emissivity and soil moisture over land, for surface energy budget, investigations to support atmospheric studies and for ice characterization. The MWR instrument on-board ENVISAT-1 is a derivative of the radiometers used on the ERS-1 and ERS-2 satellites. It is a dual channel, nadir pointing Dicke type radiometer, operating at frequencies of 23.8 GHz and 36.5 GHz.

In order to eliminate Earth's irradiation, differential measurements at two frequencies have to be performed. The optimal frequency setting is achieved by using one frequency at the maximum and one at minimum attenuation. The frequencies 23.8 GHz ad 36.5 GHz are the result of a trade off between instrument (reflector) size required to cover a horizontal area on the Earth surface comparable to the RA-2 beam and the maximum sensitivity to water vapour change in the atmosphere.

With one feed horn for each frequency, the MWR points via an offset reflector at an angle close to nadir. The instrument configuration is chosen such that the 23.8 GHz channel is pointing in the forward direction, the 36.5 GHz channel in the backward direction with a footprint of about 20 km diameter for each beam.

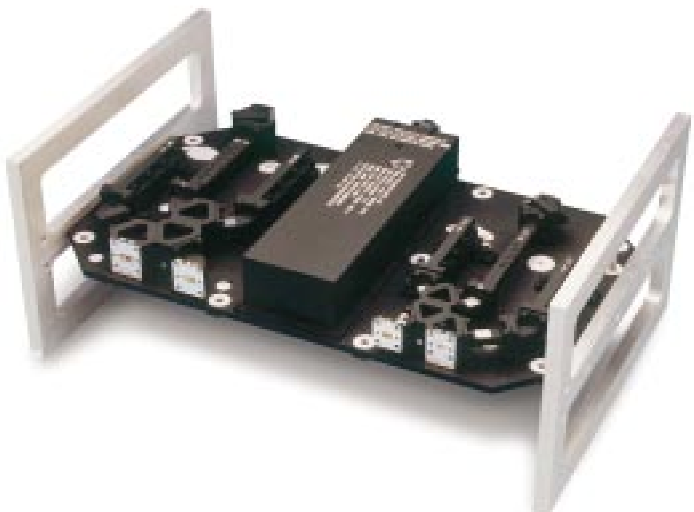
The MWR instrument design principle is based on the design for the ERS-1 instrument as shown in the functional block diagram. In nominal Dicke operation, the measured antenna temperatures are continuously compared with an internal reference load at a known temperature. In instrument internal calibration mode, the receiver is either connected to a sky horn pointing to cold space (cold reference) or to a load at ambient temperature (hot reference). The calibration range thus covered is 3 K to 300 K with a reference temperature accuracy of better than 0.1 K. Instrument internal calibration is performed every few minutes.

The microwave radiation is received by an offset feed parabolic reflector antenna, routed through a Dicke switch assembly to a down converter which translates the K- and Ka-band signals to a suitable IF range. The IF signal is passed through a band limited amplifier to a synchronous detector. The detected signal is integrated, sampled and the resulting level converted to a corresponding frequency which is measured. These measurement data, reference load temperatures and ancillary data are routed to the MWR/DORIS ICU for further transmition.

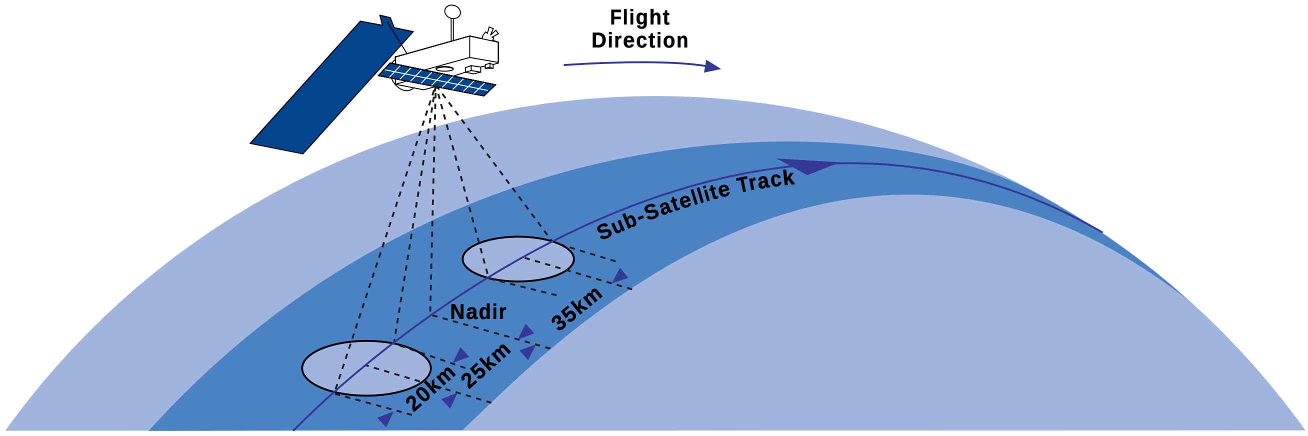
Retrieval of antenna and brightness temperature values from measurement data is accomplished by ground processing. This considers ground calibration data, antenna characteristics and in-orbit characterization data.

For ENVISAT-1 the design of the MWR had to be modified in some areas compared to its ERS 1/2 predecessor to comply with the different platform and mission requirements. The structure is a new design using CFRP technology having the old deployable antenna replaced by a non-deployable one, fully integrated into the instrument structure. The design of the Central Electronics has been adapted to the revised internal and external interface requirements and to the change of components. The Local Oscillators feature a completely new design where the Gunn Oscillators have been replaced by Dielectric Resonator Oscillators.

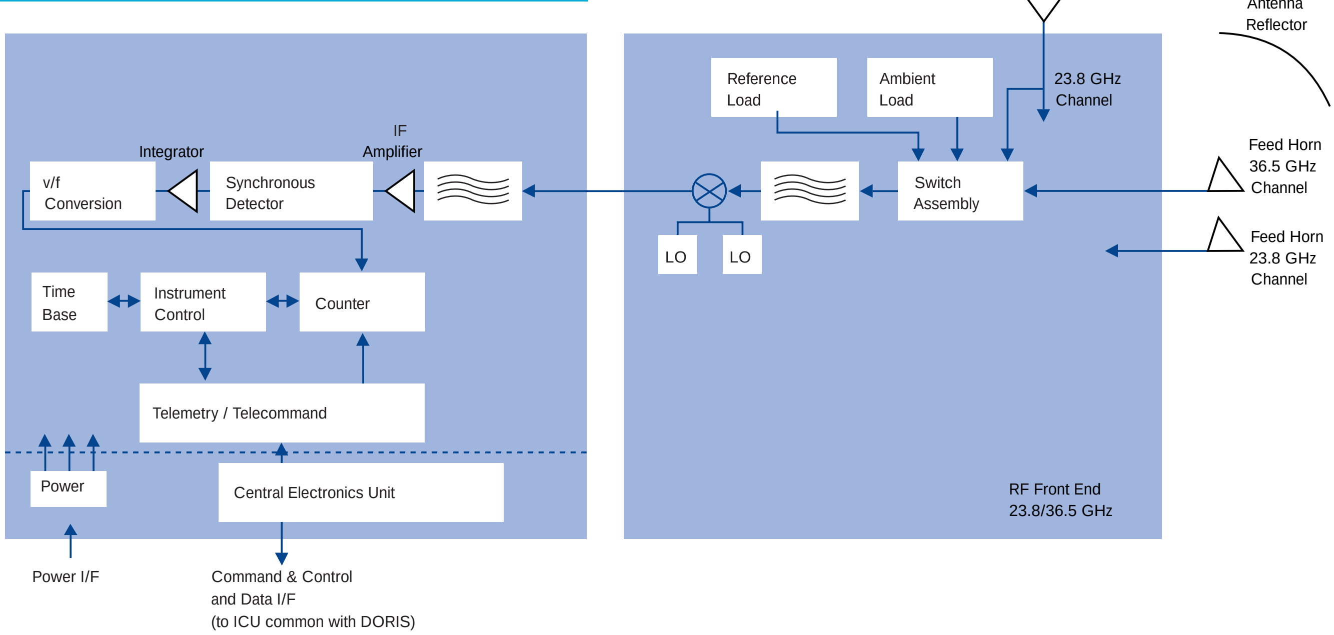
The MWR is developed under leadership of Alenia Aerospazio.



MWR PFM Switching Assembly
(Photo courtesy of EMS)



MWR Functional Block Diagram

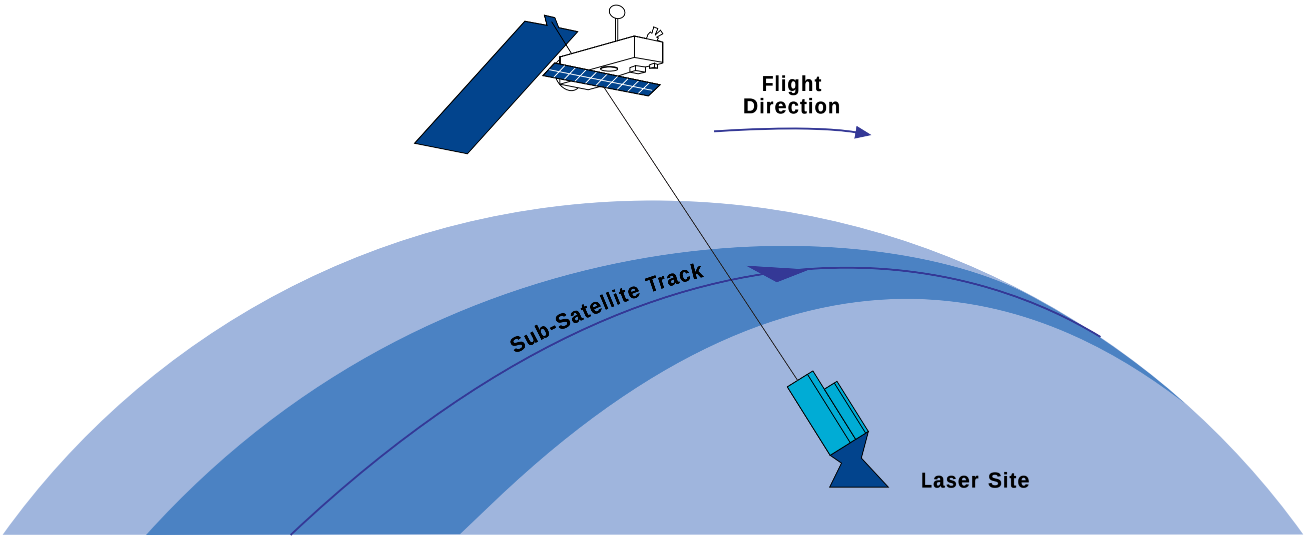


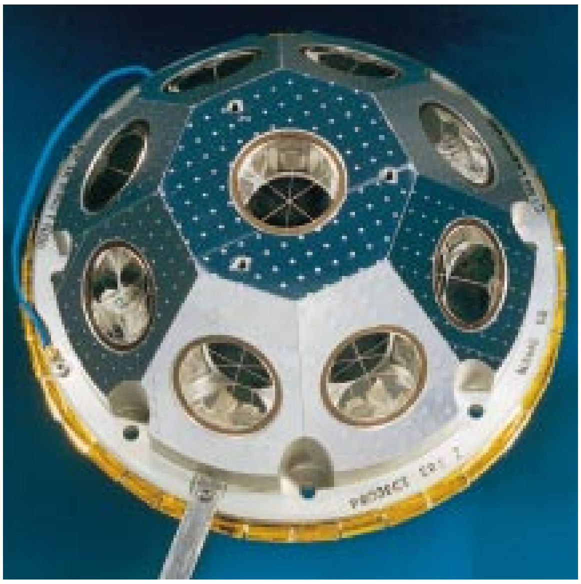
Instrument Parameters

Operating Frequencies	23.8 GHz (K-band) 36.5 GHz (Ka-band)
Dynamic Range	3 K … 300 K
Absolute Radiometric Accuracy	better 3 K
Operation	Continuously over full orbit
Data Rate	16.7 kb/s
Mass	25 kg
Power	23 W

MWR Performance Parameter and Budget Data

Laser Retro-Reflector (LRR)





ERS-2 Laser Retro-Reflector
An identical LRR will be flown
on ENVISAT-1
(Photo courtesy of AEROSPATIALE)

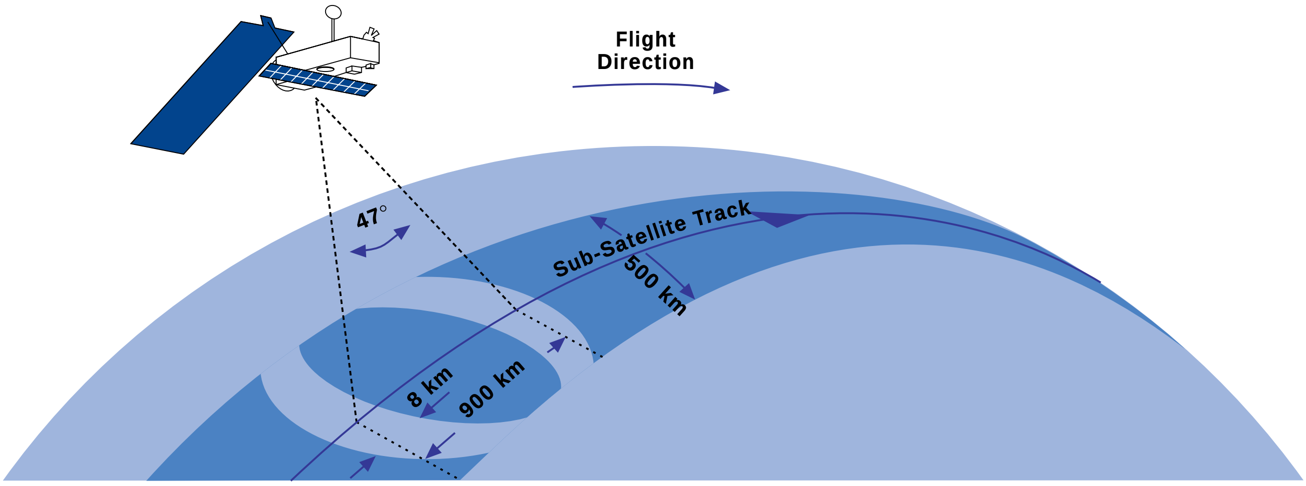
A Laser Retro-Reflector will be mounted on the nadir panel close to the RA-2 antenna to support satellite ranging and RA-2 altitude measurement calibration. The LRR is a passive device which will be used as a reflector by groundbased laser ranging stations using high power pulsed lasers.

The operating principle is to measure on ground the time of a round trip of laser pulses reflected from an array of corner-cubes mounted on the Earth-facing side of the satellite. The corner-cubes are designed to reflect the incident laser beam back directly, making the reflected beam parallel to the incident beam within a few arcseconds.

The corner-cubes, made of the highest quality fused silica, work in the visible spectrum at two specified wavelengths (λ=694 nm and λ=532 nm). The corner-cubes are symmetrically mounted on a hemispherical housing with one nadir-looking corner-cube in the centre, surrounded by an angled ring of eight corner-cubes. This will allow laser ranging in the field of view angles of 360° in azimuth and 60° elevation around the perpendicular to the satellite's -Zs Earth panel. The mass of the LRR is 2 kg.

The LRR is developed by AEROSPATIALE.

Advanced Along Track Scanning Radiometer (AATSR)



The primary scientific objective of the AATSR is to establish continuity of the ATSR-1 and ATSR-2 data sets of precise Sea Surface Temperature (SST), thereby ensuring the production of a unique 10 year near-continuous data set at the levels of accuracy required (0.5 K or better) for climate research and for the community of operational as well as scientific users developed through the ERS-1 and ERS-2 missions.

The second objective is to perform quantitative measurements over land surfaces. The land and cloud measurement objectives will be met through the use of an additional visible focal plane assembly, which will lead to indications of

- vegetation biomass,
- vegetation moisture,
- vegetation health and growth stage.

The visible channels will also contribute to the measurement of cloud parameters, like water/ice discrimination and particle size distribution.

The SST is one of the most stable of several key geophysical variables which, when determined globally, contribute to the characterisation of the state of the Earth's climate system. The precise measurement of small changes in SST provides an indication of quite significant changes in ocean/atmosphere heat transfer rates, especially in the tropics; also it is known that small amplitude anomalies occurring in specific areas are sometimes associated with massive atmospheric perturbations, leading to widespread and damaging changes in the global weather system.

For example, the 'El Nino' anomaly in the tropical East Pacific is associated with a reversal of the atmospheric 'Walker Circulation'. This in turn creates widespread perturbations to the global weather system. The exact causal relationships between such phenomena are not fully understood but a significant 'El Nino'-event can evolve from an SST anomaly of 2-3 K, and therefore the ability to detect, for example, a 10% change in the anomaly field will require measurements of the accuracy provided by the series of (A)ATSR instruments.

The principle of removing atmospheric effects in measurements by viewing the sea surface from two angles is the basis of the family of (A)ATSR instruments.

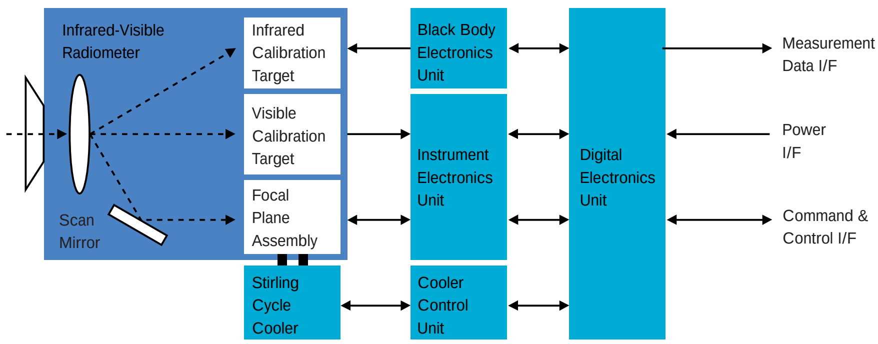
The SST objectives will be met through the use of thermal infrared channels (centred on 1.6 µm, 3.7 µm, 10.85 µm and 12 µm), identical to those on ATSR-1&2. Atmospheric modelling for ERS-1 has shown that ATSR, with its thermal IR channels and two-angle viewing geometry, can achieve a global accuracy in SST of better than 0.5 K.

AATSR Performance Parameter and Budget Data

Instrument Parameters

Spectral Channels	
Infrared	1.6 µm, 3.7 µm, 10.85 µm, 12 µm
Visible	0.555 µm, 0.67 µm, 0.865 µm
Spatial Resolution	1 km x 1 km
Radiometric Resolution	0.1 K
SST Accuracy	better 0.5 K
Swath Width	500 km
Operation	continuously over full orbit
Data Rate	625 kb/s
Mass	101 kg
Power	100 W

AATSR Functional Block Diagram



As with the AATSR thermal infrared channels, the measurement philosophy with respect to the visible channels is to develop and exploit a capability for making accurate quantitative measurements of radiation from the Earth surface, using an on-board calibration system for radiometric accuracy, also using a two-angle viewing technique to obtain accurate atmospheric corrections.

The most important two visible channels are centered on 0.865 µm and 0.67 µm respectively and will provide measurements of Vegetation Index in the same way as AVHRR. The AATSR will have the capability for making global measurements with 1 km x 1 km resolution at nadir. An additional visible channel at 0.55 µm is also incorporated, to indicate, from chlorophyll content, the growth stage and health of vegetation.

The AATSR functional principles are shown in the block diagram. The infrared-visible radiometer includes an inclined plane scan mirror which is rotated continuously in front of a reflecting telescope to provide a conical scan. The cone axis projects downwards and ahead in the along track direction of the satellite, achieving scanning across the satellite track in two regions.
The Focal Plane Assembly (FPA) is equipped with a number of oversized detectors, one per channel. A pair of Stirling Cycle Coolers, controlled by the Cooler Control Unit are used to cool the detectors to 80 K. Two blackbody infrared calibration targets controlled by the Black Body Electronics Unit and a diffuse reflector visible calibration target are viewed between the nadir and along-track scans.

The electrical signals from the FPA are conditioned by preamplifiers which deliver the signals to the Instrument Electronics Unit for further processing. The Digital Electronics Unit (DEU) performs the data formatting and command & control functions. The DEU also provides the interfaces to the PPF spacecraft.

The **AATSR**, developed under leadership of **MMS-B**, is a British/Australian contribution to the **ENVISAT**-1 Mission.

AATSR Engineering Model
(Photo courtesy of MMS-B)

Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS)

DORIS is a microwave doppler tracking system used for precise orbit determination with an accuracy in the order of centimetres. In conjunction with the Radar Altimeter, DORIS contributes to improve the accuracy of the measurements of the spatial and temporal ocean surface topography changes and the variations in ice coverage. In addition, data are provided to:

- help in the understanding of the dynamics of the solid Earth,
- monitor glaciers, landslides and volcanoes,
- improve the modelling of the Earth gravity field and of the ionosphere.

DORIS is based upon the accurate measurement of the Doppler shift of radiofrequency signals transmitted from ground beacons and received on-board the spacecraft. Measurements are made at two frequencies: 2.03625 GHz for precise Doppler measurements and at 401.25 MHz for ionospheric correction of the propagation delay.

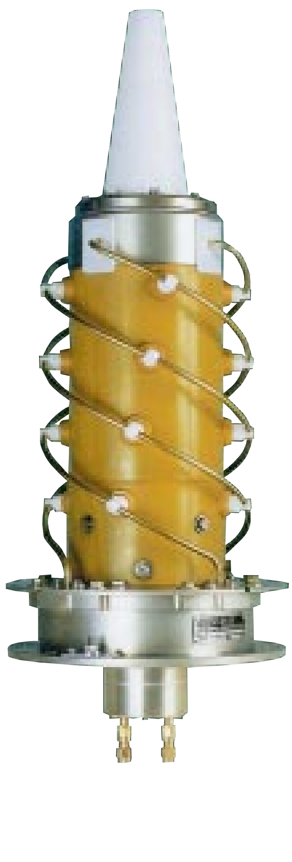
The DORIS System comprises the on-board instrument, a beacon network and the DORIS Control and Data Processing Centre. For operational aspects the DORIS control centre provides an interface to the spacecraft Flight Operation Segment. The DORIS instrument comprises a fixed omnidirectional dual frequency antenna and a redundant receiver controlled by an Ultra Stable Oscillator (USO identical to the USOs employed in the ground segment of DORIS). The receiver performs the Doppler measurements every ten seconds.
The receivers have the capability to track simultaneously two beacons. The reference frequency for the Doppler measurement is generated by the USO with a stability of 5 x 10^{-13} over 10 to 100 seconds. The orbit determination beacons are deployed on a dense world-wide network. The location of these beacons is precisely linked to an international reference frame to get absolute positioning. The time and frequency reference scale for the whole system is provided by the master beacon, connected to atomic clocks.

The DORIS Control Centre performs the instrument and beacon control on the basis of telemetry data monitoring and operational orbit determination.

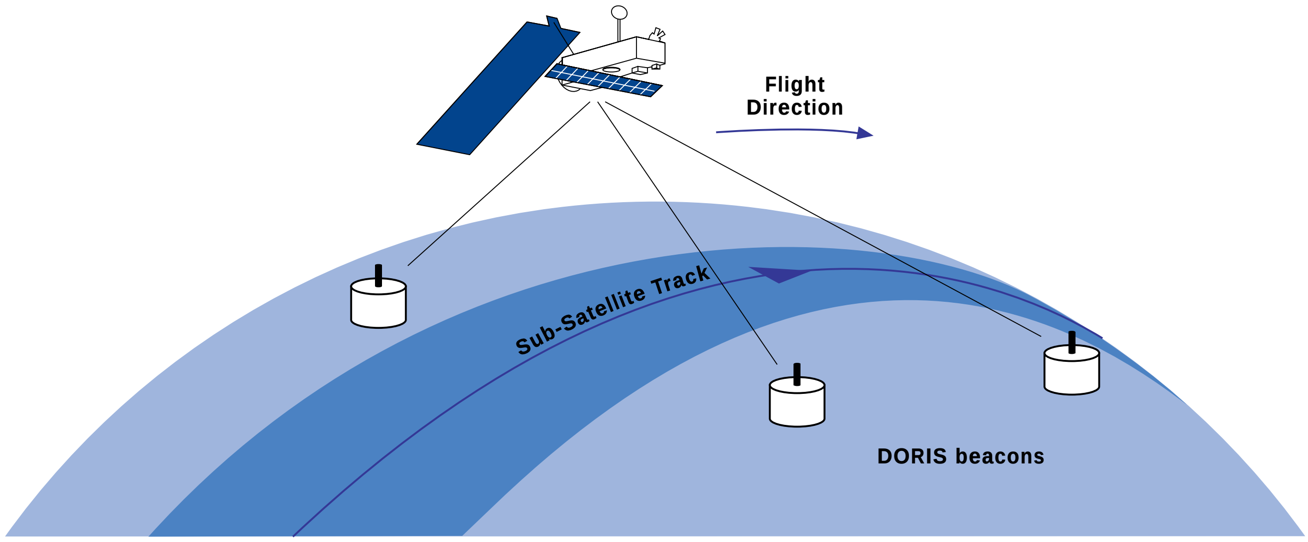
On-board measurements of the Doppler shift are performed every 7 to 10 seconds. Resulting radial velocity values (accuracy of the order of 0.4 mm/s) are used on ground in combination with a dynamic model of the satellite trajectory to perform a precise orbit determination with an accuracy of better than 5 cm in altitude. These orbit data are available within a month. The delay is mainly due to the availability of external data, such as solar flux.

The Doppler measurements are also processed on-board to obtain real-time orbit data, with less accuracy, but available for use in the Near Real Time processing at the ESA PDS stations.

DORIS is provided to the **ENVISAT**-1 Programme by the French Space Agency **CNES**.



DORIS Omnidirectional Antenna
(Photo courtesy of CNES)

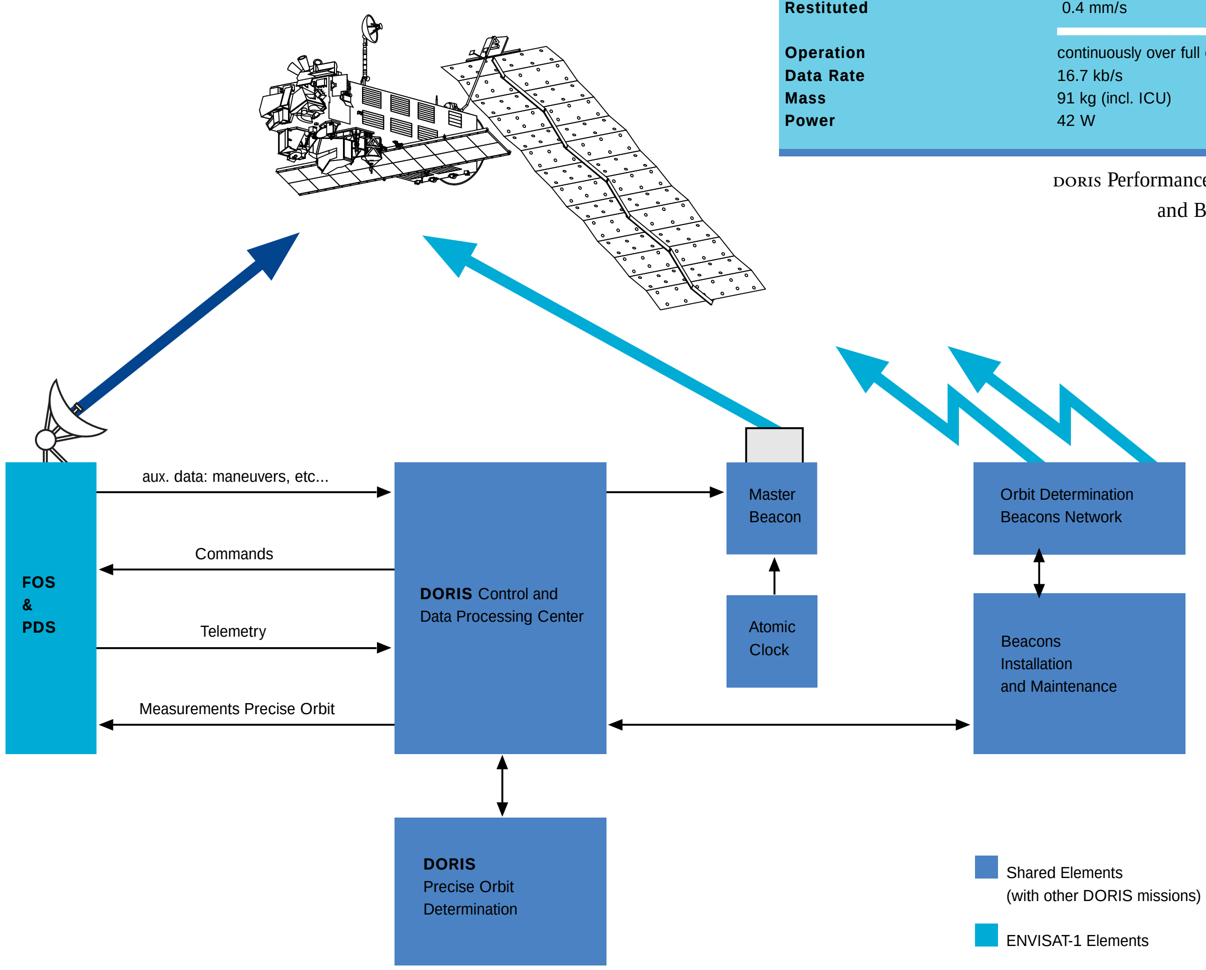


Instrument Parameters

Measurement Frequency	
for Doppler Measurement	2.03625 GHz
for Ionospheric Correction	401.25 MHz
Position Accuracy	
Real-Time	1 m
Restituted	0.05 m radial
Velocity Accuracy	
Real-Time	< 2.5 mm/s
Restituted	0.4 mm/s
Operation	continuously over full orbit
Data Rate	16.7 kb/s
Mass	91 kg (incl. ICU)
Power	42 W

DORIS Performance Parameter and Budget Data

DORIS System Block Diagram



Scanning Imaging Absorption Spectrometer for Atmospheric Cartography (SCIAMACHY)

The primary scientific objective of SCIAMACHY is the global measurement of various trace gases in the troposphere and stratosphere, which are retrieved from the instrument by observation of transmitted, back scattered and reflected radiation from the atmosphere in the wavelength range between 240 nm and 2400 nm. The large wavelength range is also ideally suited for the determination of aerosols and clouds.
The nadir and limb viewing strategy of SCIAMACHY yields total column values as well as profiles for trace gases and aerosols in the stratosphere. This enables, in addition, estimates of global trace gas and aerosol content and distribution in the lower stratosphere and troposphere.

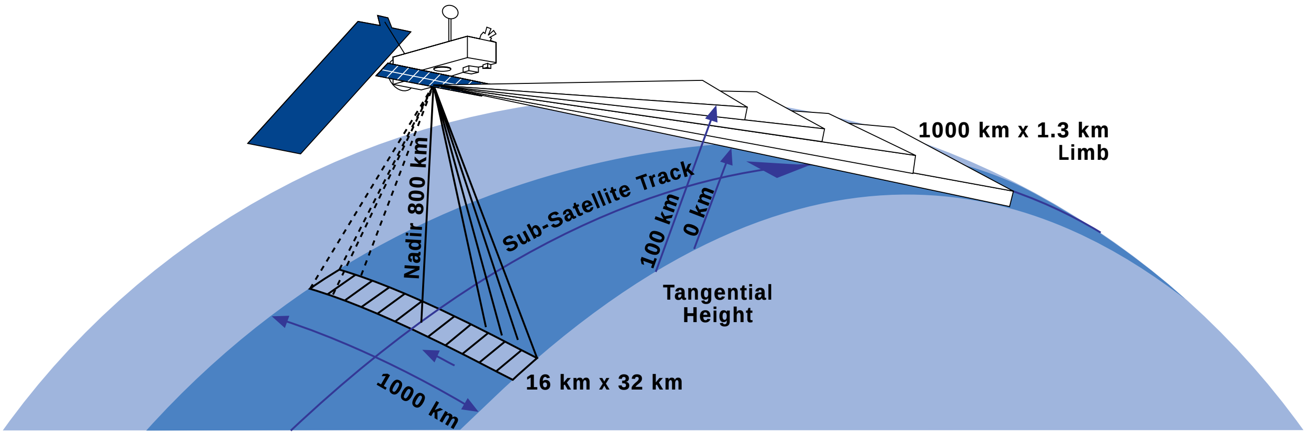
The measurements obtained from SCIAMACHY will enable the investigation of a wide range of phenomena which influence atmospheric chemistry:

- in the troposphere: biomass burning, pollution, arctic haze, forest fires, dust storms, industrial plumes,
- in the stratosphere: ozone chemistry, volcanic events and solar proton events.

In order to achieve the scientific objectives, measurements are performed by observing the atmosphere under different viewing angles. In Nadir Mode, the global distribution (total column values) of the atmospheric trace gases and aerosols will be observed. Additionally, cloud measurements are obtained. In this mode, the instrument is scanning across-track, with a swath width of ±500 km with respect to the subsatellite track. To obtain the altitude distribution of trace gases, SCIAMACHY performs observations in limb over an altitude range of 100 km, with a vertical resolution of 3 km. Starting at Earth horizon, the atmosphere is scanned tangentially over a 1000 km wide swath. After each azimuth scan, the elevation is increased until the maximum altitude of 100 km is reached.

Differential Optical Absorption Spectroscopy is applied in sun and moon occultation measurements, where sun or moon are either tracked or a vertical scan over the complete sun/moon surface is performed. The obtained spectra can then be compared with suitable calibration spectra to yield the differential absorption of the atmosphere.

In the SCIAMACHY optical assembly, the light from the atmosphere is feed by the scanner unit consisting of an azimuth and an elevation scanner into the telescope which directs it onto the entrance slit of the spectrometer. The spectrometer contains a pre-disperser which separates the light into three spectral bands followed by a series of dichroïc mirrors which further divide the light into a total of eight channels.
A grating is located in each channel to diffract the light into a high resolution spectrum which is then focused onto eight detectors. The pre-disperser also serves as a Brewster window to separate polarised light, a part of which is sensed by the Polarisation Measurement Device (PMD). The output of the PMD is later used to correct for the polarisation effects. Light reflected off the slit is directed to the Sun-Follower which controls the scan mirrors in the Sun and Moon Occultation mode.
Each spectrometer channel is equipped with a Detector Module consisting of the detectors and their Detector Module Electronics (DME). Each DME controls its associated detector, reads out the integrated charge, amplifies the analogue signal and then digitises this signal. The digital signal of each channel is transferred to the Science Data Processing Unit (SDPU).



Instrument Parameters

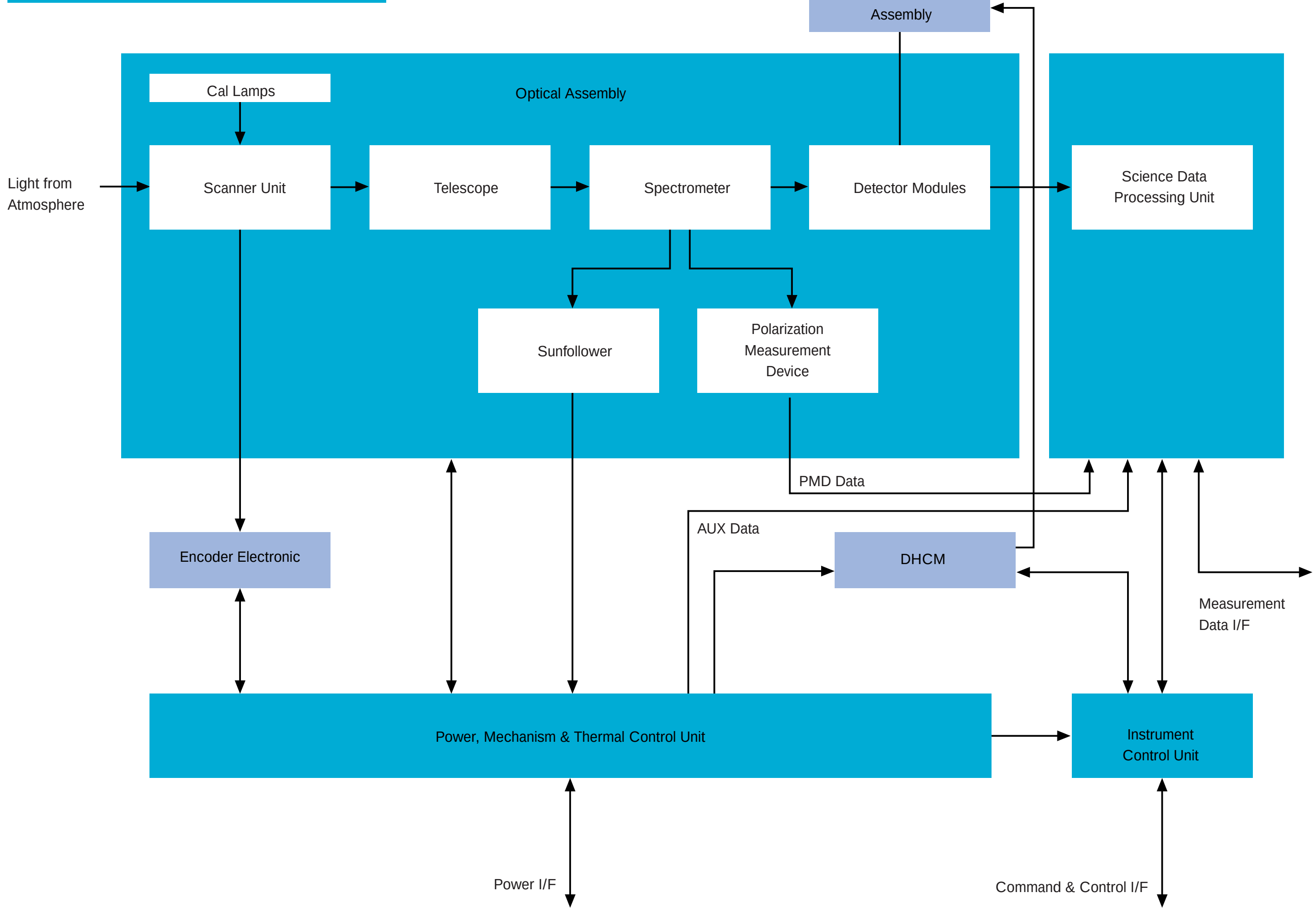
	Channel	Spectral Range	Spectral Resolution
High Resolution Channels	1	240-314 nm	0.24 nm
	2	309-405 nm	0.26 nm
	3	394-620 nm	0.44 nm
	4	604-805 nm	0.48 nm
	5	785-1050 nm	0.54 nm
	6	1000-1750 nm	1.48 nm
	7	1940-2040 nm	0.22 nm
	8	2265-2380 nm	0.26 nm
Polarisation Measurement Devices (broadband)	PMD 1 to 7	310-2380 nm	67 to 137 nm (channel dependent)
Altitude Range	10 km-100 km depending on measurement mode		
Vertical Resolution	2.4 km-3 km depending on measurement mode		
Operation	continuously over full orbit		
Data Rate	400 kb/s nominal; 1867 kb/s real time mode		
Mass	198 kg		
Power	122 W		

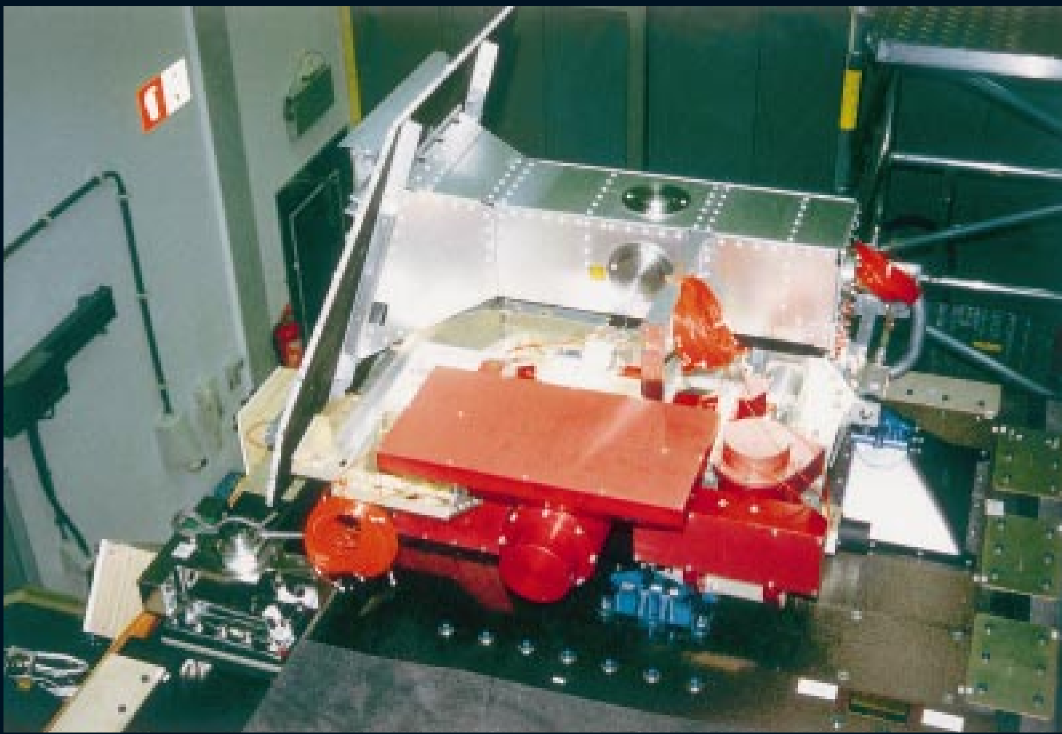
Sciamachy Performance Parameter and Budget Data

To achieve the required instrument performance the detectors of the Optical Assembly have to be cooled to around 200 K for the visible and NIR channels 1 to 6 and to around 135 K for the IR channels 7 and 8. This cooling is provided by the SCIAMACHY Radiant Cooler which is coupled through a Thermal Bus Unit (TBU) to the detectors of the Optical Assembly. The TBU is build up from two cryogenic heatpipes which cool the two IR-detectors. A tube shaped shroud, which envelopes the cryogenic heatpipes, transports the heat load from the detectors of the other six channels.
The SDPU controls the DME, acquires and processes science and auxiliary data and transmits them to the S/C measurement data interface. The Instrument Control Unit receives the macrocommands from the S/C, performs autonomously the overall management and control of the instrument and feeds back telemetry information. The Power, Mechanism and Thermal Control Unit (PMTC) provides secondary power to all equipment and controls the scanners (via the Encoder Electronics), the different mechanisms, the calibration source and the temperature of the optical bench and the detectors. Furthermore the PMTC acquires analogue housekeeping signals indicating the health and status of the instrument.
A Decontamination Heater Control Module (DHCM) performs the Radiant Cooler decontamination on/off control and the thermal knife control.

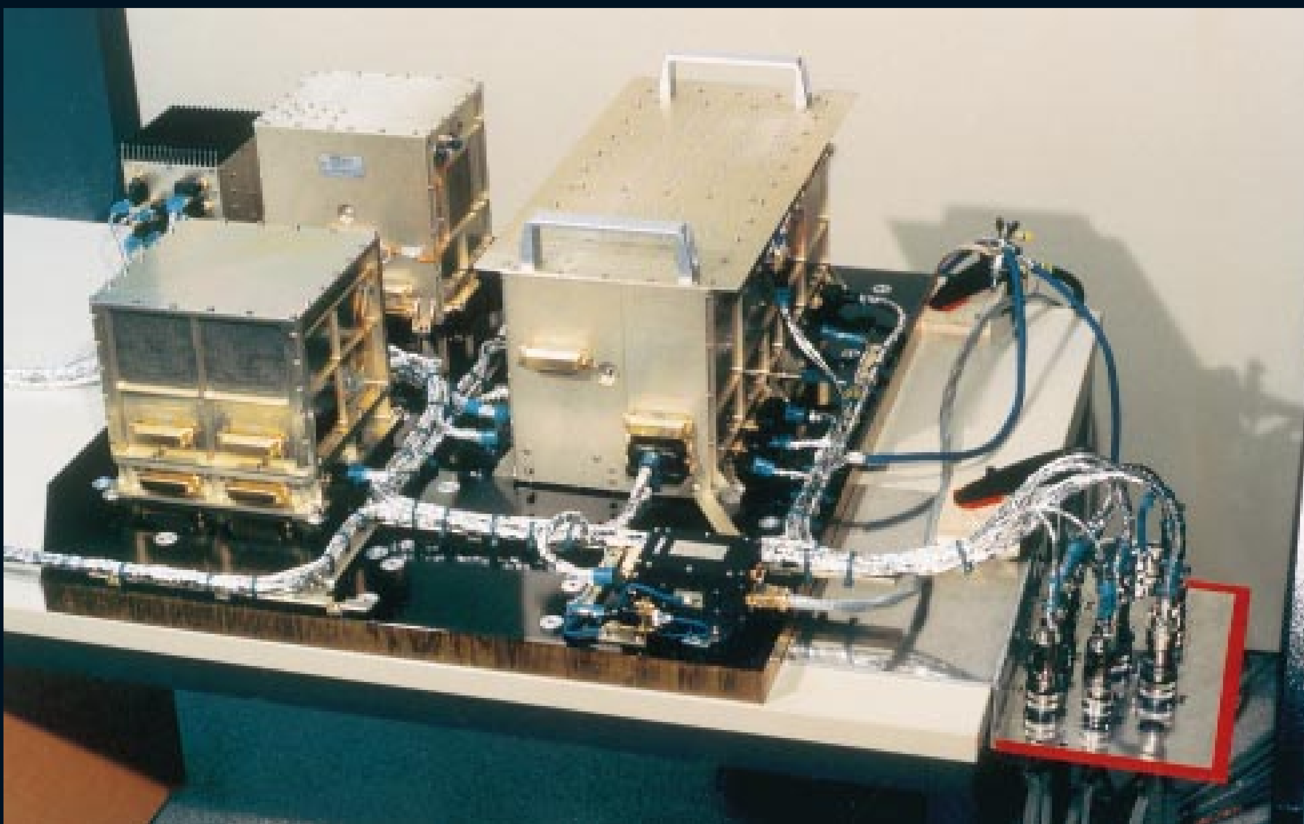
SCIAMACHY is developed by a trilateral German/ Dutch/Belgian activity under **DLR**, **NIVR** and **OSTC** contract involving Dornier Satellitensysteme GmbH and Fokker Space as the leading companies.

SCIAMACHY Functional Block Diagram





SCIAMACHY Optical Assembly
(Photo courtesy of Fokker Space)



SCIAMACHY EM
Electrical Assembly
(Photo courtesy of Dornier)

Development and Verification Programme

Model Philosophy

The ENVISAT-1 instrument design and development logic and model philosophy are driven by the need to implement a cost effective approach fulfilling the stringent technical requirements within acceptable technical and programmatic risk. Furthermore its model philosophy is strongly linked to the PPF programme in form of the deliverables from ENVISAT-1 to PPF and with respect to the qualification programme implemented.

Since the ENVISAT-1 instruments range from completely new instruments up to rebuild of existing instruments with minimum adaptation for accommodation on PPF they have to be treated from a design and development point of view quite individually.

Some specific considerations with respect to the PPF programme arose also from the fact that for already qualified instrument designs no instrument Engineering Model (EM) are available. Furthermore cost and schedule constraints led in several cases to the delivery of reduced EM instruments to the PPF programme which show full interface and dedicated operational representativity, but no relevant scientific performances. The baseline established now, constitutes an adequate compromise on both sides.

The following instrument hardware models are to be delivered to the spacecraft AIV programme:

- RF Mock-ups (RFMU's),
- Structure Models,
- Engineering Models, and
- Flight Models.

The RFMUS support the spacecraft level Radio Frequency (RF) analysis by measuring antenna RF coupling factors with the S/C RF mock-up. RF representative development models of the RA-2, ASAR and DORIS antennas have been delivered.
Structure Models (StM's) have been delivered to the PPF structure qualification programme for instruments or assemblies with a first eigenfrequency below 100 Hz. The delivered instrument StM's are of flight structure standard.
Engineering Models (EMs) are delivered to support mainly the functional verification of the overall satellite. For the rebuild instruments (MWR, DORIS and LRR) no EMs are provided. Electrical interface and functional representative reduced EMs have been delivered for GOMOS, MIPAS and SCIAMACHY. Flight Models (FM) will be delivered to the PPF programme fully verified and characterized on instrument level with the exception of ASAR, where the antenna and the central electronics will be delivered separately to the S/C programme for integration and testing.

Instrument Development and Verification

The ENVISAT-1 instruments are composed of ESA Developed Instruments (EDI's) and Announcement of Opportunity Instruments (AOI's) with model characteristics as shown.

For newly developed instruments, performance representative EMs have been developed to gain confidence as early as possible that the instruments can fulfil their mission objectives. Instrument EMS are flight representative in form, fit and function. They are equipped with commercial components suitable for thermal vacuum testing. Redundancies are not required for the EM instrument units.

Design qualification is performed to the maximum extent possible within the given programmatic constraints on the EM. For selected equipment, Proto-Flight Model (PFM) approaches are applied.
Instrument verification is completely performed at instrument level against ENVISAT-1 requirements, i.e. as a general rule no satellite level tests are needed for instrument design qualification purposes, however the satellite level tests must prove that the environment, under which the instrument design was qualified, is compatible with the actual PPF environment. When the instruments are integrated on the satellite, an ENVISAT-1 payload related verification programme will be performed in order

- to demonstrate compliance to ENVISAT-1 requirements related to the complete payload,
- to verify the satellite functions with the integrated payload as part of the PPF verification programme.
- to verify compatibility with the actual PPF level environment.

The main objective of the satellite FM programme is to confirm that the fully integrated satellite is fit for its purpose and ready for flight.

To reduce the risk of interface incompatibilities, the instrument EGSE part representing the electrical and functional interface to the spacecraft has been developed centrally as the so called Standardized Elements, which became part of each instrument EGSE. Further main areas of standardization and common approaches have been

- the development of the Remote Bus Interface (RBI) chip handling the corresponding OBDH protocol,
- the establishment of a payload TM/TC data base, and
- the definition of the software development environment and the associated software maintenance facility.

Instrument Model Characteristics

Instruments	Resp.	Develop. cat.	StM	EM	FM	Remark
ASAR	EDI	new	antenna	reduced EM	FM[3]	4 active tiles for EM
GOMOS	EDI	new	no	full EM	FM	reduced EM to serve S/C EM
MERIS	EDI	new	yes[2]	reduced EM	FM	1 out of 5 cameras (EM)
MIPAS	EDI	new	yes[1]	full EM	FM	reduced EM to serve S/C EM
MWR	EDI	rebuild	no	no EM	FM	ERS based instrument
RA-2	EDI	partially new	no	full EM	FM	ERS based instrument
LRR	EDI	rebuild	no	no EM	FM	ERS based passive optical system
AATSR	AOI	partially new	no	reduced EM	FM	ERS based instrument
DORIS	AOI	rebuild	no	full EM	FM	EM available for S/C RFC test
SCIAMACHY	AOI	new	yes[1]	reduced EM	PFM	reduced EM to serve S/C EM

[1] instrument assemblies
[2] full instrument
[3] PFM Antenna Structure

Products & Simulations

The programme commits to generate engineering and geophysical products from the observations performed by the ENVISAT-1 satellite instruments. It implies that the following activities are performed prior to the ENVISAT-1 launch:

- product definition and processing algorithm development and implementation;
- generation of test data and use of Instrument System Simulators;
- instrument characterisation;
- preparation of the in-orbit calibration;
- preparation of the level 2 product validation.

Product definition and Processing Algorithms

To ensure coherency of the data product definition, algorithm definition and validation, as well as coherency, within the PDS, between Near real Time and Offline products, a comprehensive development programme had to be put in place, implying in particular:

- provision of precise product guidelines applicable to all products;
- provision of a suite of mission software to ensure proper use of orbit data and proper geometry calculations for geolocation through all products;
- development of instrument system simulators whenever reconditioning of in-flight acquired data from similar instruments are not available;
- Setting up of Expert Support Laboratories (ESLS) and supporting industries to document the products, develop and document the algorithms, test them on prototype processors using simulated data and later on participate to the product validation;
- Setting up of Science Advisory Groups (SAGS), per instrument, to advise the Agency on instrument performances, product definition, processing algorithms and validation approach issues.

By the time of the EMS-CDR, all level 1B and level 2 products formats are defined.
It has been possible to define product formats and processing algorithms which are common to both Near real Time and Offline Products, the difference being in the quality of the auxiliary data available at processing time (calibration parameters, orbit data and supporting meteorological information).

All ENVISAT-1 products follow the same product format structure which permits providing to the users:

- a coherent product inventory with efficient search mechanisms;
- simple software tools for opening and reading products,
- generation of products as a continuous stripe for an acquisition segment with possibility to deliver either the stripe or extracted scene products as well as to select subsets within a product (i.e. subsets of spectral bands).

For all instruments, but ASAR and DORIS, the detailed product definition and processing algorithm documentation is produced by ESLS with the help of supporting industries and delivered to the PDS consortium for implementation of the corresponding operational processors.

All processing algorithms are prototyped by ESLS in order to validate the documentation produced and to generate reference test data to be used for the acceptance testing of the PDS processors.

All PDS processing chain developments have been started, except for SCIAMACHY for which the ESL provided Detailed Processing Model documentation is planned for the fall 1997. For the ASAR image processing, due to the past industrial experience , the PDS development is performed directly based upon image quality requirements. For DORIS, the multimission processing chain is already available at CNES, this instrumentation being already exploited on several in-flight missions.

Instrument System Simulators

In the frame of the payload development programme, Instrument System Simulators for GOMOS, MERIS, MIPAS and RA-2 have been developed. For SCIAMACHY, the instrument provider has also developed a similar system simulator.

The end-to-end instrument system simulators include the simulation of the target, the signal path from target to instrument, the orbit and attitude of the satellite, the instrument (including analog part and digital signal processing) and are capable of generating simulated instrument data in the specified instrument format (Instrument Source Packets).

The simulators are used to support the:

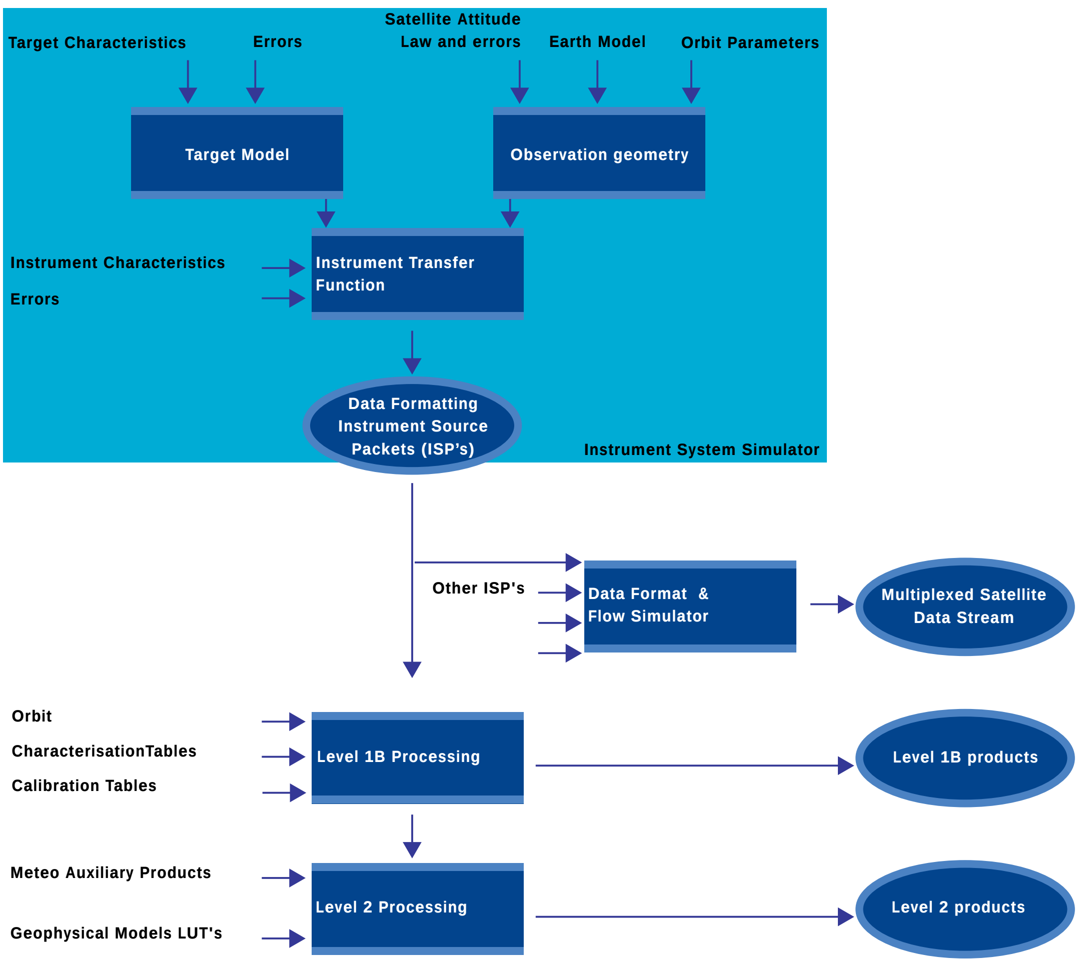
- system development, in particular development of ground processing and calibration algorithms, and fine-tuning of processing parameters,
- system performance monitoring including demonstration of system performance prior to launch and investigation of instrument effects,
- system verification by provision of realistic science data sets supporting the testing of the ground processing and calibration software,
- investigation/correction of measurement data anomalies (after launch), support to the generation of ground processing tables and operational calibration processing.

The simulators have been developed for SUN SPARC station 10, the programming languages are C and FORTRAN. The same hardware/ software environment is also used for the processing algorithm prototyping.

The development of the instrument system simulators has been completed in the time frame July 1995 to March 1996, subsequently the simulators have been delivered to ESTEC Project Team and are extensively used in the generation of test data for use in combination with the level 1B and level 2 processing prototypes.

For ASAR and AATSR, since there is no System Simulator, reconditioning of ERS in-flight acquired data to the ENVISAT-1 Instrument Source Packet format is being performed to provide the necessary data for test of the processing algorithms.

Data Flow Diagram for Simulation and Data Test Generation



The Data Format and Flow simulator (DFFS)

The Data Format and Flow Simulator comprises the simulation of the on-board measurement data stream (including the High Speed Multiplexer) and the transmission to ground. The DFFS was completed in January 1997.

Using the simulated instrument data, provided by the System simulators, and the reconditioned ERS data, the DFFS is used to provide simulated multiplexed data streams for test of the PDS data acquisition and processing chains. Some referenced orbit scenarii have been defined, all simulated data adhere to these scenarii.

Instrument Characterisation

A detailed list of instrument elements to be characterised before launch has been established. The corresponding characterisation results, to be obtained during on ground verification test of the Flight Model instruments, will be provided via computer file for use in the level 1B processing algorithms.

In-flight Calibration

The in-flight calibration requires processing of data acquired via:

- use of instrument internal calibration loops, the instrument carrying its own stimuli;
- use of instrument external well characterised stimuli, natural targets (i.e. stars, rain forest , deserts or ice sheets) or specific artificial targets (i.e. ASAR transponders)

The corresponding results will be processed off-line in the Instrument Engineering Calibration Facility (IECF), specifically equipped for handling these data and for generating the calibration tables to be delivered to the PDS for the corresponding level 1B processing chains.

Level 2 Algorithm Validation

The level 2 processing algorithms use numerous models to convert engineering quantities into geophysical parameters (i.e. absorption lines into atmospheric species, brightness temperatures into surface temperatures, radar cross section return echo into wind or wave). Wherever possible these models are being validated using the experience acquired before ENVISAT-1 launch, using in particular data acquired in-flight (when available) or airborne campaign data.

During ENVISAT-1 in-orbit Commissioning, it is planned to use two approaches in parallel:

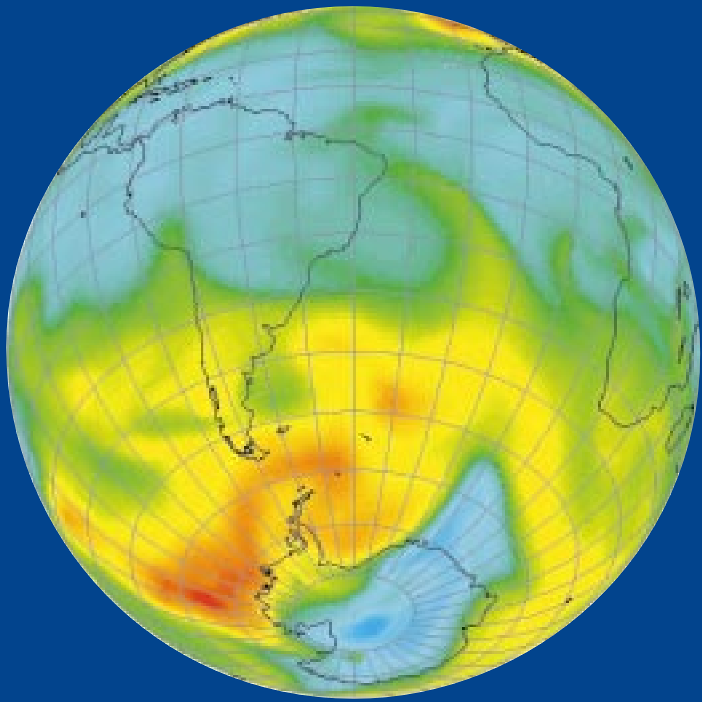
- pre assimilation of level 2 products by operational centres (i.e. meteo centres),
- comparison with in situ data on specially equipped campaign sites.

These two approaches have been shown to be complementary and extremely powerful in the ERS-1 and 2 missions:

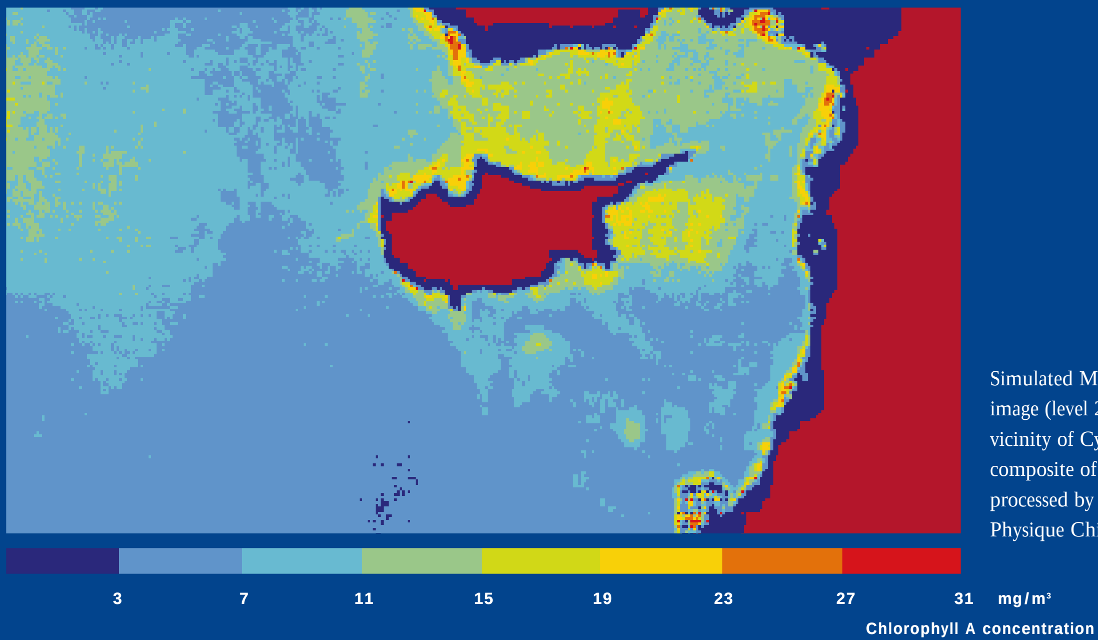
- the in situ data provide precise measurements within the constraints of well identified sites;
- the pre-assimilation of data products provides comparison with operationally used models, this product analysis, on a global scale, permits potential physical problems in the overall behaviour of the instrument processing algorithm to be highlighted.

Preparation for In Orbit Commissioning

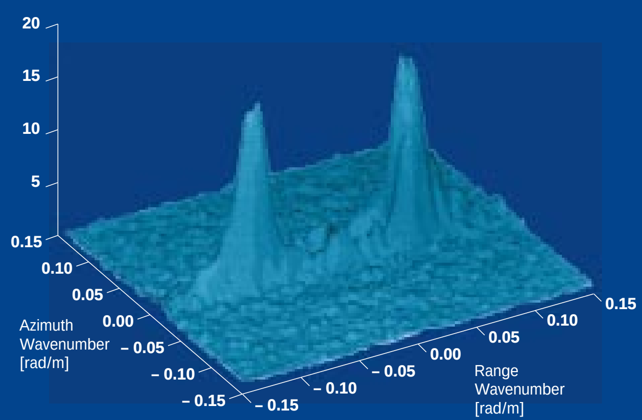
As shown above, the provision of level 1B and level 2 products to users requires the setting up of a comprehensive list of complementary activities in parallel with the satellite development phase. These activities aim at preparing the in-orbit Commissioning Phase: all processing chains have to be operable with corresponding mechanisms for updating the tunable parameters (Look Up Tables for the level 1B calibration parameters and for the level 2 model validation parameters). Within the 6 months duration of the Commissioning phase, the calibration activities will permit to deliver level 1B products. The validation of the level 2 products shall be such that, by the end of this phase, products will start to be delivered to the users.

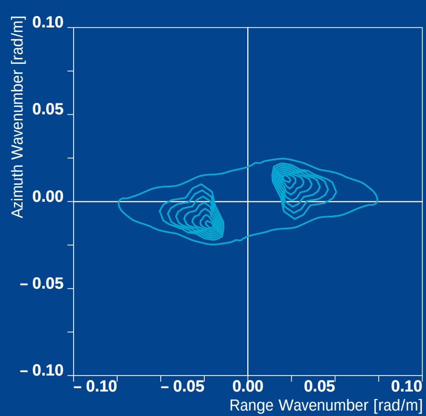


Total ozone observed by GOME on ERS-2
(Photo courtesy Anke Piters KNMI)



Simulated MERIS Chlorophill image (level 2 product) in the vicinity of Cyprus, built up from a composite of CZCS images processed by the Laboratoire de Physique Chimie Marine (France).





ASAR Image Cross Spectrum (level 1B) product derived from ERS-2 SAR data. The Ocean Wave Spectrum (level 2 product) is subsequently obtained by applying the Transfer Function from SAR image spectra to ocean wave spectra.

FOS

The Flight Operation Segment (FOS) provides monitoring and control of the satellite for all in-orbit operations.
The Flight Operation Control Centre (FOCC), located at ESOC Darmstadt, hosts the following major subsystems:

- The Flight Operation Control Software;
- The Flight Dynamics Software;
- The Mission Planning System;
- The ENVISAT-1 Satellite Simulator;
- The Data Archiving System;
- The Satellite Software Maintenance Facility.

The FOCC provides also all the communication interfaces, internal to the FOS as well as external interfaces to the PDS and to the specific entities supporting the Mission Operation.

The Flight Operations Control Software is based on the SCOS-1B system successfully used on the ERS missions: this approach presents minimum development risks with a system capable of fulfilling all specified user requirements.

The Flight Dynamics Software is derived from the ORATOS system, already used on the ERS missions. The major upgrade is the addition of the Star tracker control and performance monitoring.

The Mission Planning System (MPS) is a new development. The MPS functions and corresponding requirements are specific to the ENVISAT mission but the split of responsibilities between the FOS MPS and the PDS Mission Control Facility is very similar to the ERS missions. The Global Mission planning, specified in the Reference Operation Plan (ROP), is directly planned by the FOS; the Regional Mission scheduling, mainly driven by user requests, is built up at the PDCC and transferred to the FOS as a Preferred Exploitation Plan (PEP). The FOS MPS is in charge of building up the complete satellite scheduling sequence, verifying the compatiblity between the satellite constraints and the operation requirements of the ROP and the PEP. The corresponding satellite operation schedule is delivered to the PDCC as a Detailed Mission Operation Plan and implemented via a set of time tagged macrocommands routed form the FOS to the satellite via the TT&C station of Kiruna.

The ENVISAT-1 Satellite Software Simulator is built to be as representative as possible of the on-board software for all aspects related to satellite control in all mission phases (LEOP, routine operations and contingencies). This simulator includes emulation of the flight software of the Service Module and Payload Module Computer and simulations of the other satellite subsystems, including the Instrument Control Units. The main objective is to permit rehearsals of all critical operations as well as to train the operators in the execution of nominal and contingency procedures.

The Performance Analysis System will allow the storage and retrieval of satellite control and monitoring information throughout the complete mission lifetime.

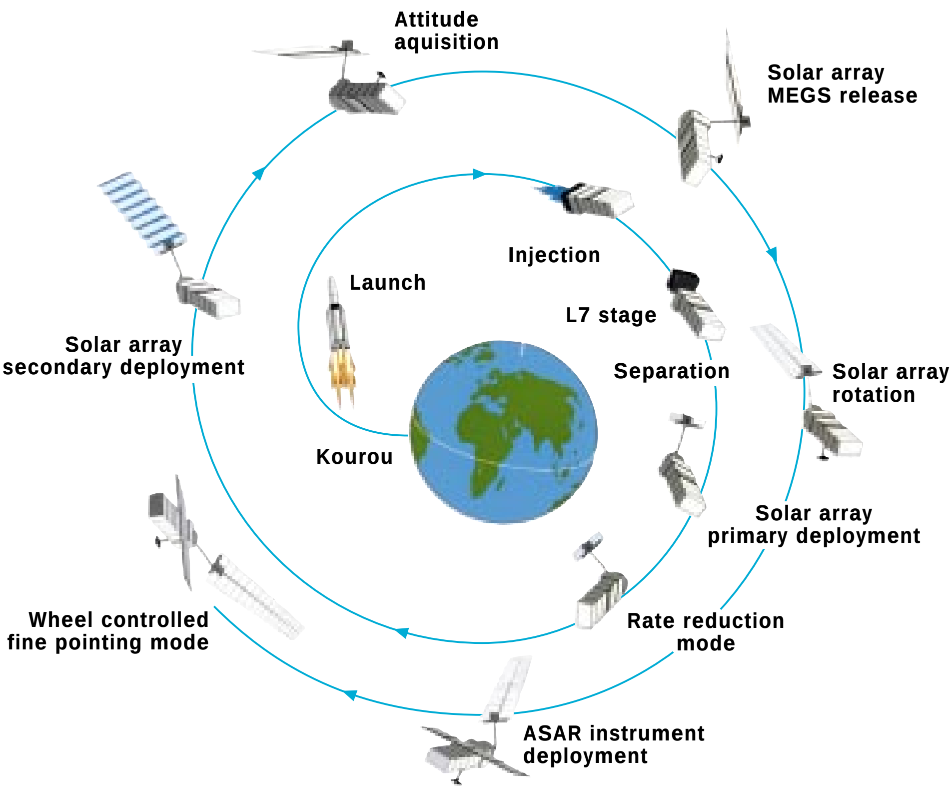
The Satellite Software Maintenance Facility is based on software maintenence tools delivered by the satellite and instrument manufacturers. For the software of the Service Module, due to its mission criticality and complexity, a significant part of the maintenance activities will remain with the corresponding satellite contrator.

The Kiruna Station upgrade, includes refurbishment of the existing 15 meter antenna, upgrade of the TT&C part and installation of the X-band receiving chains, including the demodulators.

The development of all the FOCC software systems is on going. A phased delivery is foreseen for the Flight Control Software. This will permit a step by step integration at the FOCC and the verification of the satellite compatibility via the System Verification Tests. Between end 1997 and satellite shipment to the launch pad, 4 campaigns of System Verification Tests (SVT's) are planned; during these SVT's, the satellite will be directly under control of the FOCC Flight Control Software. These SVT's will permit, in particular, the critical sequence of activities foreseen during the Launch and Early Orbit Phase (LEOP) to be tried out.

Satellite Control Room at the Flight Operation Control Centre (FOCC)

ENVISAT-1 Launch and Early Orbit Phase (LEOP) Sequence



PDS

Centres/stations their function and location

The Payload Data Segment (PDS) provides all services related to the exploitation of the data produced by the instruments of on-board the ENVISAT-1 satellite.
The PDS comprises ESA provided centres and stations:

- The Payload Data Control Centre (PDCC) at ESRIN,
- The Payload Data Handling Stations (PDHS's) at ESRIN and Kiruna,
- The Payload Data Acquisition Station (PDAS) at Fucino,
- The Low rate Reference Archive Centre (LRAC) at Kiruna

as well as centres and stations procured nationally:

- The Processing and Archiving Centres (PAC's) located in ESA member states,
- The National Stations providing ESA Services (NSES) and located in programme participating states.

The PDS will also interface with national and foreign stations duly authorised to receive ENVISAT-1 regional data.

The PDCC at ESRIN, is in charge of instrument and ground segment planning, and of overall PDS monitoring and control. It also co-ordinates user services and provides quality and engineering support for the products.

The PDHS's at ESRIN and Kiruna acquire measurement data downloaded by the spacecraft (respectively in Ka- and X-band), process it and disseminate products, according to PDCC directives. A short term rolling archive is provided. Local services are also offered to users.

The PDAS at Fucino acquires only measurement data (in X-band) and forwards it to the PDHS at ESRIN for processing.

The LRAC at Kiruna archives and processes the global low rate data off-line, to provide a complete consolidated low rate level 1B data set for EDIS (ESA Developed Instruments) and ASAR-LR Instruments, and a pre-consolidated level 1B for other AOI's (Announcement of Opportunity Instruments). Local services are also offered to internal users.

The PAC's located in ESA member states, archive and process off-line high rate data and generate off-line geophysical products for regional High Rate or Full Resolution instruments and global Low Rate instruments.

PACS and NSES, while developed from national funds, will use some elements, known as 'Generic Elements', designed and developed as part of the ESA PDS industrial contract.

PDS Centre & Station functions

	Product Generation Acquisition Demultiplexing Processing		Products Administration Archiving Dissemination		User Services Access to service Production Inventory	Supervision System Supervision Planning Monitoring & Control (M&C)	Support to production Product control Engineering support
PDHS	Acquisition of X-band signals	Generation of NRT products	Rolling Archive	Dissemination of NRT products	Providing services to users	Planning, M&C of PDHS activities and resources	
LRAC		Cleaning and consolidation of LBR products	Archiving of LBR level 0 & 1B products	Products dissemination	Providing services to internal users	Planning, M&C of LRAC activities and resources	
PDCC			Software Browses Archiving	Products dissemination	Providing services to users	Planning, M&C of PDCC activities and resources	Monitoring of product quality
					Administration & Coordination of user services	Planning, M&C of System Mission and resources. Interface with FOS	Engineering support to PDS activities
PACs		Generation of higher level products	Archiving of generated products	Products dissemination	Providing services to users	Planning, M&C of PAC activities and resources	

PDS architecture

What are the PDS facilities?

Each PDS centre or station has to fulfil a set of services and functions.

Many common functions are implemented in different centres and stations. For example the PDHS's, LRAC and PAC's have to process instrument data to generate products: the algorithms to be implemented are identical, only the quality of the auxiliary data used for the processing will be different.

Another example concerns the user services to be offered: they shall be identical, and the level and quality of the service shall be independent of the centre that the user accesses.

The major design driver has been to define a modular architecture requiring a minimum set of facilities. These facilities will be assembled to construct the different PDS centres and stations and will be available as Generic Elements for the PAC's.

PDHS Architecture and Operation

The operation strategy is defined at the PDCC. The corresponding instructions are passed to the Centre Monitoring and Control (CMC) of each PDHS.

At the beginning of a pass (period corresponding to the acquisition of measurement data for a single orbit), all production facilities as well as the archiving and dissemination facilities receive the instructions from the CMC for the operations to be performed.

The Acquisition Facility (AF) acquires the satellite signal, using Ka- or X-band. It sends raw data CADUS to the Front End Processor (FEP), and records them simultaneously on media for backup.

The FEP assembles the Instrument Source Packets (ISP's) to be delivered to the Processing Facility (PF).

Kiruna Salmijarvi Station
(Photo courtesy of Dornier)

The PF, which comprises of the host structure and the different Instrument Processor Facilities (IPF's), generates Near Real Time (NRT) products from the ISP's using auxiliary data retrieved from the Archiving Facility (ARF), and sends them to the ARF.

The ARF stores the products in the on-line archive and sends associated product headers to update the INventory (INV).

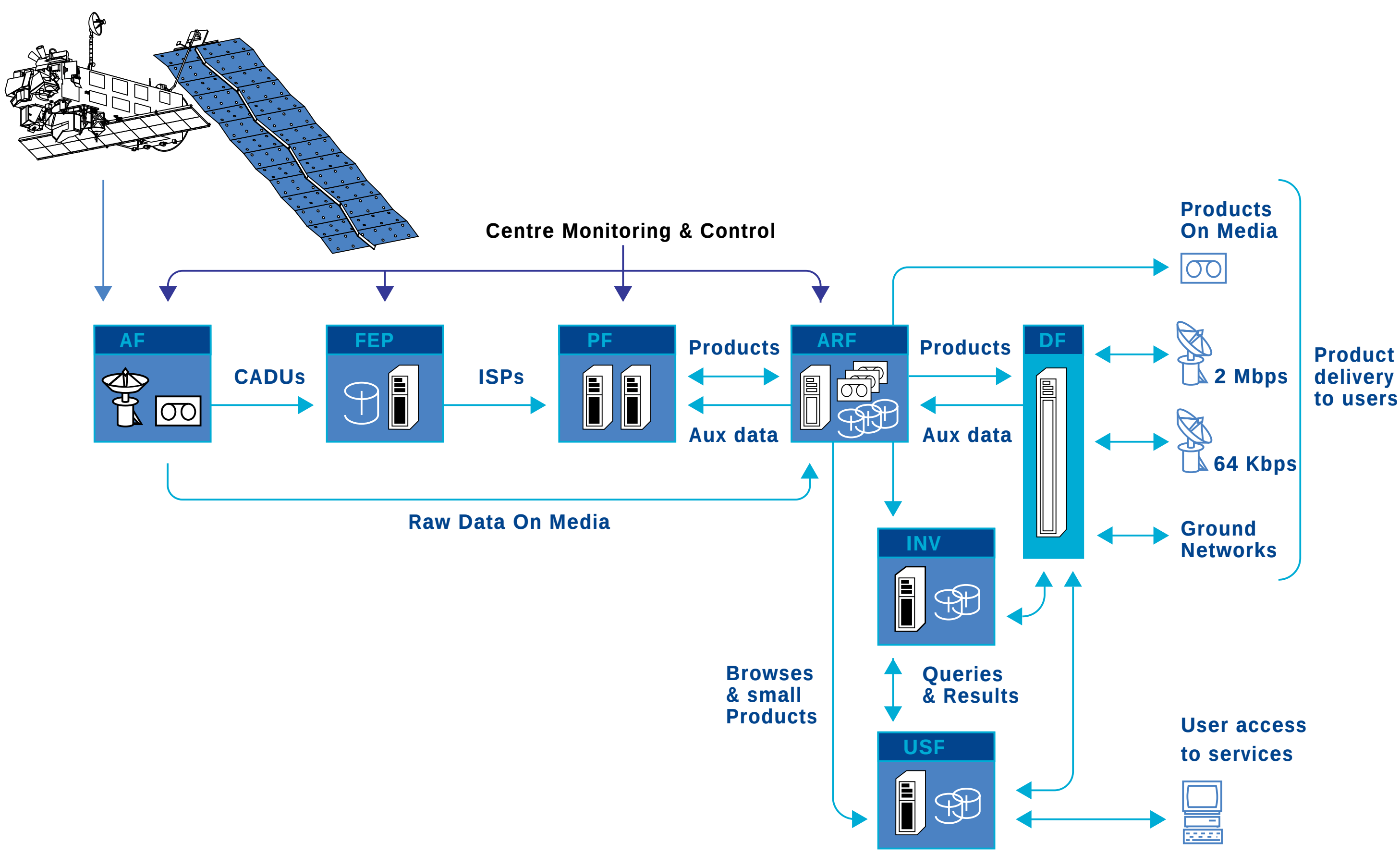
In parallel, the Dissemination Facility (DF) retrieves products from the ARF and disseminates them on the ground network or on the satellite data dissemination channels according to the instructions provided by the PDCC.

At any time, users can query the INV through the User Service Facility (USF), and ask, for example, for the on-line delivery of browse or small products.

The products generated at the PDHS (level 0, 1B and 2) are copied and delivered on physical media to the PAC's and the LRAC.

The CMC reports to the PDCC on the operations performed by the PDHS.

Functional architecture of a PDHS



Centre/Station architecture overview

All centres/stations are built from the same group of facilities, by selecting specific elements to meet particular requirements.

Any national centre or station providing ESA services (PAC's or NSE's) will use PDS generic elements at least for the following 3 functions: data processing, user services (USF) and centre monitoring and control (CMC).

This will guarantee to the user uniform services whatever PDS station or centre is selected for processing and product delivery.

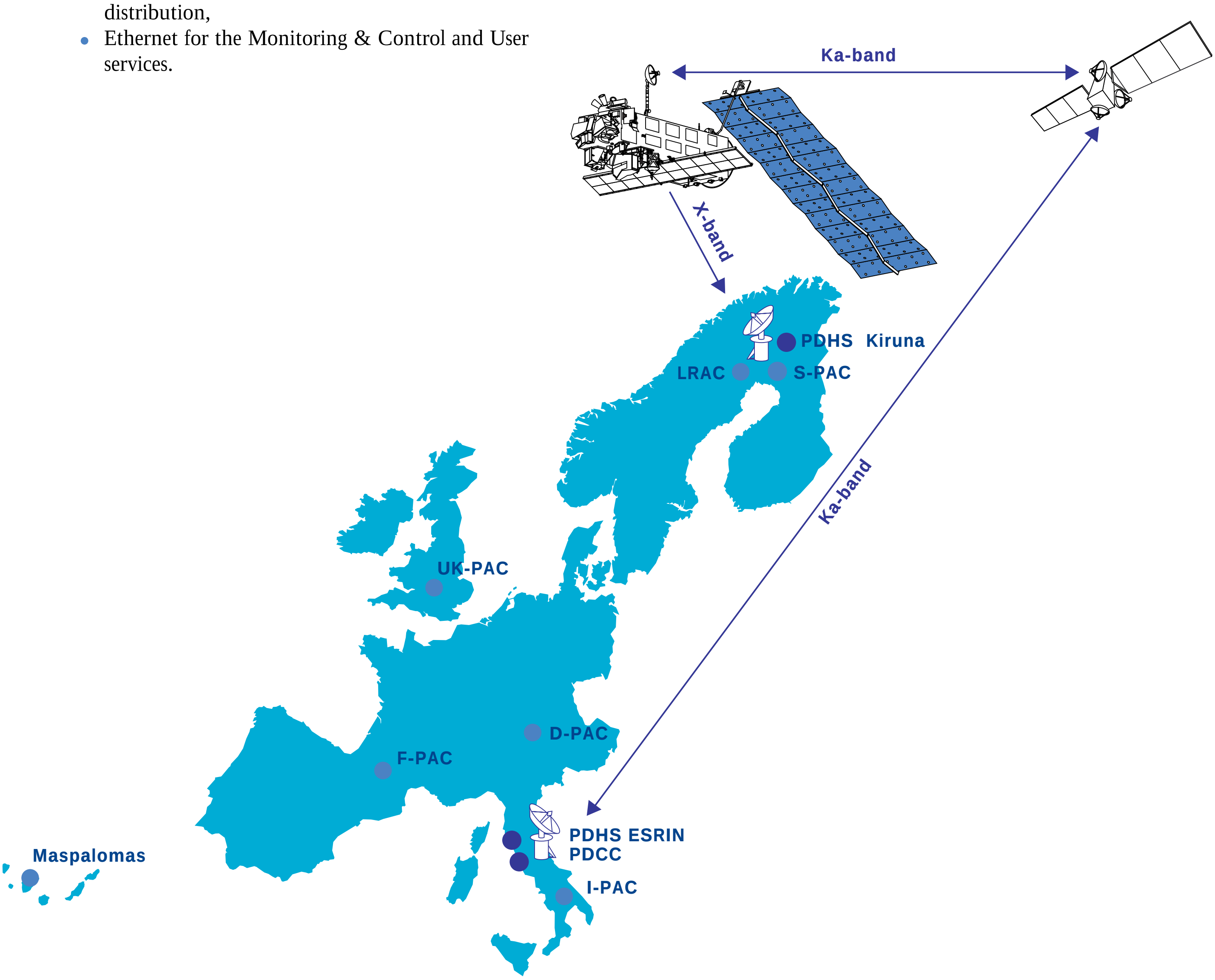
Centre/Station hardware architecture

The architecture is based on a specific set of computers:

- The IBM SP2 for all the processing chains: its multi computer capability is used to dynamically allocate one computer at a given time for the processing of one product. The global throughput is simply obtained by adding up computers according to the required throughput performances.
- The IBM J40 for the ARF, with state of the art robotics and media for automatic handling of archived products,
- The IBM 43 P workstation for the other facilities,
- ATM (high speed data link) for internal product distribution,
- Ethernet for the Monitoring & Control and User services.

PAC Assignments

ASAR High Rate	to be shared between UK-PAC, D-PAC and I-PAC
MERIS Full Resolution	to be shared between UK-PAC, I-PAC and Maspalomas station
ALTIMETRY & ASAR WAVE	located at F-PAC
ATMOSPHERE CHEMISTRY	located at D-PAC (with FMI Finland for GOMOS)
AATSR	located at UK-PAC
MERIS Reduced Resolution	located at S-PAC (Kiruna-Salmijärvi)



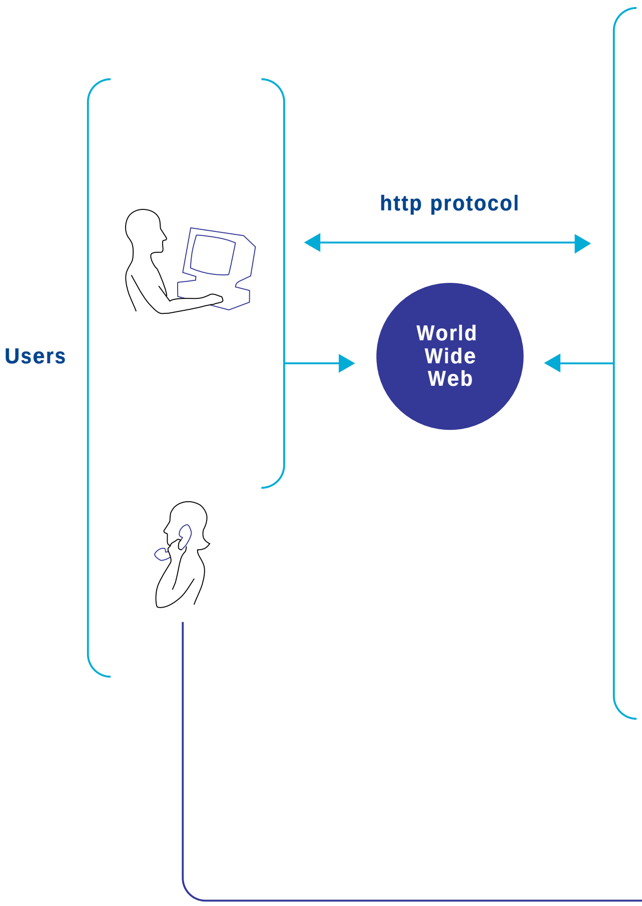
ENVISAT Products

The main objectives of the ENVISAT PDS are to generate, archive and distribute to the user's community the ENVISAT products derived from the data collected by the satellite.

ENVISAT archive will include data products from all instruments over the satellite lifetime (nominally 5 years). This huge data flow can be summarised as follows:

- up to 22 Gbytes of data to be acquired and processed every 100 minutes at PDHS;
- 700 Gbytes of data exchanged every week between the centres and stations, representing up to 100 tapes distributed.
- a total volume of 1000 Tera bytes of data to be archived over the whole mission.

User Services



Services Types	Services	Services Availability	Centre providing services
Consultation	Directory (description of user services bulletin board information on tools)	Free	Local centre
	Guide	Free	
Retrieval	Browse	Free	Local Centre or archives in PDS centres
	Free software tools	Free	
Inventory	Inventory	Free	Inventories in PDS centres
Order	Restricted software tools	Restricted	PDCC or station centre
	Get auxiliary data	Restricted	
	Get product	Restricted	
	Get On-demand product	Restricted	
	Order future product	Restricted	
	Subscription for global products	Restricted	
	Order for acquisition	Restricted	
	Request for dissemination link	Restricted	
Administration	Register user	Free	PDCC
	Get account information	Restricted	
	Complaint	Free	

Helpdesk

User access to the PDS

Users will access the PDS mainly to order data to be acquired, products to be processed or copied from the archive.
The PDS will offer the following type of services, some of them being restricted to registered users only:

- Consultation accesses general information on ENVISAT mission, products and services,
- Retrieval allows the transfer on the User's workstation of some PDS data, such as Browse,
- Inventory supports the search of existing products in the PDS archives,
- Order allows the user to request the production and the delivery of ENVISAT products either on physical media or directly through electronic links,
- Administration helps the user to dialogue with the PDS support operators.

Access to the services will be provided through Internet, via a USF server installed at each PDS centre and station location. All services will be transparently provided to the users by any PDS access point.

Once connected, the user will be able to retrieve information on the PDS products and services, to place or modify an order, and to retrieve the status of any order previously registered. The display of graphical information is maximised to help the users: satellite tracks, instrument coverage, outline of products will be displayed on a world map.

Users' orders are analysed in real time to check their compatibility with the ENVISAT-1 capability, the user privileges according to data policy rules, and also to identify possible conflicts among user requests.

All users' orders requesting acquisition of data by the satellite are centralised at the PDCC for the construction of the satellite work plan, called the Preferred Exploitation Plan (PEP). In case of conflicts between orders a priority scheme is used to select among the orders.

The PEP is submitted to the FOCC and the Detailed Mission Operation Plan (DMOP) is returned by the FOCC permitting the satellite scheduling and the corresponding PDS station/centre schedules to be formulated.

PDS development & integration

The PDS architecture leads to the build up of stations and centres by the assembly of facilities. It implies the following PDS development and integration logic:

- PDS facilities are developed by subcontractors and acceptance tested at this level;
- Assembly, integration and testing of the various facilities is performed on a reference platform, representing the configurations of the PDHS, PDCC, LRAC and a reference PAC;
- The full deployment and assembly of facilities is then performed at the ESA sites for a final onsite acceptance test

PDS testing will make extensive use of instrument test data provided by ESA through the use of instrument simulators or reconditioning of ERS in-flight data.

The PDS Critical Design Review was held in July 1996, and the PDS Detailed Design Review took place in March 1997.

A first version of the PDS, version 1, will be installed at ESRIN. This version will allow a complete system overall validation with the other elements of the ENVISAT system. Generic elements for PAC assembly will be available with version 1.

Full PDS operations will be possible with version 2, includes the processing of all ENVISAT instruments.

Overall Development and Verification Programme

Model Philosophy

The ENVISAT-1 satellite development programme is composed of two main elements, the instruments and the PPF.

The development logic and model philosophy is driven by the need to implement a cost effective approach fulfilling the stringent technical requirements within acceptable technical and programmatic risks. Furthermore, while the instrument and the PPF have their own development cycles, they are strongly coupled by the satellite level test requirements in the form of deliverable models as well as by the qualification programme logic.

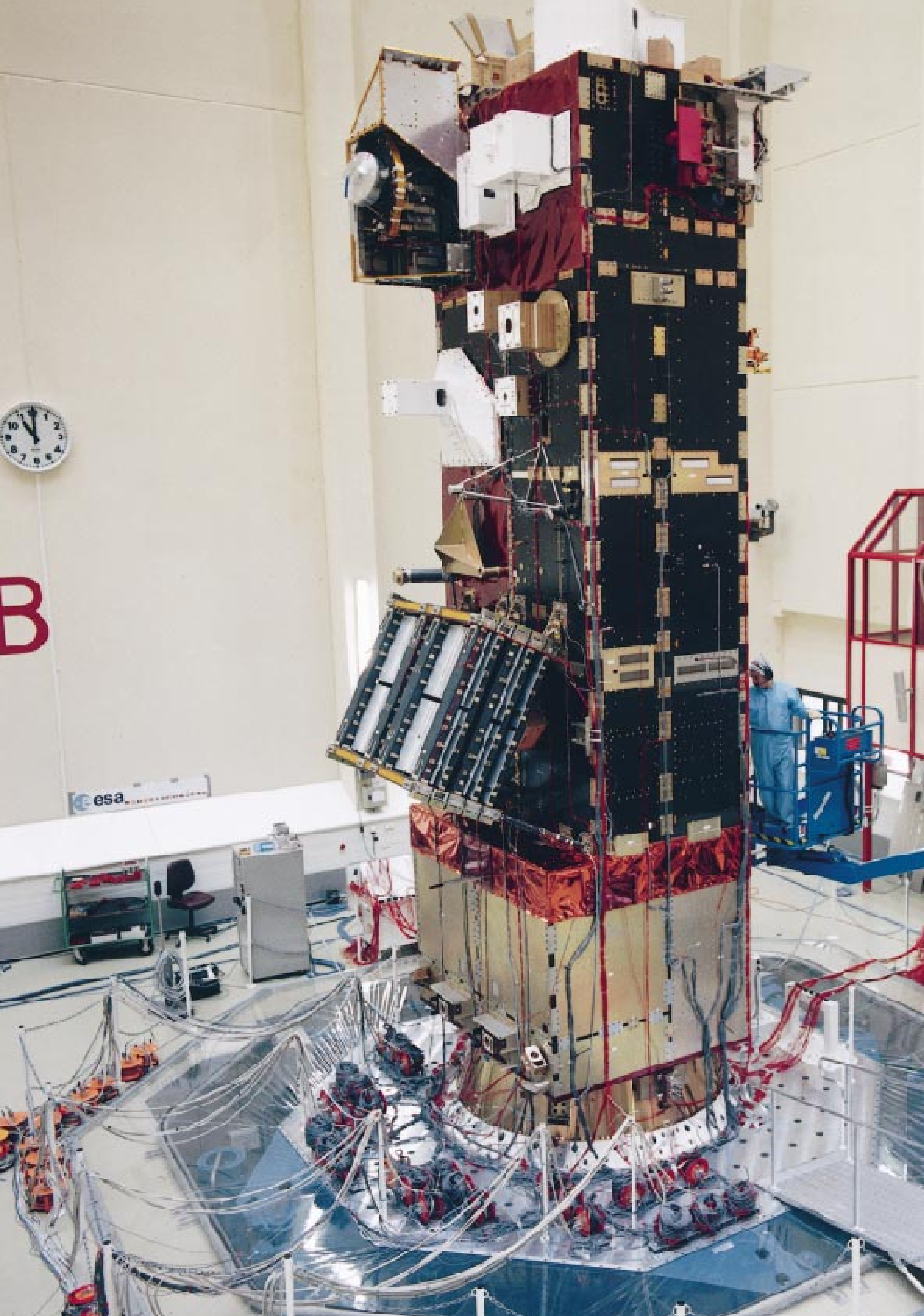
The Radio Frequency Mock-Up (RFMU) supports the spacecraft level radio frequency analysis by measuring antenna RF coupling factors. RF representative development models of the instrument and PPF antennas have been provided for this test.

A complete satellite Structure Model (StM) has been built to perform a PPF structure qualification programme, including structural models at flight standard for all instruments below 100 Hz first eigen frequency.

To fulfil the EM satellite programme objectives within schedule and cost constraints, it has been necessary to accept for several instruments reduced EM models, fulfilling the electrical and functional interfaces requirements and allowing vacuum tests to be performed.

Qualification is performed on PPF subsystems and instruments before assembly at satellite level. In several cases a Protoflight Model approach has been selected.

The ENVISAT-1 Structural Model
mounted on the ESTEC HYDRA Facility
during vibration testing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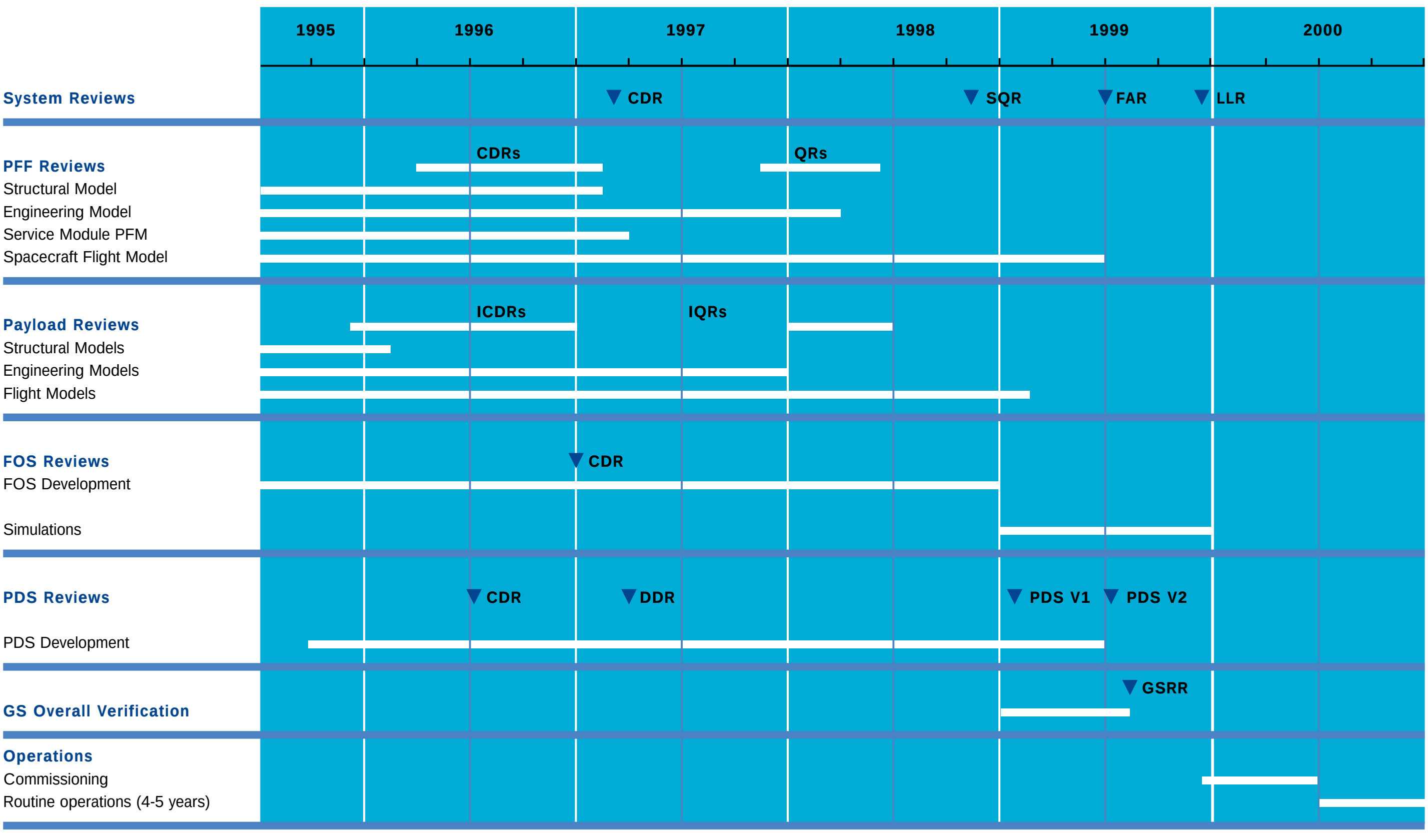
The satellite Flight Model integrates subsystems and instrument which have already been fully verified and characterised. For ASAR, the antenna and the central electronics will be delivered separately for integration at satellite level. The satellite level tests shall prove that the environment under which the subsystem or instrument design was qualified is compatible with the actual PPF environment. An ENVISAT-1 satellite verification programme will be performed in order to:

- perform satellite functional tests with the integrated payload and PPF
- demonstrate compliance of the total satellite to the ENVISAT-1 requirements
- verify compatibility of all elements within the actual satellite level environment.

Satisfactory completion of the FM programme permits the satellite to be declared ready for flight.

ENVISAT-1 Development Summary Schedule



Legend

CDR	Critical Design Review	**IQR**	Instrument Qualification Review
DDR	Detailed Design Review	**LRR**	Launch Readiness Review
FAR	Flight Acceptance Review	**PFM**	Proto Flight Model
GSRR	Ground Segment Readiness Review	**QR**	Qualification Review
ICDR	Instrument Critical Design Review	**SQR**	Satellite Qualification Review

Ground Segment Development & Integration

The Ground Segment follows a development schedule in parallel to the satellite. The two main elements, FOS and PDS, follow their own development cycles.

For the FOS the overall development and integration schedule is governed by the meeting points with the satellite: four System Verification Tests (SVT's) are foreseen between end 1997 and the Flight Acceptance Review (FAR). The flight operation control software, based on the system already used for the ERS missions, will be delivered in an incremental fashion according to the objectives of the SVT's. The FOS integration process is performed directly on the final sites retained for the operation phase (FOCC at ESOC and Kiruna station for TT&C).

The PDS has been decomposed into a set of facilities. Each facility fulfils a set of specific functions with well defined input and output interfaces. All facilities are developed in parallel, with acceptance testing at the level of each facility. The build up of each centre or station is performed by assembly of facilities. Assembly and test of representative configurations of stations and centres will be performed on a reference platform prior to deployment to the ESA PDS sites. Two PDS versions are planned to be delivered, version V1 and V2: with version V1, it will be possible to perform the Ground Segment Overall Verification (GSOV), whereas V2 provides the remaining of the low rate processors not included in V1.

Mayor Reviews

To ensure coherency of the ENVISAT-1 Mission & System development, integration and verification programme, major reviews have been defined, preceded by the necessary subsystem reviews and verification tests. These reviews are listed below:

- The ENVISAT-1 Mission & System Preliminary Design Review (EMS-PDR) was held in July 1994;
- The ENVISAT-1 Mission & System Critical Design Review (EMS-CDR), permitting the verification of the coherency of the design, the development and the verification plan, was held in March 1997;
- The Flight Acceptence Review (FAR) will allow the conclusion of the satellite development and verification programme and declare the satellite ready for shipment to the Kourou launch site;
- The Ground Segment Readiness Review (GSRR) will permit, by analysis of the GSOV results, readiness of the Ground Segment to support launch and operations of the satellite to be declared.
- A few days before launch, the Launch Readiness Review (LRR) will assess the readiness of the satellite, launcher and ground segment to support the launch and flight operations.

In-Orbit Operation

A week after launch, the Launch and Early Operation Phase (LEOP) will be completed, the satellite having acquired its nominal orbit, with all it's appendages deployed. The instrument switch-on phase will then begin. Three weeks after launch, all payload links being operational and the instrument being capable of supporting nominal operations, the commissioning phase will be initiated. A six months period is foreseen for this system characterisation in-orbit including:

- calibration of the instruments allowing release of the level 1B products;
- validation of the geophysical algorithms involved in the level 2 product generation.

At the end of the commissioning phase, the satellite will enter in its nominal exploitation phase. The programme participants have approved the financing of ENVISAT-1 operations over four and a half years, following its six month commissioning, commensurate with the satellite design lifetime objectives.

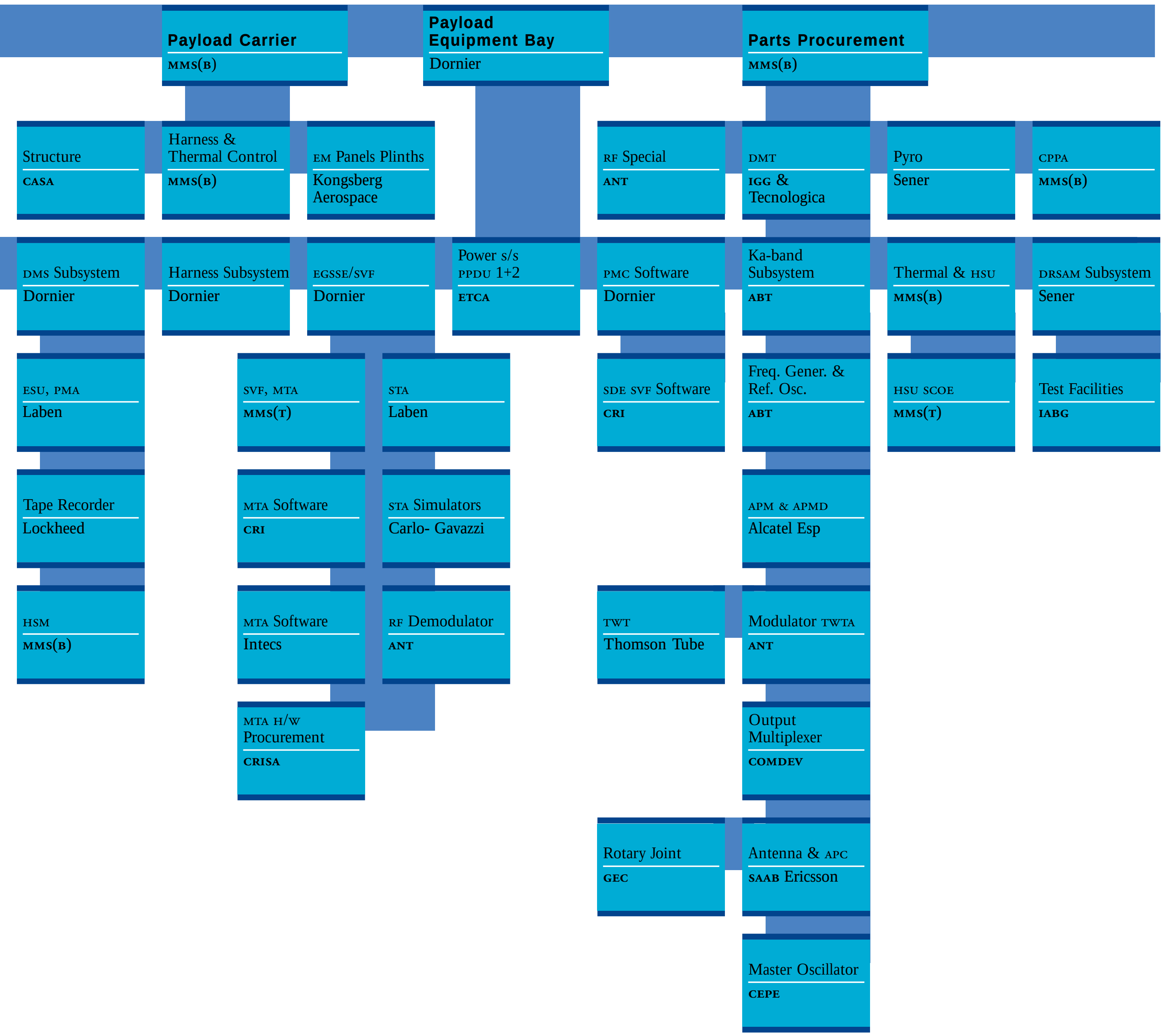
Industrial Organization

Polar Platform & Satellite
Prime: MMS(B)

- **Service Module** — MMS(T)
  - Mechanical Subsystems — MMS(B)
  - Structure — CASA
  - Onboard Software — MMS(T)
    - DMS Software — Intecs
  - Propulsion (Pipework) — MMS(B)
    - Propulsion Equipment — SEP
  - Power Subsystem — MMS(T)
    - Power Electronics — ETCA
    - Batteries — Saft
  - Solar Array — Fokker
    - PVA — DASA
    - Support Beams — Contraves
    - PDM — MMS(B)
    - Mechanism — UCN
  - DMS Subsystem — MMS(T)
    - CCU — SAAB Ericsson
    - EDR, BSP, CBS, IFEX — Sextant
    - USO — FTS
  - Thermal Control, EIU & Harness — MMS(B)
  - Comms Subsystem — MMS(T)
    - S-band Transp — Alenia Spazio
    - S-band Antenna — MMS(T)
  - Sun Sensor Support Bkt — Kongsberg Aerospace
  - AOCS Subsystem — MMS(T)
    - SST, T4S, SAS, UMS — MMS(T)
    - EAIM — Alenia Spazio
    - Optical Sensors — Sodern
    - Gyros — SAGEM
    - RRPM — Aerospatiale
    - Magnetorquers — Ithaco
    - EPRM — Laben
    - SADM — SEP
  - EGSE/SVF — MMS(T)
    - SAPS — FIAR
    - BCU SCOE — K Serras
    - Umbillical SCOE — CEIS
    - RF SCOE — ATNE
    - TM/TC FEE — Laben
    - MTA H/W AOCS Bay — CRISA
    - SST Bay SCOE — MMS(T)
  - X-band Subsystem — ANT
    - TWTA, Assy Comms Units — ANT
    - Antenna Reflector — Dornier
    - TWT — AEG
- **EEE** — MMS(V)
- **System Support S/W** — Logica
- **System Support S/W** — CRI
- **MGSE** — OHB

Polar Platform

The European Polar Platform (PPF) is being developed by a consortium of European industrial companies led by the prime contractor Matra Marconi Space in Bristol (UK) who is also responsible for the final satellite integration and preparation for launch. Dornier in Germany has major development responsibility for Payload Equipment Bay which is a part of the Payload Module, and Matra Marconi Space in Toulouse (F) is leading the Service Module development. In all, about 50 companies are participating in this major undertaking.



Payload
Prime: Dornier Satelliten-Systeme GmbH (DSS)

Mission & System
DSS

- GOMOS & MERIS System Simulators — ACRI
- RBI ASIC — ADV/ABB-HAFO
- Laser Retro-Reflector — AEROSPATIALE
- PA Support — ASTREC
- MIPAS System Simulator — BOMEM
- DFFS & Engineering Support — CRI
- Antenna Coupling Analysis — ERA TECHNOLOGY
- Support to GOMOS System Simulator — FMI
- System Support & Liaison to PPF — MMS-B
- EGSE Standard Elements Development — MMS-F
- System EGSE support — OHB
- DORIS/MWR ICU — SEXTANT
- Parts Procurement Agents — TECHNOLOGICA/IGG
- ADA Compiler — TLD
- RA-2 System Simulator — UCL
- EGSE Operation — VEGA

ASAR
MMS-P

- Tile s/s & Equipment — ALCATEL ESPACE
- CESA Design & AIV — ALENIA AEROSPAZIO
- Antenna MGSE, Dummy Tiles, Instrument MGSE — APCO
- Radiator Panels, CESA & ASS Harness — CASA
- Instrument EGSE DANC — CRI
- Depl. Control Unit, APSM, DC-Converter ICE — CRISA
- Tile PSU, CESA PCU — ETCA
- Antenna HRM — FOKKER
- Standard EGSE — MMS-F
- Control s/s — MMS-P/MMS-F
- Ant. Serv. s/s & Equipment, TCIU/TR-Modules — MMS-P
- RFPF/AFW Components — OCI
- Antenna Mounting Structure, Antenna StM — OCW
- Pulse Power Support for RF s/s — RESCOM
- Control s/s EGSE — ROVSING INT./TERMA
- Antenna DEM — SENER
- Cross Strap Assembly — SCHRACK
- RF s/s, Data s/s, Antenna Analysis — SES
- Ant. Eng. Design Support, RFPF/AFW Integration — SPAR
- SSPA/ACMM — TELETTRA
- Data s/s EGSE — TERMA

GOMOS
MMS-F

- Instrument MGSE — APCO
- Performance Test Facility — CSL
- Telescope Structure — DSS
- CCDS for DMSA/B — EEV
- Science Data Electronics, AIV Support, EGSE — FINNYARDS
- Harness & ATC — EUROFARAD
- Environment Test Facility — INTESPACE
- Steering Front Assembly, Harness & Active TCH — MMS-B
- Standard EGSE — MMS-F
- Structure & Passive TCH — ORS
- Telescope Mirrors — REOSC
- Instrument Control Unit — SES
- SFA MDE — SENER
- Spectro-Detectors, Photometers Star Tracker — SIRA
- Focal Plane Optics, Perf. Test Fac., OGSE — SPACEBEL
- Instrument s/w & SMF — SSF
- Detectors DMFP — THOMSON
- Spectrometer Lab. Model — VTT

MERIS
AEROSPATIALE

- MGSE, OGSE — APCO
- Harness — CASA
- AIC S/W ESE — CAPVOLMAC/AMOS
- Optical Subassembly — CERCO
- PDU, AIC VEU, EGSE — CIR
- Calibration Mechanisms — CSEM/AER
- OGSE — CSL
- AIC DSU — ETCA
- AIC-CCD — EEV
- ICU Application S/W, SMF — GMV
- SDPSS & SMF — LABEN
- Flat Plate Diffuser, Calibration H/W — LABSPHERE
- Standard EGSE — MMS-F
- CCSS — SES
- Depointing Mechanism — SENER
- OGSE Solar Simulator — SESO
- Analogue Imaging Chain — SODERN
- Diffuser Characterization — TPD

MIPAS
DSS

- Calibration Black Body — AEA
- EGSE — AFI
- Performance Analysis, Interferometer Support, OCF — BOMEM
- Signal Processing Electronic — COMDEV
- Structure, Scan Units, Front End Optic — OCW
- Instrument Control Unit — CRISA
- Power Distribution Unit — DELFT INT.
- Focal Plane S/S Analysis — FOKKER SPACE
- Detector Preamplifier Unit — GMIRL
- Optical Encoder — HEIDENHAIN
- Test Facility — IABG
- Optical Path Sensors — KOG
- Cooler Assembly — MMS-B
- Standard EGSE — MMS-F
- Interferometer Assembly — OFFICINE GALLILEO
- External Harness — OHB
- Thermal Control HW, MGSE — ORS
- ASU/ESU — SENER
- Telescope — SESO
- Interferometer Engineering Support — SPACEBEL
- Focal Plane Optics, Afocal Reducer — TPD

MWR
ALENIA AEROSPAZIO

- Local Oscillators — COMDEV
- Switch Assembly — EMS
- Feed Waveguides — HYPER CBM
- Mixer, Amplifiers — MILITECH
- RF Front End — OCI
- Structure, MLI, MGSE — ORS
- Reflector — REOSC
- Radiometer Test Facilities — RSI
- CEU, EGSE — SCHRACK
- Black Body Targets — ZAX

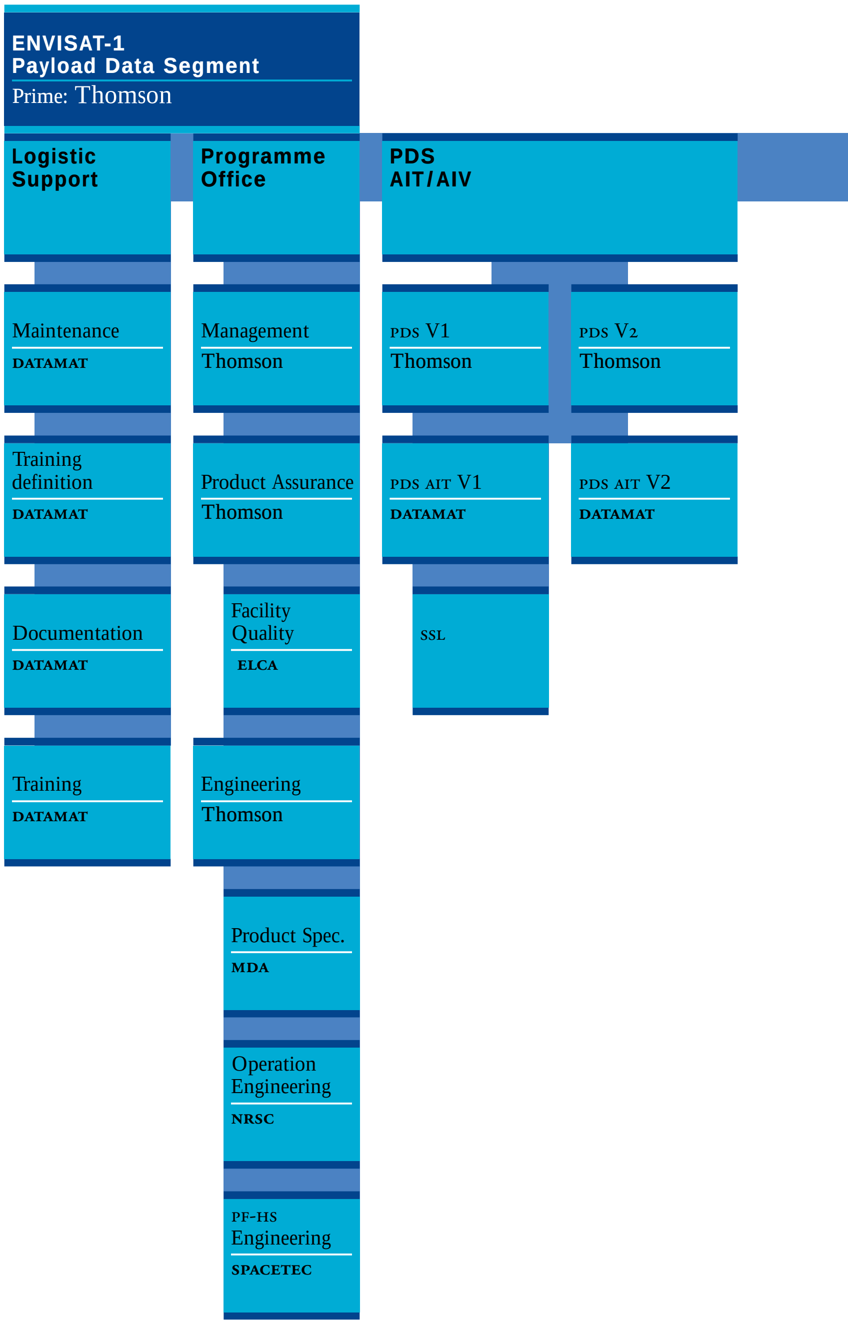
RA-2
ALENIA AEROSPAZIO

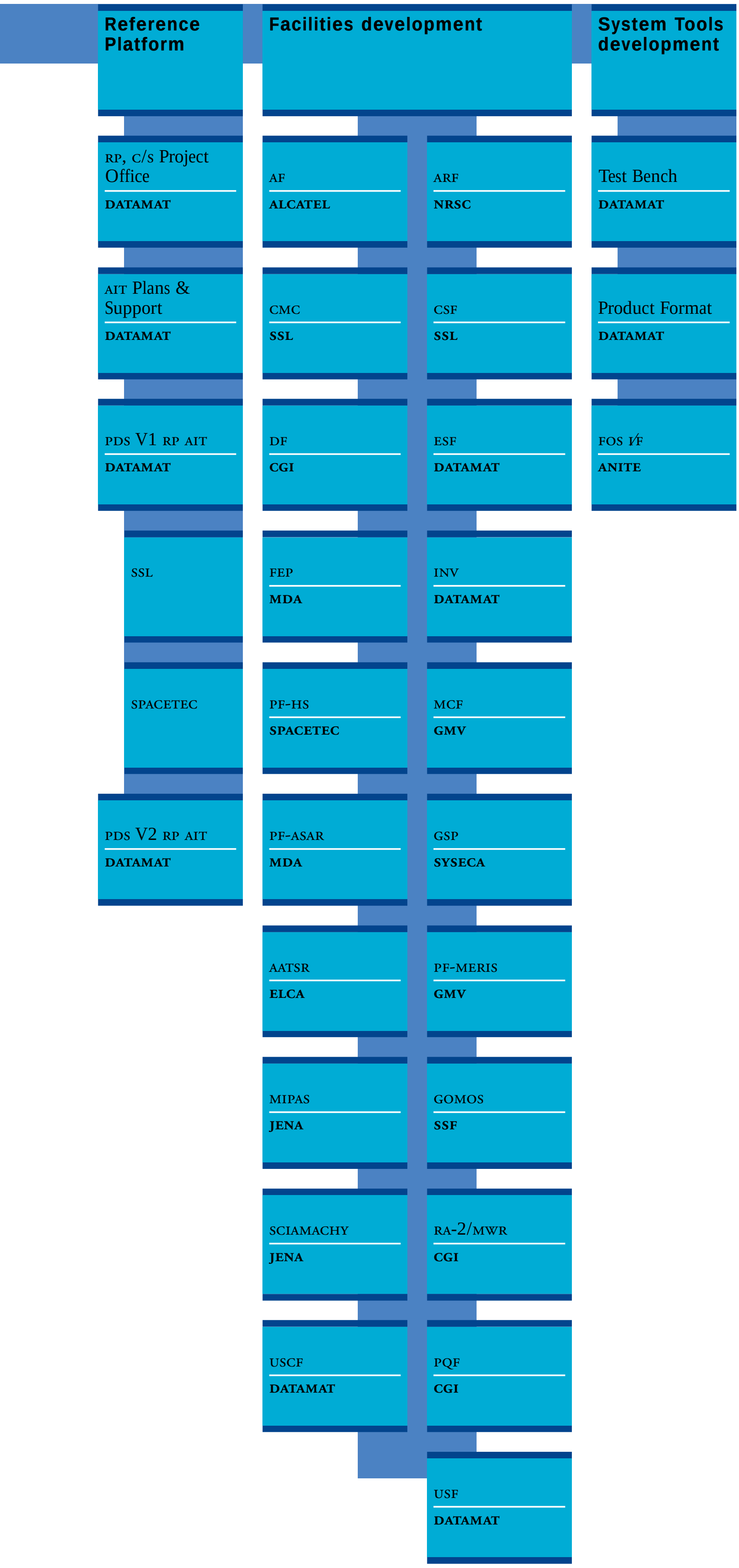
- TWT — AEG
- Chirp Generator — AME SPACE
- ITE, S.E. S/W — CARLO GAVAZZI
- Antenna Reflector — CASA
- Ku & S-band Front End Electronics — EMS
- LVPS — ETCA
- HPA, FGCU, Stx — FIAR
- Standard EGSE — MMS-F
- Return Signal Simulator — SCHRACK
- EGSE S/W — SSI

ENVISAT-1 Payload

The industrial team is led by Dornier Satellitensysteme GmbH, responsible for the ESA Development Instruments and certain Mission/System aspects.

The ENVISAT-1 team includes leading European and Canadian companies which have gained significant experience from their involvement in European Earth observation programmes. Many have been particularly involved in the ERS 1/2 programme providing a continuity and transfer of experience from that very successful programme.


ENVISAT-1
Payload Data Segment
Prime: Thomson
Logistic Support
Maintenance
DATAMAT
Training definition
DATAMAT
Documentation
DATAMAT
Training
DATAMAT
Programme Office
Management
Thomson
Product Assurance
Thomson
Facility Quality
ELCA
Engineering
Thomson
Product Spec.
MDA
Operation Engineering
NRSC
PF-HS Engineering
SPACETEC
PDS AIT/AIV
PDS V1
Thomson
PDS V2
Thomson
PDS AIT V1
DATAMAT
PDS AIT V2
DATAMAT
SSL



Payload Data Segment

Thomson-CSF Services & Systemes Sol Spatiaux is the prime contractor responsible for overall programme management, central procurement of hardware and software, sytem engineering, and system validation and acceptance.

Individual facility development contracts have been awarded to European and Canadian subcontractors having the appropriate expertise and experience due to their involvement in other Earth observation programmes.

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