ERS-1 EUROPE's FIRST REMOTE SENSING SATELLITE

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Preface :
On July 16th, 1991 at 10.46 pm local time, Europe launched from Kourou, French Guyana, the most complex satellite ever built by European Industry - ERS-1.

After a development period of more than six years a mission began where the first results already produced after the initial switch-on period were beyond all earlier expectations. The so called "commissioning phase" dedicated to final verification and calibration of the on board instruments as well as operational center, processing and data distribution facilities on ground was terminated end of 1991 with very positiv results.

By this the ERS-1 System (Satellite, ground control and dataprocessing and distribution facilities) was declared operational and is ready to serve the needs of both scientific and commercial users.

1. THE PROGRAMME OBJECTIVES

The ERS-1 mission is mainly dedicated to ocean and ice application. The capabilities include measurement and detection of :

- Windspeed and -direction
- Wavehight and -fronts
- Ocean pollution
- Ice zones and ice bergs
- Water surface temperature
- Water vapour content of the atmosphere
- Cloud temperature

In addition to the above, allweather imaging of:

- Costal zones
- Polar ice regions and
- Land areas

is one of the features of the satellite.

To pave the way towards enhanced sientific and commercial/technical applications fast data processing and product distribution (e.g. distribution of applicable products within 3 hours after the data have been obtaines to the user concerned) is one ot the priority objectives of the mission.

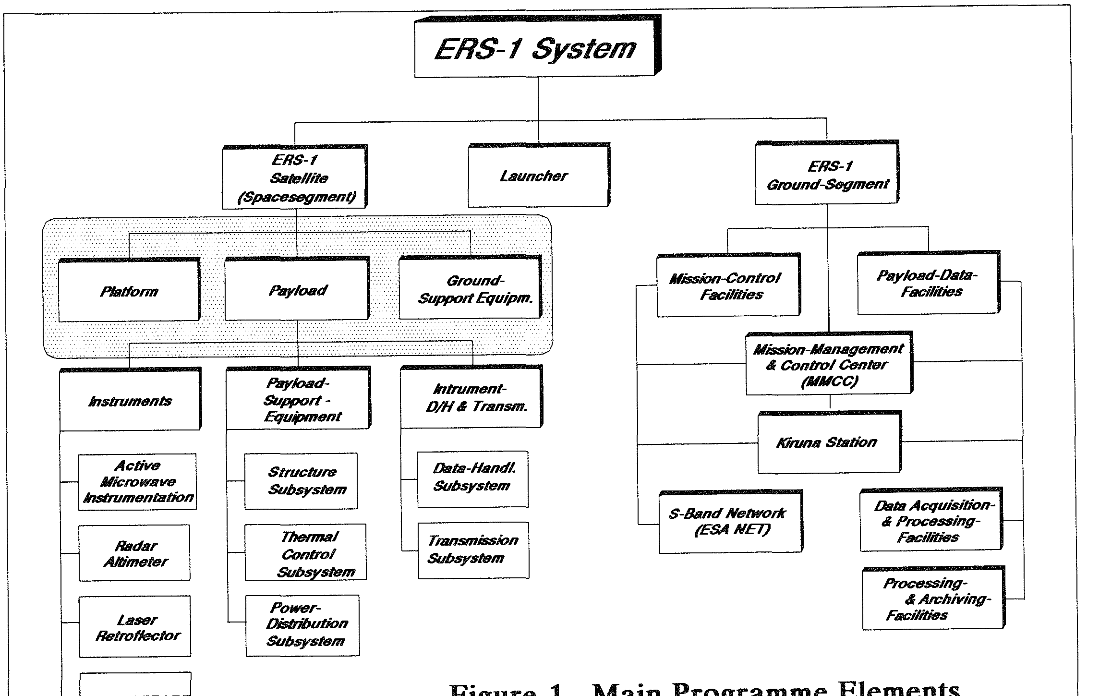

Figure-1 Main Programme Elements

With this approach the ERS-1 programme contributes to :

- Ocean- and climat research
- Glaciology
- Environmental research
- First operational applications and their promotion

2. THE ERS-1 SYSTEM

ERS-1 (= European Remote Sensing Satellite No. 1) is a "end to end system " for allweather and global environmental monitoring. This means that the overall programme is not limited to the development and operation of the satellite proper but includes data processing, archieving and distribution.

The main programme elements are shown in figure 1.

2.1 The Satellite

The satellite basically consists of the platform which provides for power-generation and distribution, attitude control and measurement, command handling for the satellite and S-band telemetry for the housekeeping data of the spacecraft.

This platform is derived from the French Spot programme and adapted to the specific needs of ERS-1.

The main element, however, is the payload module which comprises the set of instruments together with the payload dedicated support hardware like structural support, thermal control, power distribution and the data handling and transmission subsystem for the instrument data which are handled separately from the "normal" spacecraft housekeeping data. The specified measurement performances and the related instruments can be seen in figure 2.

The main elements of platform and payload respectively can be seen on the exploded view of figure 3

ERS-1/2 Programme

- Measurement Performance -

Dornier

Deutsche Aerospace

Geoph. Parameter	Range	Accuracy	Main Instrument
Wind Field - Velocity	4 - 24 m/sec	+/- 2 m/s or 10% whichever is greater	Wind Scatterometer & Radar Altimeter
-Direction	0 - 360 degree	+/- 20 degree	Wind Scatterometer
Wave Field - Signif. Wave Height	1 - 20 m	+/- 0.5 m or 10% whichever is greater	Radar Altimeter
- Wave Direction	0 - 360 degree	+/- 15 degree	SAR Wave Mode
- Wavelength	50 - 1000 m	20 %	SAR Wave Mode
Earth Surface Imaging - Oceans - Coastal Zones - Sea-Ice - Land	100 km	geometric/radiometric resolutions: a) 30 m / 2.5 dB b) 100 m / 1 dB	SAR Image Mode
Altitude - Over Ocean - Over Ice Sheets	745 - 825 km	+/- 10 cm less than 1 m	Radar Altimeter
Satellite Range		+/- 10 cm	PRARE
Sea Surface Temp.	500 km swath	+/- 0.5 K	ATSR (IR)
Water Vapour	in 25 km spot	10 %	ATSR (Microwave Sounder)

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Figure 2 Measurement Performance

ERS-1 Overview

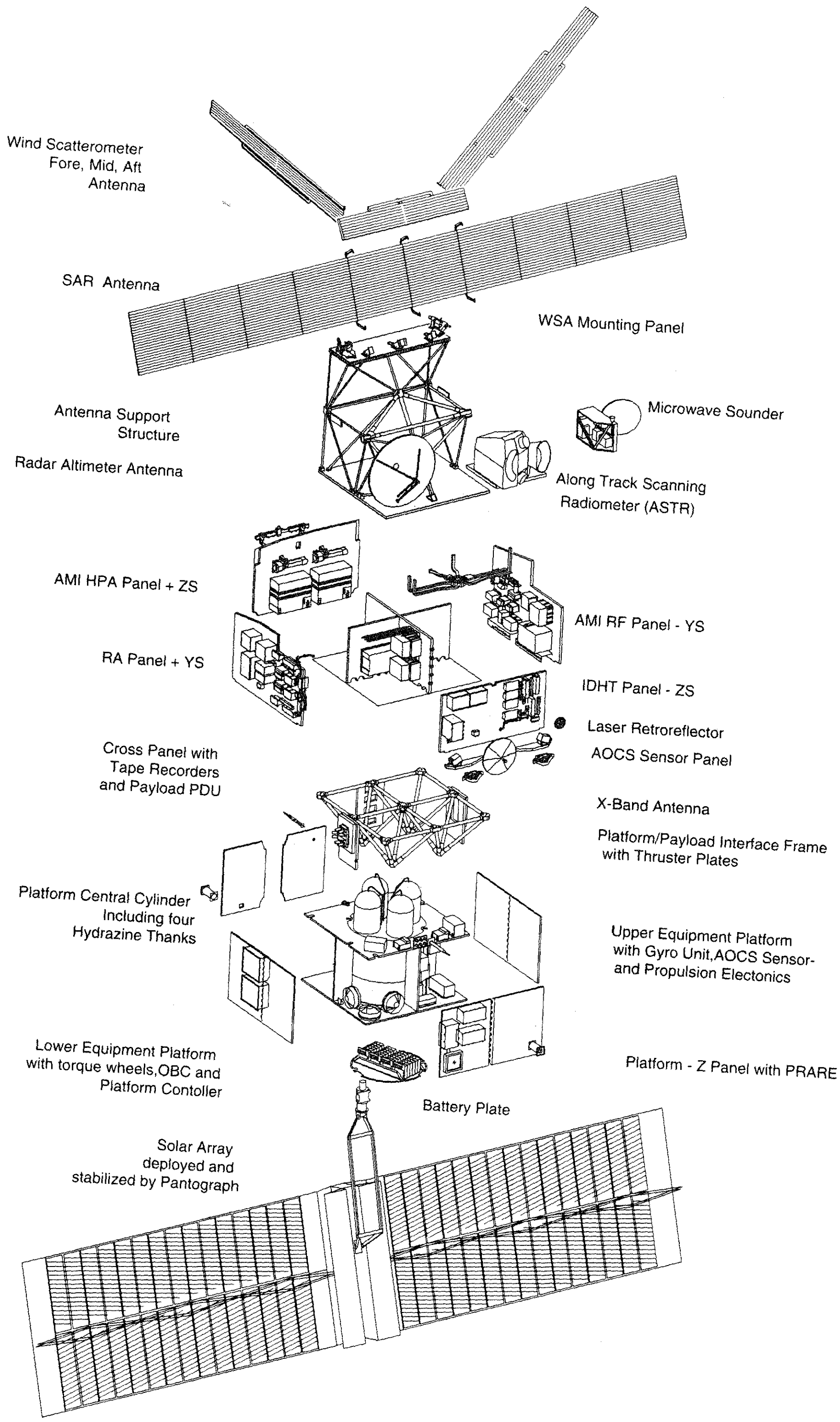

Figure 3 Exploded View

2.2 The Ground segment

The mission dedicated ground station is located in Kiruna, Sweden and interfaces with the Mission Management and Control Center (MMCC) at ESOC; Darmstadt.

Apart from further European stations like Maspalomas, Fucino etc. numerous other stations (mainly to receive real-time SAR - data) are being phased in worldwide. During the operational phase which began late December 1991 the main responsibility for planning and operation of the system lies in the hands of ESRIN (European Space Research Institute) in Frascati, Italy.

The interrelation of the various ground elements of the ERS-1 System also seen from a user point of view are shown in figure 4.

2.3 The Main Instrument Operation

The C-band (5.3 GHZ) ACTIVE MICROWAVE INSTRUMENTATION (AMI) comprises two different Instruments, a Synthetic Aperture Radar (SAR) which can be operated in either imaging or wave mode and a Scatterometer the operational mode of which is the wind mode. The swath width in imaging mode is 100 km. The data are being downlinked at a rate of 105 Megabit per second in realtime to a ground station being in direct receiving contact with the satellite.

The image measurement geometrie is outlined in figure 5.

In the wave mode operation the SAR takes "snapshots" every 200 km of a 5 times 5 km "wave cell" from the sea surface measuring the variation of the radar echo created by the waves of the ocean. The data allow determination of a two dimensional wave spectra. Like all data (except SAR image data) they can be sent in realtime and/or stored on board for a complete orbit cycle for transmission during contact with a dedicated ground station.

The wind scatterometer uses 3 different antennas: a far-, mid and aft -antenna relativ to flight direction.

The measurement principles asks for one measurement of each "measurement cell" by each antenna. By aid of a mathematical model windspeed and winddirection are being derived out of the returned radar echos.

SCATT measurement geometry is outlined in figure 6.

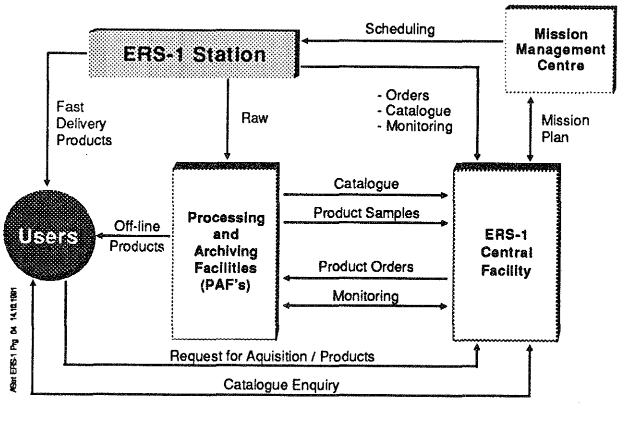

Figure 4 ERS-1 Central Facilities

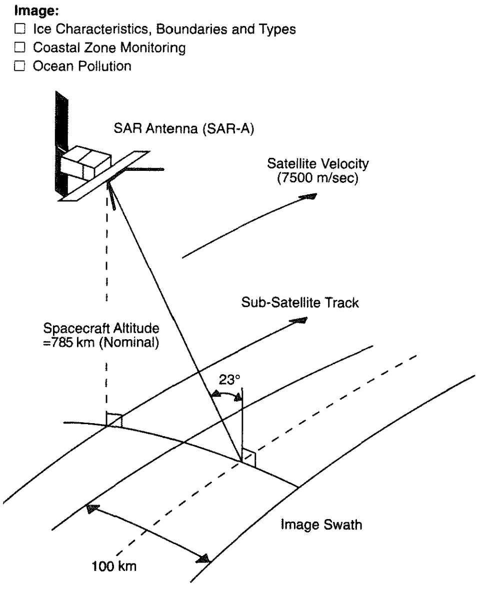

Figure 5 Image Mode Measurement Geometry

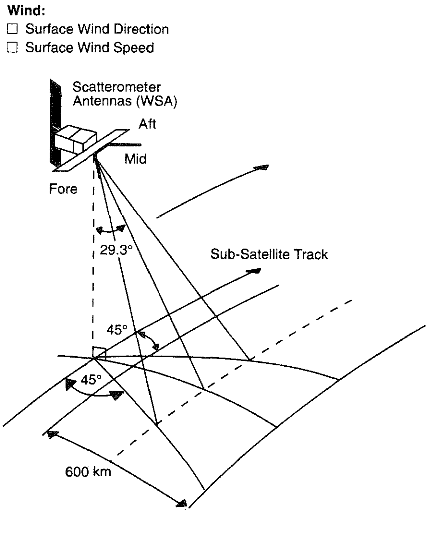

Figure 6 SCATT Measurement Geometry

The Ku-band (13.8 GHz) RADAR ALTIMETER is also an active mircowave instrument pointed to earth center. The instrument measures significant wavehight and windspeed over ocean. Over ice the ice topography and its character as well as ice water separation line can be determined.

The significant wave hight (SWH) is being determined out of the signal form of the returned radar echo, whereas the strength of the returned signal is both a measure of the wind speed and is also being used for determination of sea ice separation line.

The ALONG TRACK SCANNING RADIOMETER (ATSR-M) comprises two different instruments, an infrared radiometer (IRR) and a microwave + radiometer (MWR).

The passive infrared radiometer scans the earth simultaneously in two different viewangles and four different channels (1.6; 3,7; 11; 12 micrometer). The instrument determines :
- sea surface temperature,
- temperature of the cloud top,
- cloud coverage and
- radiation density of land and ice surfaces.

The accuracy of temperature measurement in a 50 times 50 km measurement field is better than 0,5°K and reaches 0,1°K for measurement cells of 1 times 1 km in cloudfree areas.

The second ATSR-instrument is a nadir pointing microwave sounder operating at 23.8 GHz and 36.5 GHz which mainly determines athmospheric water vapor content.

3. THE PROGRAMME DEVELOPMENT

First conceptual studies for an allweather (radar based) earth observation system started already some 15 years ago. The basic mssion idea was defined in the early eithies and a phase B study was done from summer 82 to September 83.

After a technical and geographical distribution "harmonisation process" the main development phase started in December 1984. The main programmatic data are summarized in figure 7.

Customer	European Space Agency (ESA)
Prime Conractor	Dornier / Deutsche Aerospace
Contract Value	@ 1,3 Billion German Mark (= @ 800 Million US$)
Participating Comp.	@ 50 from 14 countries (12 European, Canada and USA)
Progamme Duration	6 Years main developement phase
Personel Deployment	@ 3000 engineers in the participating industry during the main developement phase.

Figure-7 ERS-1 Main Programmatic Data

4. FIRST MISSION RESULTS

4.1 Imaging

Numerous pictures have been taken by the onboard SAR instrument irregardless of a day-time and cloud coverage thus demonstrating its allweather capability. The accuracy/resolution being approximately 25 m is better than originally specified.

Spectacular results could be achieved through multi-image processing thus gaining information about changes occured during a given time period or longer term ice observation. The system also demonstrated its capability to observe oil slicks and pollution of the oceans.

4.2 Wind- and wave-detection and observation

The global aspect and usefulness of the Radar Altimeter and Scatterometer measurements could be very well demonstrated and the data are already now being fed into the various meteorological services to assist in improving the long term weather forecast and to assist in climate modelling.

The consortium led by Dornier-Deutsche Aerospace consisted of some 50 companies. The first layer of the industrial organisation which also reflects the responsibility sharing within the consortium is shown in figure 8.

The main development phase not only covered the building of the flight model and the ground segment but also two more satellite models being used for mechanical, thermal and functional verification and system qualification.

The phasing of these elements and their timely duration is given in figure 9.

The launch of ERS-1 took place during the night from 16th to 17th of July at 01,46 UT from Kourou by means of an ARIANE to launcher (Vol 44), and after successful deployment of all stowed appendages like Dolar Array, SAR antenna, Scatterometer antennas, ATSR antenna etc. shortly thereafter, followed by the initial switch-on period a promissing mission began.

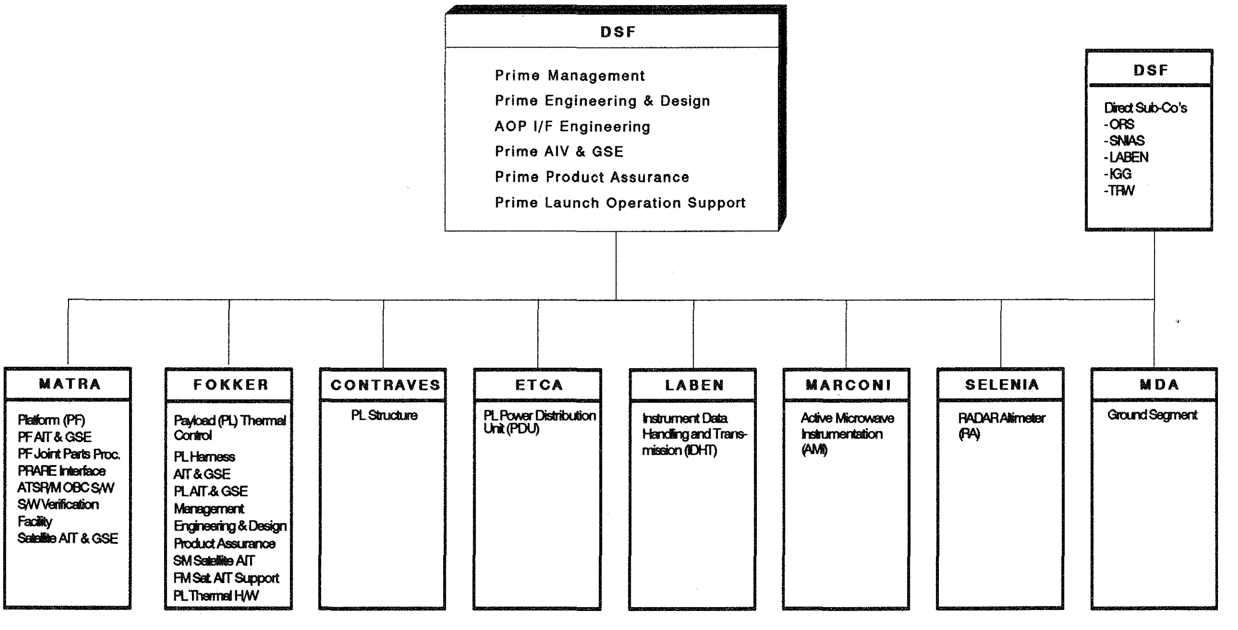

Figure 8 Industrial Consortium (Cocontractor Level)

ERS-1 Summary Schedule

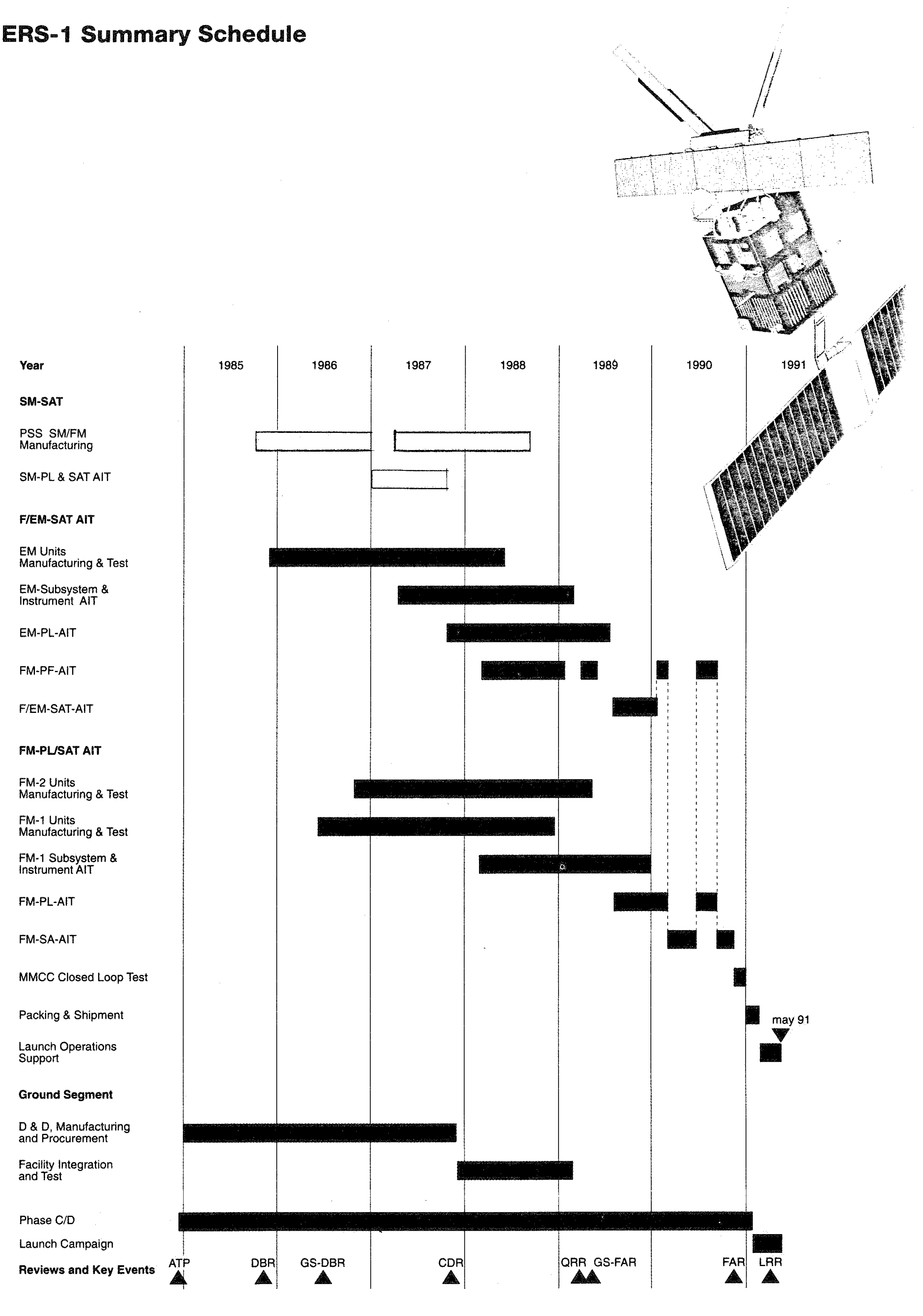

Figure 9 ERS-1/2 Programme (Summary Schedule)

4.3 ATSR measurements

Data on seasurface temperature, water vapour content etc. being of high importance for climate- and ocean circulation observation could be obtained both regionally and globally with an outstanding accuracy.

4.4 Pilot projects

Pilot projects are dedicated projects using ERS-1 data to demonstrate the range of either scientific or commercial/technical application. The example taken here is the ship routing through the "north Passage" (northerly route from Scandinavia to Japan through the Bering Street) using ERS-1 SAR images to guide a polar vessel.

With this approach the passage could be done in some 20 days compared with approx. 60 to 70 days for the normal southern route.

The set-up of this pilot project is given in figure 10 and worked as follows :

- ERS-1 took a SAR image of the polar sea area concerned
- The data were received and processed in Kiruna
- Transmission of the product via satellite link to ESA, where a group of experts analysed sea and ice conditions deriving from this routing instructions for the polar vessel.
- Routing instructions and the SAR image were then transmitted to the captain onboard via INMARSAT

5. THE CONTINUATION

Continuation mainly means to guarantee data continuation, upgrading of the instruments, enforcing by future missions the environmental aspect and development of new instruments.

A medium or longer term aspect is the promotion of new markets like e.g. verification.

With the decision for building the ERS-2 spacecraft (being an upgraded version of ERS-1 including a global ozon monitoring experiment and two more channels for the ATSR instrument allowing vegetation monitoring) as well as the declaration/decision for the polar mission programme Europe accepts, underlines and adheres to the above aspects.

The next generation of earth observation satellites strengthening the climate and atmosphere aspects is already under development in the POEM (Polar Earth Observation Mission) programme.

ERS-2 will be ready for launch in late 1994 and the POEM mission number 1 is scheduled to be launched in 1998.

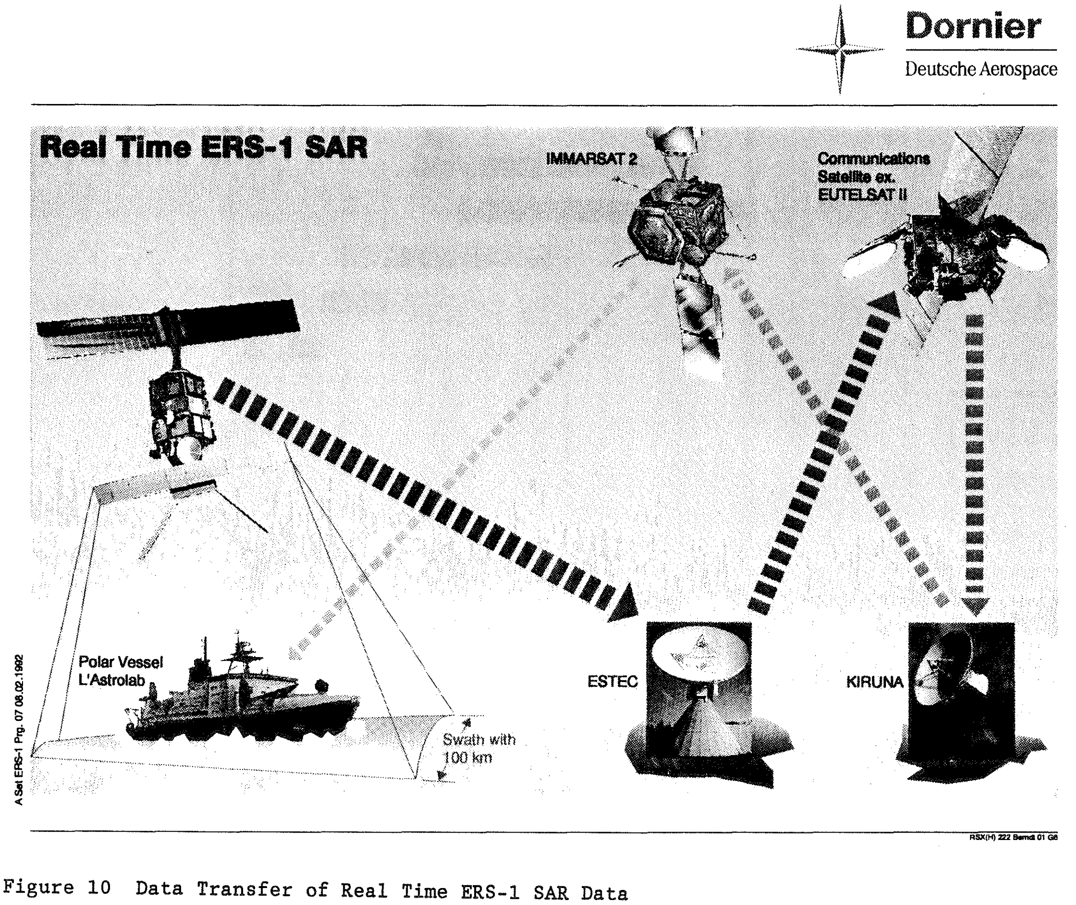

Figure 10 Data Transfer of Real Time ERS-1 SAR Data