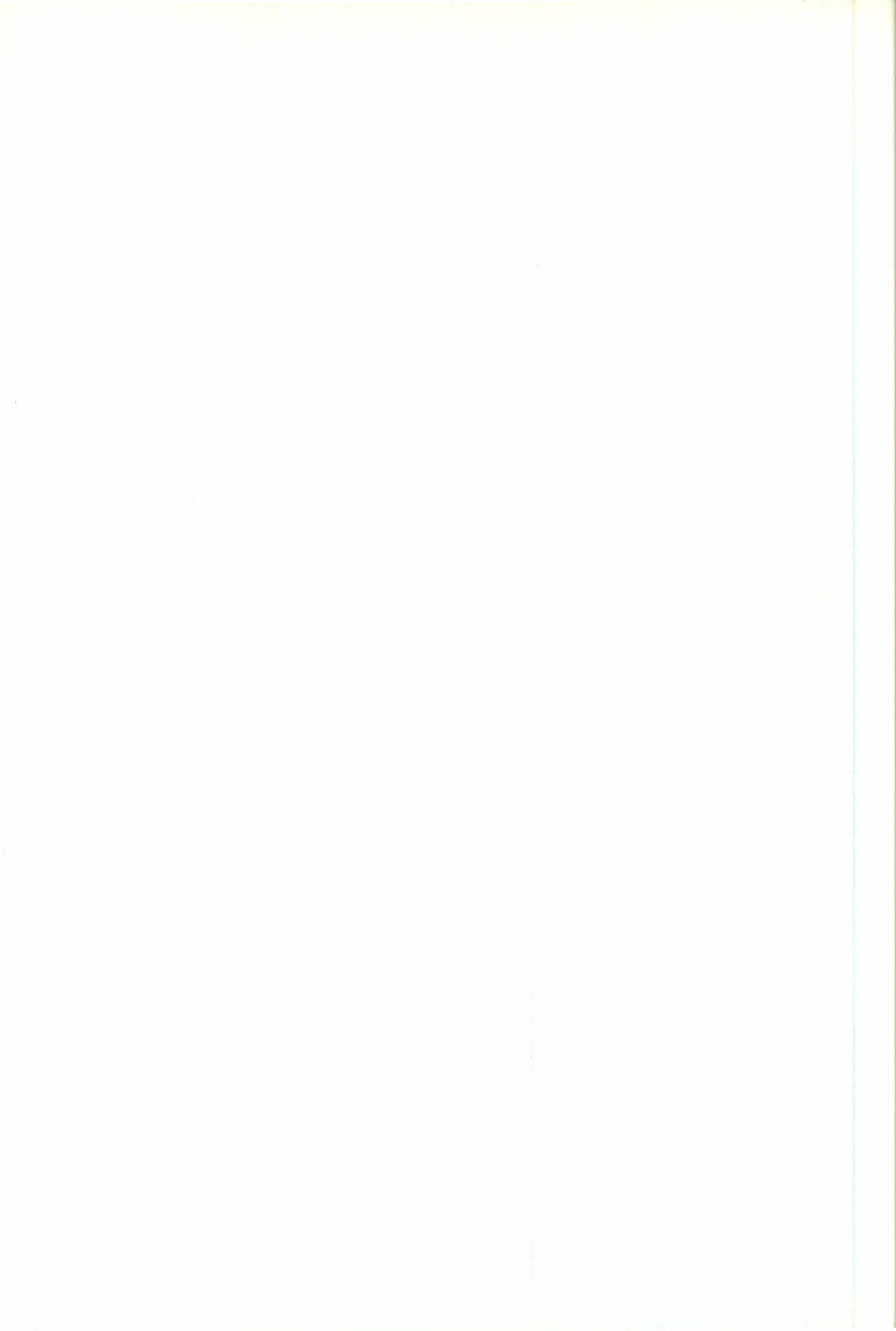


# **Two Years of ERS-1 Data Exploitation**

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The ERS-1 mission has fully lived up to expectations and today, after two years of operations, it continues to demonstrate the ability of such a sophisticated remote-sensing system to provide valuable earth-observation data to several categories of users, ranging from the real-time operators involved in meteorological, oceanographic and environmental applications, to long-term research-project groups working off-line.

The ERS-1 system is also being exploited for a wide range of commercial applications, thereby opening up new horizons in the earth-observation field. Its success is further underlined by the very large number of national and foreign stations acquiring or planning to acquire ERS-1 data, already allowing coverage of the majority of globe's land masses. They represent by far the largest community of international operators covered by a single project.

ESRIN, via its ERS Exploitation Division, has operational responsibility for the ERS-1 Payload Data Ground Segment as well as the related User Services.

## The Payload Data Ground Segment

The overall ERS-1 Payload Data Ground Segment is composed of the following facilities:

- the ESRIN ERS Central Facility (EECF)
- the ESA Ground Stations network
- the ESA Processing and Archiving Facilities (PAFs)
- the National and Foreign stations.

Figure 1 shows the overall interfaces between these facilities and their relationship to the User Community.

## The ESRIN ERS Central Facility (EECF)

The EECF, located in Frascati, includes the User Services, the Product Control Service (PCS), and the Reference System. It provides:

- the user interface
- definition on tasks for the whole ERS Ground Segment

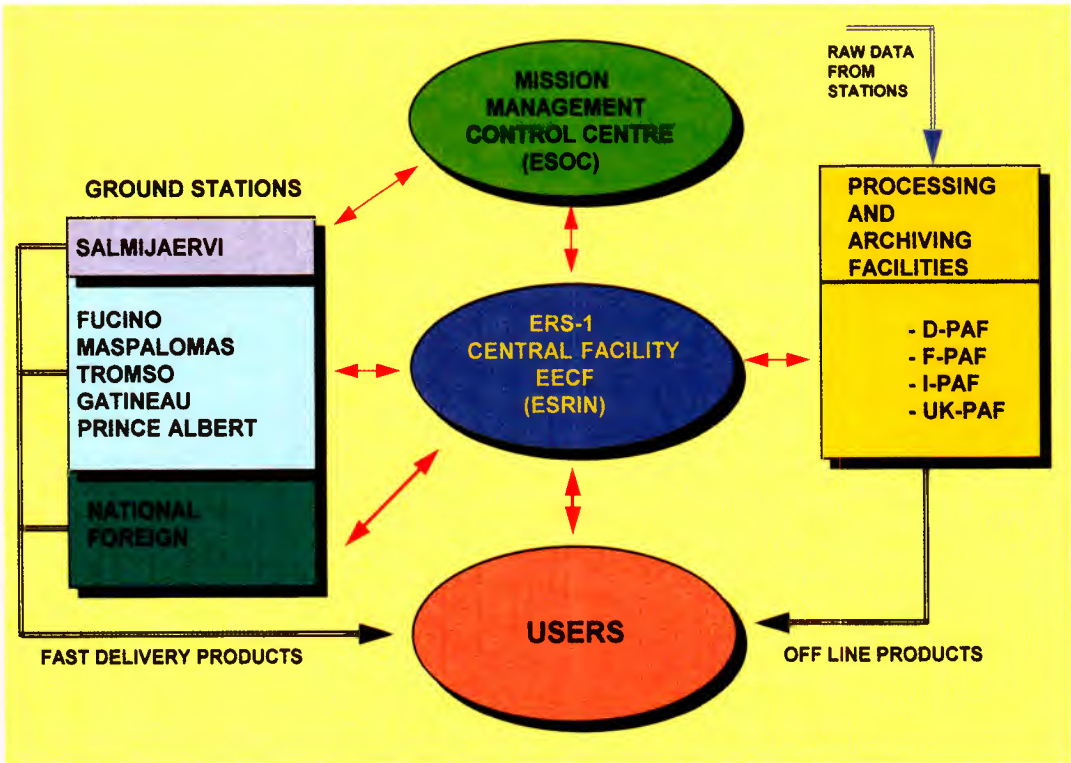


Figure 1. Schematic of the overall ERS-1 ground segment



- mission planning in conjunction with the Mission Control Centre at ESOC
- management of a facilities network for the acquisition, archiving, processing and distribution of fast-delivery and off-line products
- coordination of the national and foreign stations network
- routine monitoring of sensors
- fast-delivery and off-line product quality checks
- the interface to the industrial consortium charged with the promotion and distribution of data to commercial users
- maintenance of data-processing software for the entire ESA network.

activities in conjunction with the industrial consortium for the ERS-1 commercial applications development, including the preparation of materials for symposia, conferences and public-relations purposes.

The Product Control Service's operational tasks include the monitoring and control of ERS data-product quality and assessment of the compliance of system performance with the system specifications. Another of its main roles is to assess instrument behaviour and the related margins. This information represents vital feedback for future programmes, including the analysis and development of algorithms for calibration and validation activities.

The Product Control Service uses a range of systems, including the so-called 'Reference System' for the High- and Low-Rate Fast-Delivery Processing chains, which also supports the maintenance of the operational software installed at the ESA Ground Stations.

#### The ESA station network

The ESA station network has been set up not only to ensure that the satellite telemetry data are correctly acquired along the orbits, but also to allow the maximum coverage over the European area for the Synthetic Aperture Radar (SAR) and Low Bit Rate (LBR) payload data acquisitions.

The ERS-1 payload data network, managed by ESRIN, includes six ground stations, sited at

Salmijaervi (Kiruna, Sweden), Fucino (Italy), Maspalomas (Canary Islands), Tromsø (Norway), and Gatineau and Prince Albert (Canada). These stations have already been operational for two years.

Except for Salmijaervi, which is operated by ESOC and is fully dedicated to ERS operations and telemetry, tracking and control (TT&C) activities, all of the other stations are multi-mission in nature. Under contract to ESRIN, they perform the operations and services for ERS-1 payload data acquisition, processing and dissemination, as well as hosting the ESA



**The Maspalomas Station,  
in the Canary Islands**

The User Services unit is responsible for planning the ERS-1 mission in line with the user requests and for scheduling the world-wide data acquisition accordingly. In addition, it supports the end users, maintains the centralised catalogue of acquisition and production, and handles user requests and product orders.

Another important activity of the User Services unit at ESRIN is the support it provides for training programmes for Developing Countries in the application and exploitation of ERS data. The User Services also covers the promotional



equipment for the requisite operations. They also provide similar operational services vis-a-vis other international earth-observation satellites, such as Landsat (USA), Spot (France), JERS-1 (Japan), and Tiros (USA).

The sharing of tasks and responsibilities between these stations takes into account the constraints related to the high- and low-rate payload data characteristics:

- Salmijaervi
  - Global Low Bit Rate (real-time and on-board tape-recorder data dumping)
  - Regional SAR over Northern Europe and the North Pole
- Fucino
  - Regional SAR and LBR over the Mediterranean area, North Africa and Central/Southern Europe
- Maspalomas
  - Global LBR
  - Regional SAR over Northwest Africa and the Eastern Atlantic
- Tromsø
  - ATSR data real-time processing and operational backup for Kiruna acquisitions
- Gatineau
  - Global LBR
- Prince Albert
  - Global LBR.

This network ensures global LBR data acquisition (mainly from the on-board recorder dumping) on a daily basis. The typical daily activities of the stations can be summarised as:

- satellite tracking and scheduled data acquisition
- recording of the data on high-density magnetic tapes
- processing of the Fast Delivery (FD) Products to be made available within three hours of data sensing, to nationally nominated centres
- processing of scheduled products for distribution to users
- reporting of the activities to the EECF
- transmission to the Product Control Service at ESRIN of relevant parameters and products for routine sensor-performance monitoring.



**ESA's Salmijaervi ground station on northern Sweden**

During the first two years of operations, more than 10 000 LBR and 12 000 SAR passes (typically a few minutes of transmission each) have been acquired and high-density tapes carrying approximately 40 terabytes of raw data have been stored at the ESA archiving facilities.

#### **The ESA Processing and Archiving Facilities (PAFs)**

The PAF concept was derived from proposals by some ESA Member States to implement facilities dedicated to specific scientific and application domains, based on the existence of groups or institutes in their countries already internationally active in these fields. Consequently, the PAFs were established as joint



**The Fucino station's ERS antenna**





**The French Processing and Archiving Facility (PAF) in Brest, at the IFREMER site**

national/ESA endeavours to support and expand the applications of ERS-1 with an extensive products list.

The four PAFs, managed under contract to ESA are:

- F-PAF in Brest, France, operated by IFREMER, with the primary role of:
  - archiving all the LBR data (Wave, Scatterometer, Radar Altimeter and Wind) over oceans and generating the associated products
  - backup archiving of the ATSR (Along-Track Scanning Radiometer) global dataset, and generation and distribution of ATSR Microwave Sounder data
  - storage of relevant ESA-provided campaign data.
- UK-PAF in Farnborough, UK, operated by NRSCL, with the task of:
  - primary archiving of SAR and global ATSR data and Altimeter data over ice and land
  - secondary archiving of LBR data
  - processing and distribution of SAR, ATSR and Altimeter data over ice and land.

**The UK Processing and Archiving Facility (PAF) in Farnborough**

**The German Processing and Archiving Facility (PAF) at Oberpfaffenhofen**



- D-PAF in Oberpfaffenhofen, Germany, operated by DLR, with the allocated tasks of:
  - archiving and processing the SAR data acquired at the O'Higgins Antarctica station as well as selected data sets acquired at other ESA and foreign stations
  - primary processing centre for SAR precision and geocoded image data
  - high-level Altimeter product generation and precision orbit calculations.
- I-PAF in Matera, Italy, operated by the Italian Space Agency and charged with:
  - archiving, processing and distribution of regional SAR data acquired by the Fucino and Maspalomas stations
  - archiving, processing and distribution of LBR products covering the Mediterranean area.

The PAFs are the core of the ERS-1 product distribution system and their overall role can be summarised as:

- long-term ERS-1 payload data archiving and retrieval



- generation and distribution, on request, of the offline geophysical standard products to users as instructed by the EECF via product orders
- support to ESA for sensor data calibration, data validation and long-term sensor performance evaluation.

Each PAF receives the relevant ERS-1 payload telemetry data on a regular basis from the ground stations and ensures the long-term archiving, the routine production and the distribution of the data. Their activities are managed and monitored from ESRIN.





**The National and Foreign stations**

In addition to the ESA station network, some national (i.e. belonging to countries participating in the ERS-1 Programme) and foreign (belonging to non-participating countries) ground stations have been set up or are in the process of being set up around the world in order to acquire ERS-1 SAR payload data.

The current situation is summarised in Table 1. These stations operate under the terms and conditions of a standard Memorandum of Understanding with ESA.

All ERS-1 ground stations receive, from the EECF in Frascati, the input data needed to acquire, process and distribute the SAR data and they report back to the EECF on their station activities and status. These stations generate and distribute products developed nationally to ESA Principal Investigators, Pilot Projects and commercial users. In particular, low-resolution near-real-time products are distributed as a service from the Tromsø and Gatineau stations.

The stations listed in Table 1 will, together with the ESA stations, provide the world-wide data coverage presented in Figure 2.

**Data flow and product generation**

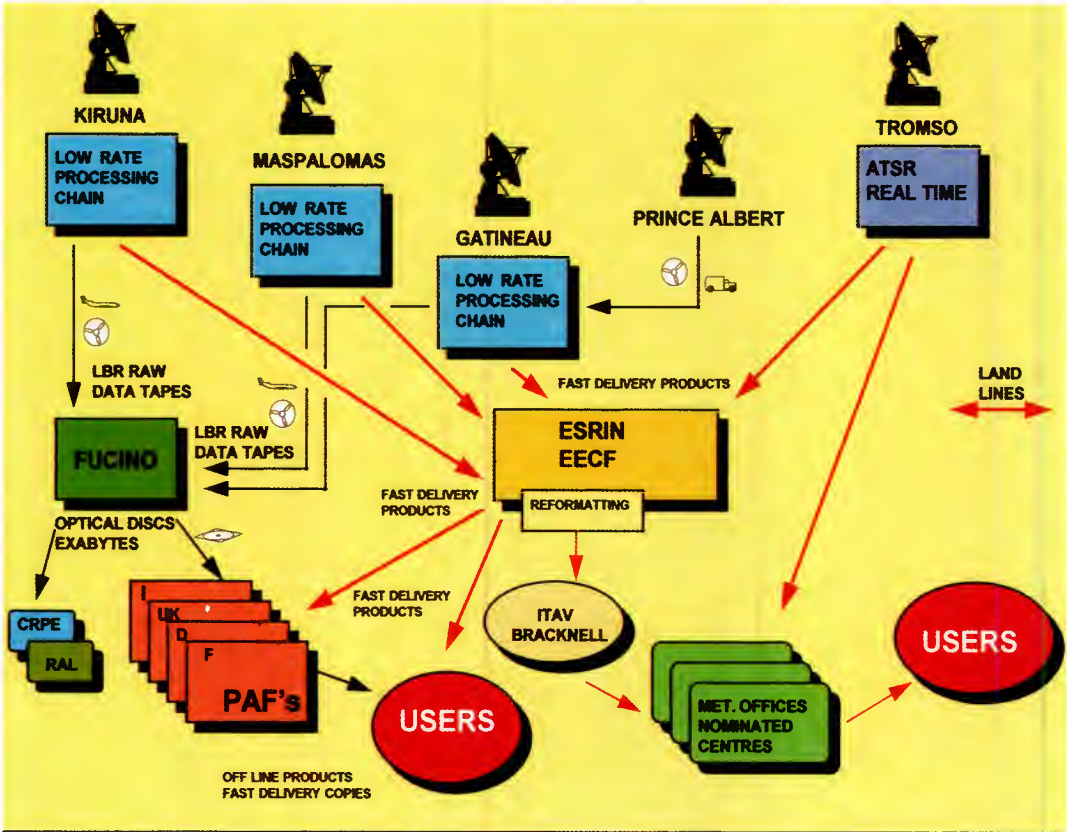
ERS-1 LBR and SAR products are distributed to users either on a routine basis or on specific request. The full list of currently available products is shown in Table 2.

The flow of the ERS-1 LBR data is summarised in Figure 3. These LBR data – obtained from the Wind-Scatterometer, the Radar Altimeter and the Active Microwave Instrument (in Wave mode) – are processed immediately after reception to 'so-called 'Fast Delivery' level (UWI, URA, UWA) at the ESA stations. They are then collected at the ERS Central Facility and,

**Figure 2. Total planned ERS-1 ground-station coverage**

| Table 1. Status of national and foreign ground stations acquiring, or planned to acquire, ERS-1 SAR data |               |                                        |
|----------------------------------------------------------------------------------------------------------|---------------|----------------------------------------|
| Tromsø                                                                                                   | Norway        | Operational                            |
| Aussaguel                                                                                                | France        | Operational (campaign basis)           |
| West Freugh                                                                                              | UK            | Operational                            |
| O'Higgins                                                                                                | Antarctica, D | Operational (campaign basis)           |
| Fairbanks                                                                                                | Alaska        | Operational                            |
| Cotopaxi                                                                                                 | Ecuador       | Operational                            |
| Gatineau                                                                                                 | Canada        | Operational                            |
| Prince Albert                                                                                            | Canada        | Operational                            |
| Hyderabad                                                                                                | India         | Operational                            |
| Alice Springs                                                                                            | Australia     | Operational                            |
| Kumamoto                                                                                                 | Japan         | Operational                            |
| Hatoyama                                                                                                 | Japan         | Operational                            |
| Syowa                                                                                                    | Antarctica, J | Operational (campaign basis)           |
| Cuiaba                                                                                                   | Brazil        | Operational                            |
| Bangkok                                                                                                  | Thailand      | Acquisition only; processing by end-93 |
| Hobart                                                                                                   | Australia     | Planned for end-93 (acquisition only)  |
| Riyadh                                                                                                   | Saudi Arabia  | Under test                             |
| Pare-Pare                                                                                                | Indonesia     | Under test                             |
| Beijing                                                                                                  | China         | Under test                             |
| Taipei                                                                                                   | Taiwan        | Under test                             |
| Tel Aviv                                                                                                 | Israel        | Planned for end-93                     |
| Libreville                                                                                               | Gabon, DLR-D  | Planned for early-94 (campaign basis)  |
| Pretoria                                                                                                 | South Africa  | Planned for mid-94                     |
| Singapore                                                                                                | Singapore     | Planned for end-94                     |

Figure 3. Global low-rate data flow



after being converted, are injected into the Global Telecommunication System (GTS) of the World Meteorological Organisation (WMO), as well as being disseminated to selected facilities and users (including the PAFs, from which they can be obtained as offline copies).

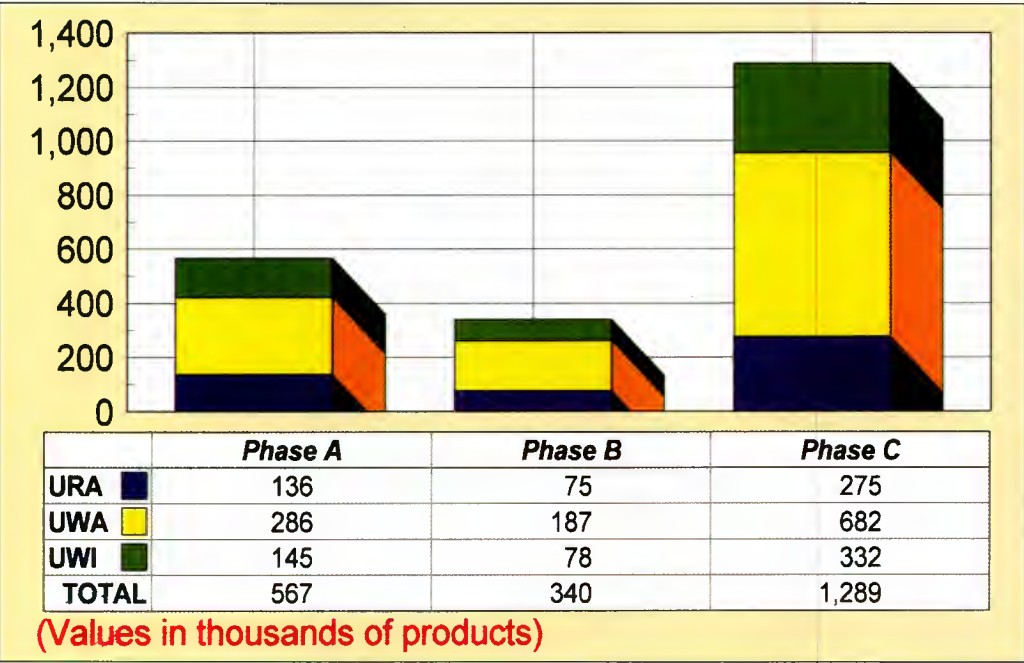
For the ATSR data, real-time processing is performed at Tromsø for the generation of the Sea Surface Temperature Measurement, and the data is sent thereafter directly to the meteorological offices and also collected at ESRIN for further distribution.

The full LBR data set is archived at the PAFs for the offline generation of precision products.

Figure 4 shows the number of LBR Fast Delivery Products distributed during the various mission phases: Commissioning Phase (August – December 1991, 3-day repeat cycle), First Ice Phase (December 1991 – March 1992, 3-day repeat cycle), Multidisciplinary Phase (April 1992 – December 1993, 35-day repeat cycle), etc.

ATSR data are also archived at RAL in the United Kingdom and CRPE in France for their internal investigations and support to ESA production activities.

Figure 4. Distribution of Low Bit Rate (LBR) Fast Delivery products



The SAR data flow for the ESA station is represented in Figure 5. The SAR data are processed to Fast Delivery level at the ESA ground stations and disseminated via the BDDN (Broadband Data Dissemination Network, under ESRIN control), which allows the transmission of SAR Fast Delivery images from Kiruna or Fucino nominally within 24 h of data sensing to Nominated Centres (one per country in Europe), using a Eutelsat satellite link for image transmission.



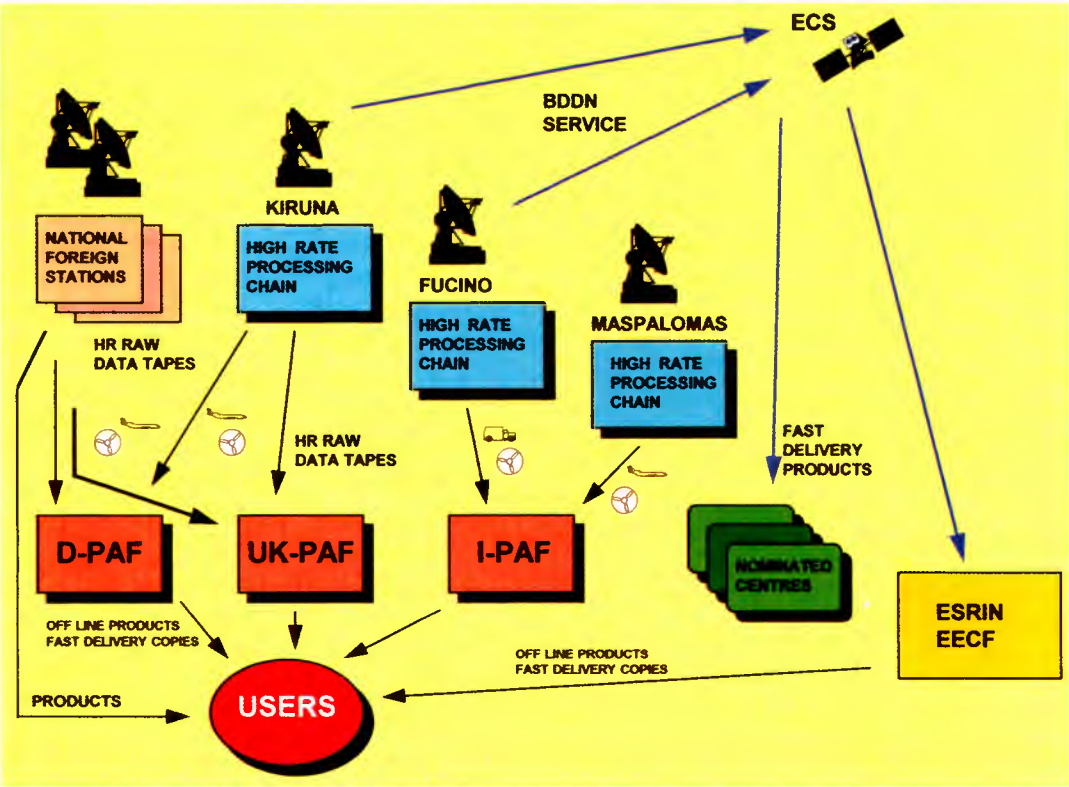


Figure 5. Global high-rate data flow

The Nominated Centres then distribute the data to the final users. The raw data are sent to the PAFs for the offline generation of ESA standard products (PRI, SLC, Geocoded, Fast Delivery copies, etc.).

Figure 6 shows the numbers of each ESA product type delivered to the users by the ESA processing facilities. Figure 7 shows the distribution of products by user category, and Figure 8 that by production facility.

User Services

The User Services unit provides support to the ERS-1 user community via:

- User interface functions, performed via the ERS Help Desk (for queries, documentation, etc.) and via the ERS Order Desk (for data requests from Principal Investigators, Pilot Project leaders, Ground Station operators, etc.). The requests from commercial and research users are dealt with by the ERSC Customer Service, where ERSC represents a Consortium formed by Eurimage, Radarsat International and Spotimage.
- Internal functions, including mission planning, production planning, data dissemination control, telecommunication network monitoring, system and database management.

Table 2. ERS-1 products

| Data type                   | Code      | Production facility <sup>1</sup>  |
|-----------------------------|-----------|-----------------------------------|
| SAR                         |           |                                   |
| Annotated Raw Data          | SAR.RAW   | D-PAF, UK-PAF <sup>2</sup>        |
| Fast-Delivery Image         | SAR.UI16  | Fucino, Kiruna                    |
| Fast-Delivery Copy          | SAR.FDC   | D-PAF <sup>2</sup>                |
| Single-Look Complex Image   | SAR.SLC   | D-PAF, I-PAF <sup>2</sup>         |
| SLC Full                    | SAR.SLCF  | UK-PAF                            |
| Precision Image             | SAR.PRI   | D-PAF, I-PAF, UK-PAF <sup>2</sup> |
| Ellipsoid Geocoded Image    | SAR.GEC   | D-PAF                             |
| Terrain Geocoded Image      | SAR.GTC01 | D-PAF <sup>3</sup>                |
| SAR WAVE MODE               |           |                                   |
| Fast-Delivery Product       | SWM.UWA   | Gatineau, Maspalomas, Kiruna      |
| Fast-Delivery Copy          | SWM.FDC   | F-PAF                             |
| WIND SCATTEROMETER          |           |                                   |
| Fast-Delivery Product       | WSC.UWI   | Gatineau, Maspalomas, Kiruna      |
| Fast Delivery Copy          | WSC.FDC   | P-PAF                             |
| ALTIMETER                   |           |                                   |
| Fast-Delivery Product       | ALT.URA   | Gatineau, Maspalomas, Kiruna      |
| Fast-Delivery Copy          | ALT.FDC   | F-PAF                             |
| Ocean Product               | ALT.OPR02 | F-PAF                             |
| Sea-Surface-Height Model    | ALT.SSH   | D-PAF                             |
| Quick-Look SSH <sup>4</sup> | ALT.SSHQL | D-PAF                             |
| Quick-Look OPR <sup>5</sup> | ALT.QLOPR | D-PAF                             |
| Ocean Geoid                 | ALT.OGE   | D-PAF                             |
| Ocean Topography            | ALT.TOP   | D-PAF                             |
| ORBIT                       |           |                                   |
| Preliminary Orbit           | ORB.PRL   | D-PAF                             |
| Precise Orbit               | ORB.PRC   | D-PAF                             |

<sup>1</sup>D-PAF, F-PAF, I-PAF and UK-PAF, respectively, indicate German, French, Italian and United Kingdom PAFs; <sup>2</sup>Back-up production capability possible at ESRIN; <sup>3</sup>If terrain model exists at D-PAF; <sup>4</sup>SSH = Sea Surface Height; <sup>5</sup>OPR = Ocean Product

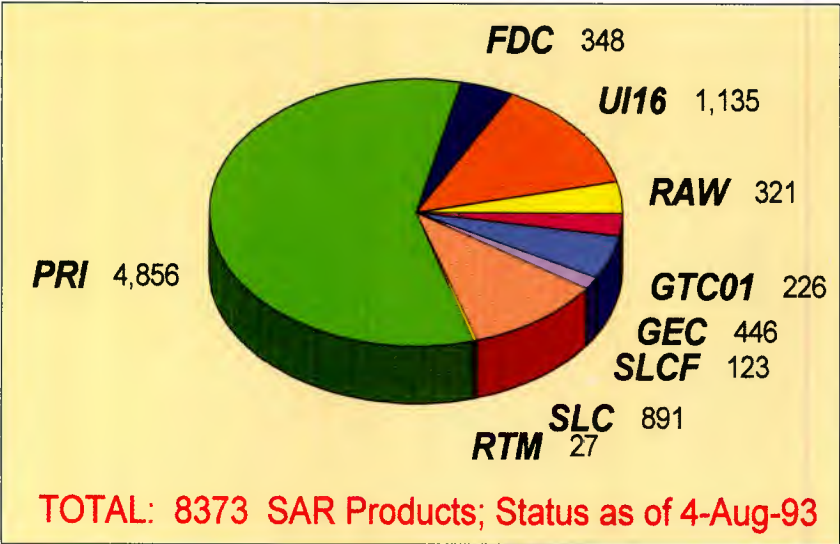


Figure 6. Synthetic Aperture Radar (SAR) products distributed, by type

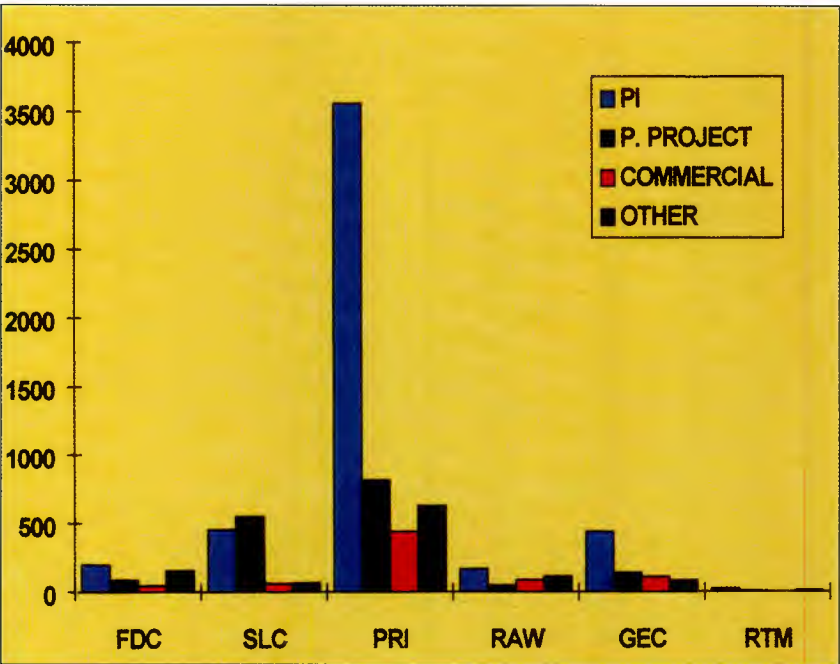


Figure 7. Synthetic Aperture Radar (SAR) products distributed, by user category

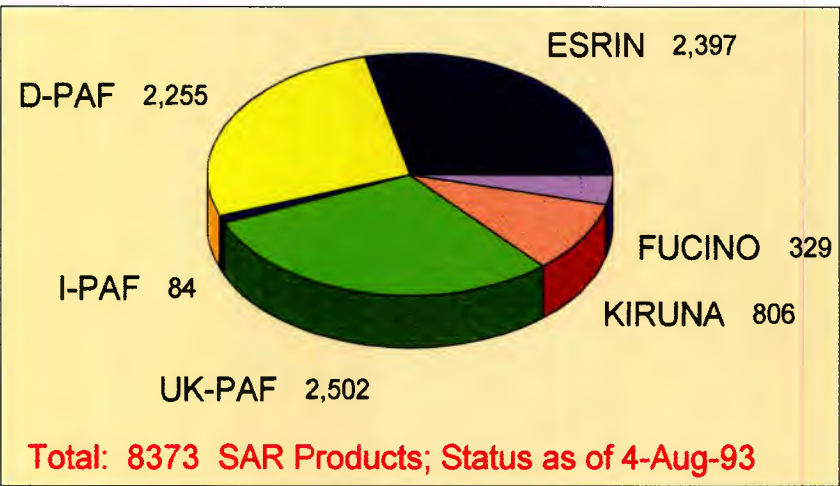


Figure 8. SAR products distributed to users from ESA facilities

Figure 9 shows the User Services organisation, with the various user categories at the top, the ERS ESRIN services in the central area and the external facilities below, controlled and operated via the telecommunications infrastructure.

The user requirements are generally expressed in the user requests (including the type of product required, the geographical area and the time window) with the exception of the LBR products, for which the distribution is performed on a global basis.

Figure 10 shows the number of SAR user requests per country and mission phase. The processing flow of the requests for SAR products is shown in Figure 11.

The SAR user requests may involve data already acquired and archived: hence those requests are converted into production orders for the PAFs, where the required products are generated and dispatched to the end user. In cases where the request concerns data still to be acquired, the relevant acquisition is planned taking into account possible conflicts, alternatives, or anticipated needs and then confirmed in cooperation with the Mission Management and Control Centre (MMCC) at ESOC.

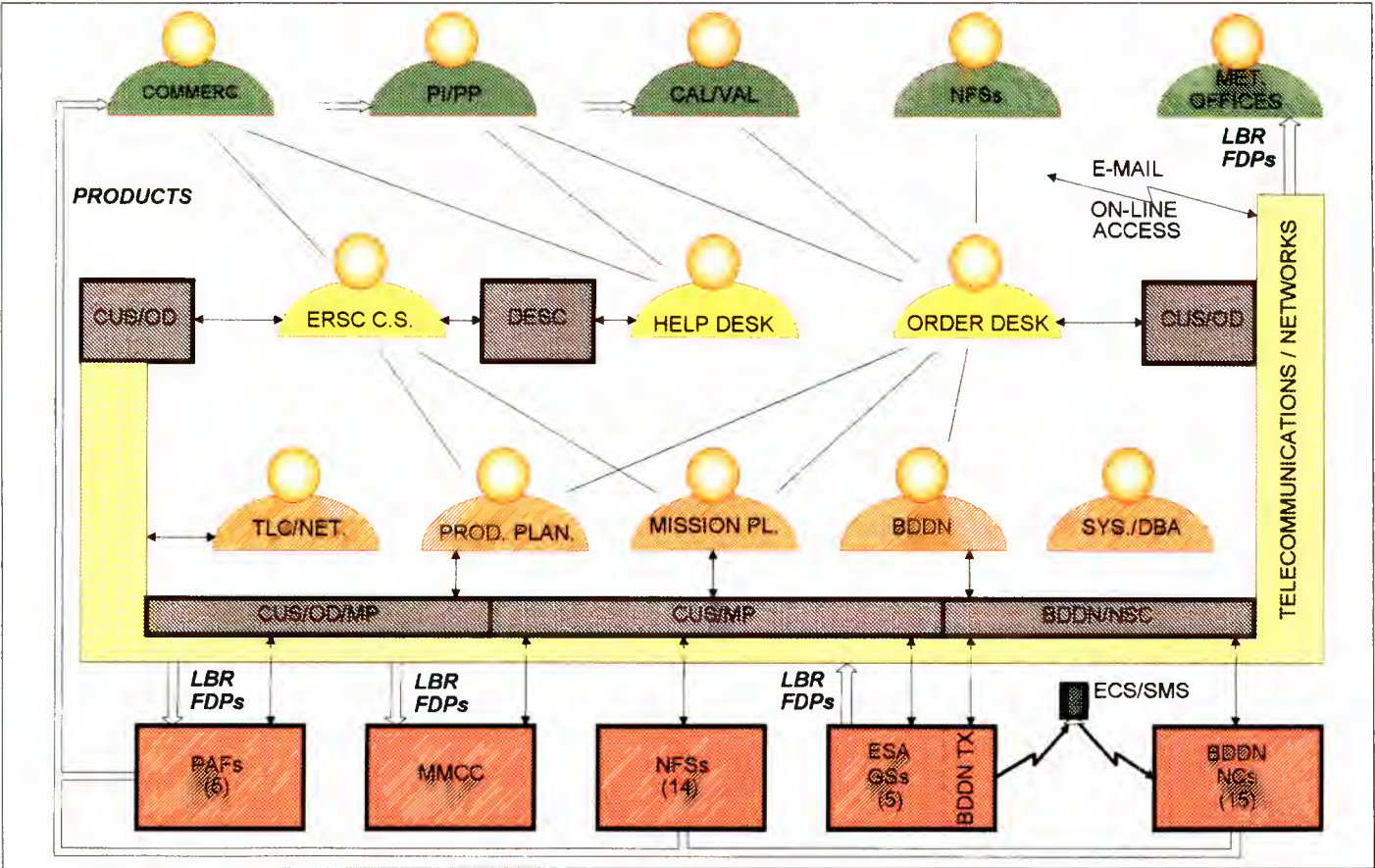
Upon confirmation of data reception from the relevant ground station, the product order is placed and data delivered to the end user either via the BDDN (Fast Delivery products) or by the relevant processing facility (offline products).

The mission planning performed at ESRIN includes a 'baseline' mission, which adds expected and future needs as well as repetitive coverage for multi-temporal analysis to the specific user requests. It permits the optimal use of satellite resources, by limiting the number of SAR on/off switchings per orbit and exploiting the SAR for close to its 12 minute limit per orbit.

The results of this planning are shown in Figures 12 (world-wide acquisition for Multi-disciplinary Phase C) and 13 and 14 (acquisitions by station for the three mission phases).

As well as all the other information, the EECF maintains a Catalogue of the ERS-1 data acquired worldwide and of the products archived at the PAFs. This Catalogue is regularly updated whenever the new acquisition reports are generated at the acquisition stations and the data is ingested into the database.





Users can query on-line the SAR catalogue or the Global Activity Plan (GAP), which contains updated information on the planned operations of the different payload instruments. Users can also browse through a simplified version of the SAR Catalogue on their PC using the 'Display ERS-1 SAR Coverage' (DESC) software package. This tool can also support the users in defining their requirements for products and services.

and to the Quick Look OPR products. In addition, a database of world-wide articles and documents related to ERS-1 applications and findings is available online and continues to grow as new input is regularly generated.

Figure 9. ERS-1 User Services organisation

In February 1992 ESA signed an agreement with the ERSC Consortium under which the latter has world-wide commercial distribution rights for data from the ERS-1 satellite.

Figure 10. Number of user requests received, by country

Also generated at ESRIN, in collaboration with ESA Publications Division at ESTEC, is the printed material for supporting the user activities and training, such as the ERS User Handbook, the ERS System Description, the ERS Products Specification document, and the CD Guide to ERS-1, etc. In addition, the user can make use of an on-line server via Internet, Span or X.25, which provides free access to the GAP, to the weekly update of the DESC catalogue files, to the database of the ERS-1 SAR Low Resolution Images, generated daily at Kiruna,

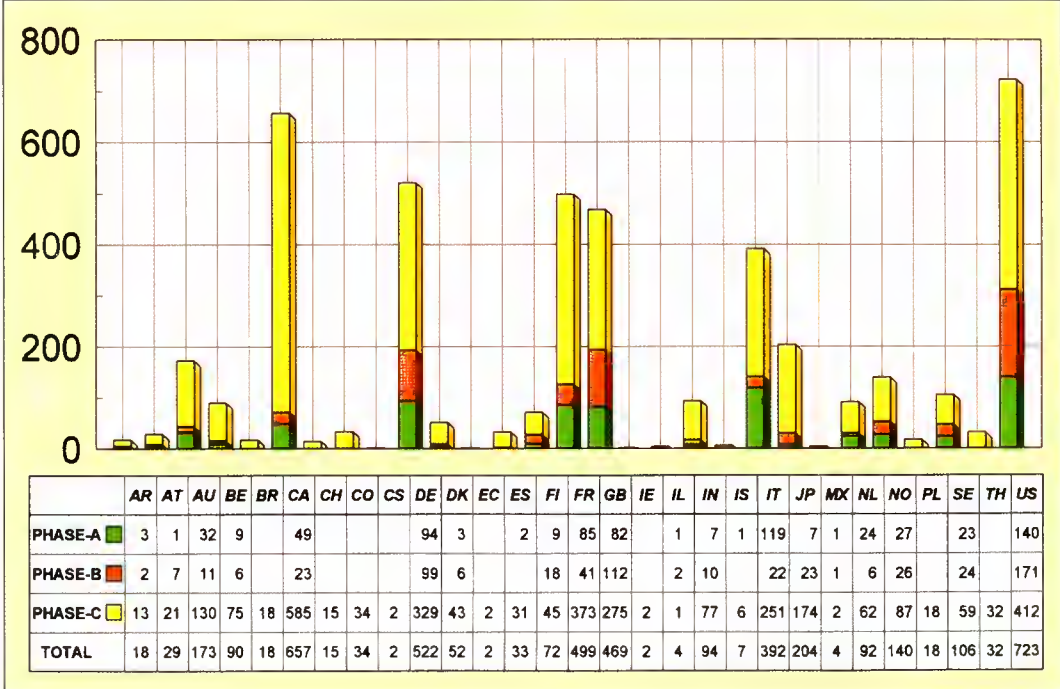




Figure 11. User request processing flow for SAR products

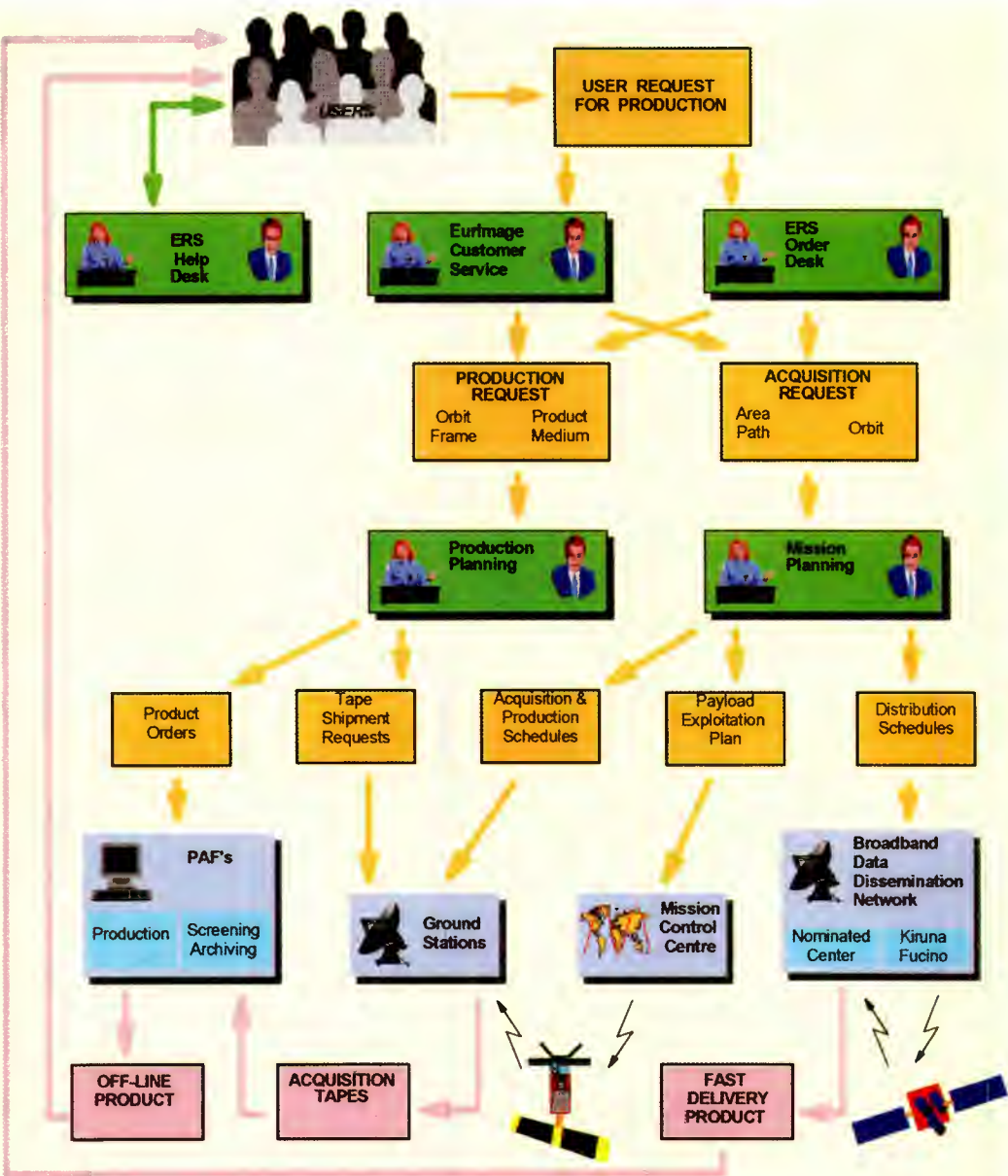
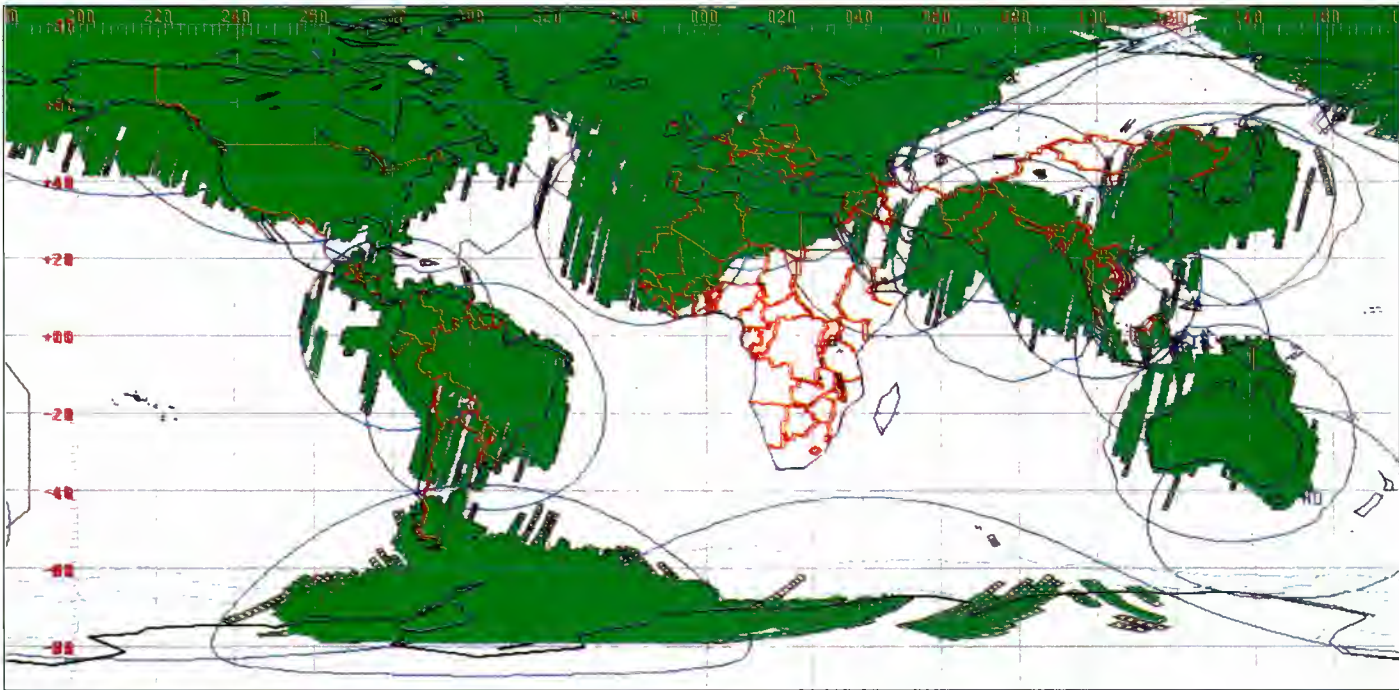


Figure 12. SAR acquisition worldwide for the Multi-disciplinary Phase-C





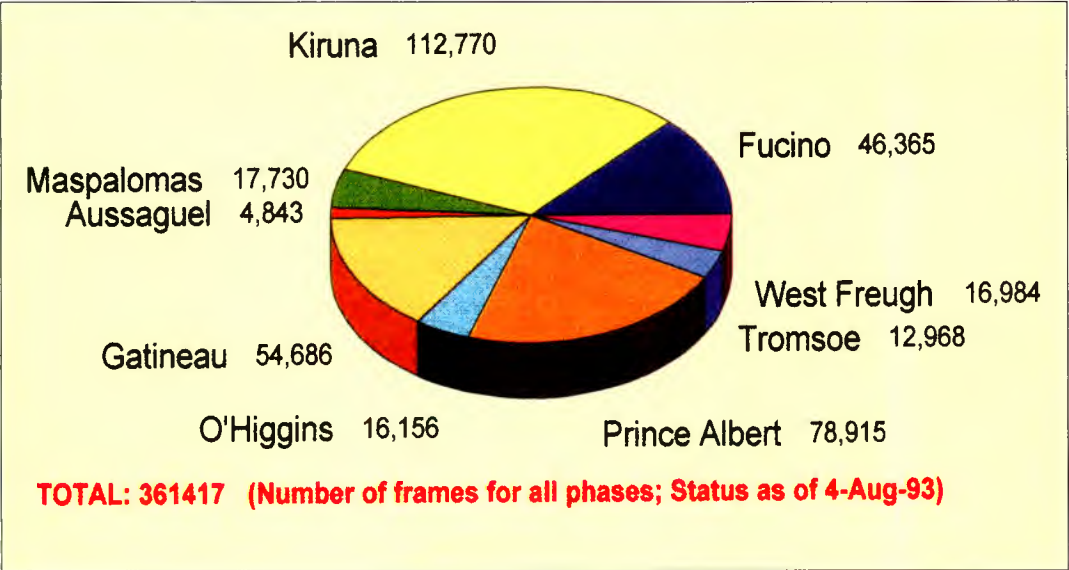


Figure 13. SAR acquisition by ESA and national stations

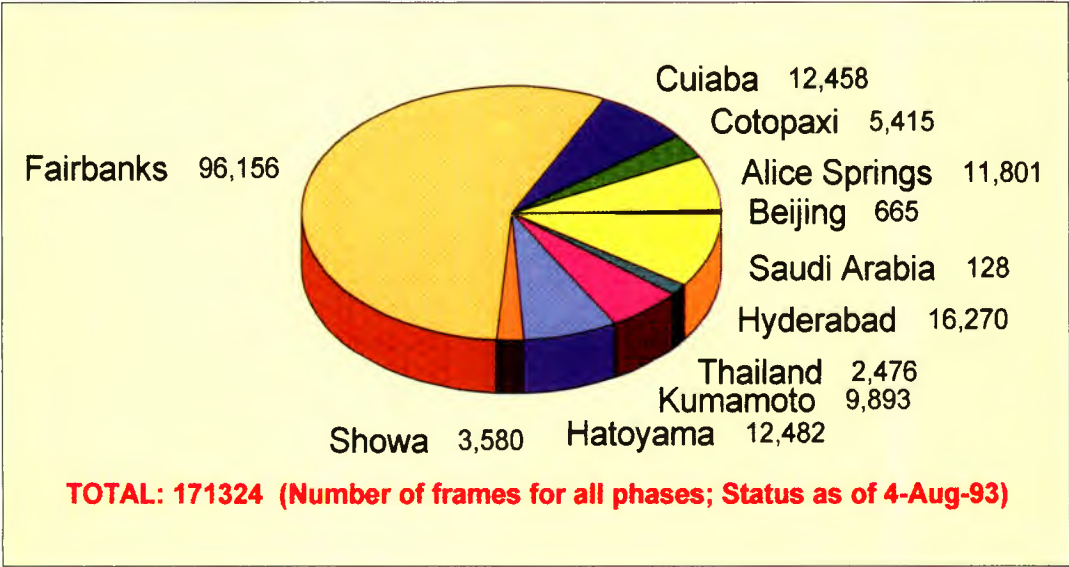


Figure 14. SAR acquisition by foreign stations

The three companies in this Consortium – Eurimage, Radarsat International and Spotimage – have a wealth of experience in the promotion, marketing and distribution of earth-observation satellite data. Each member of the Consortium is responsible for the users of a specific geographical coverage: Eurimage for Europe, North Africa and the Middle East; Radarsat International for Canada and the United States; and Spotimage for all other parts of the world.

Conclusion

ERS-1's first two years have been those of a very successful demonstration mission that has experienced only minor satellite hardware/software problems. The payload has performed well, in terms of both data quality and sensor availability (around 96%). ESRIN and the facilities under its management have successfully overcome early teething troubles, typical in the start-up phase of such a complex venture, to provide users with the high-quality

products and support information necessary to allow them to make optimum use of the data being distributed.

ESRIN is currently working hard to improve its services still further, especially those oriented towards enhancing the user application aspects, the integration of data from different sensors and satellites, the timely distribution of information, and the promotion of ERS-1 data utilisation.

ESRIN is also presently actively involved in further upgrading the ground-segment network in time for the launch of ERS-2 at the end of 1994.

