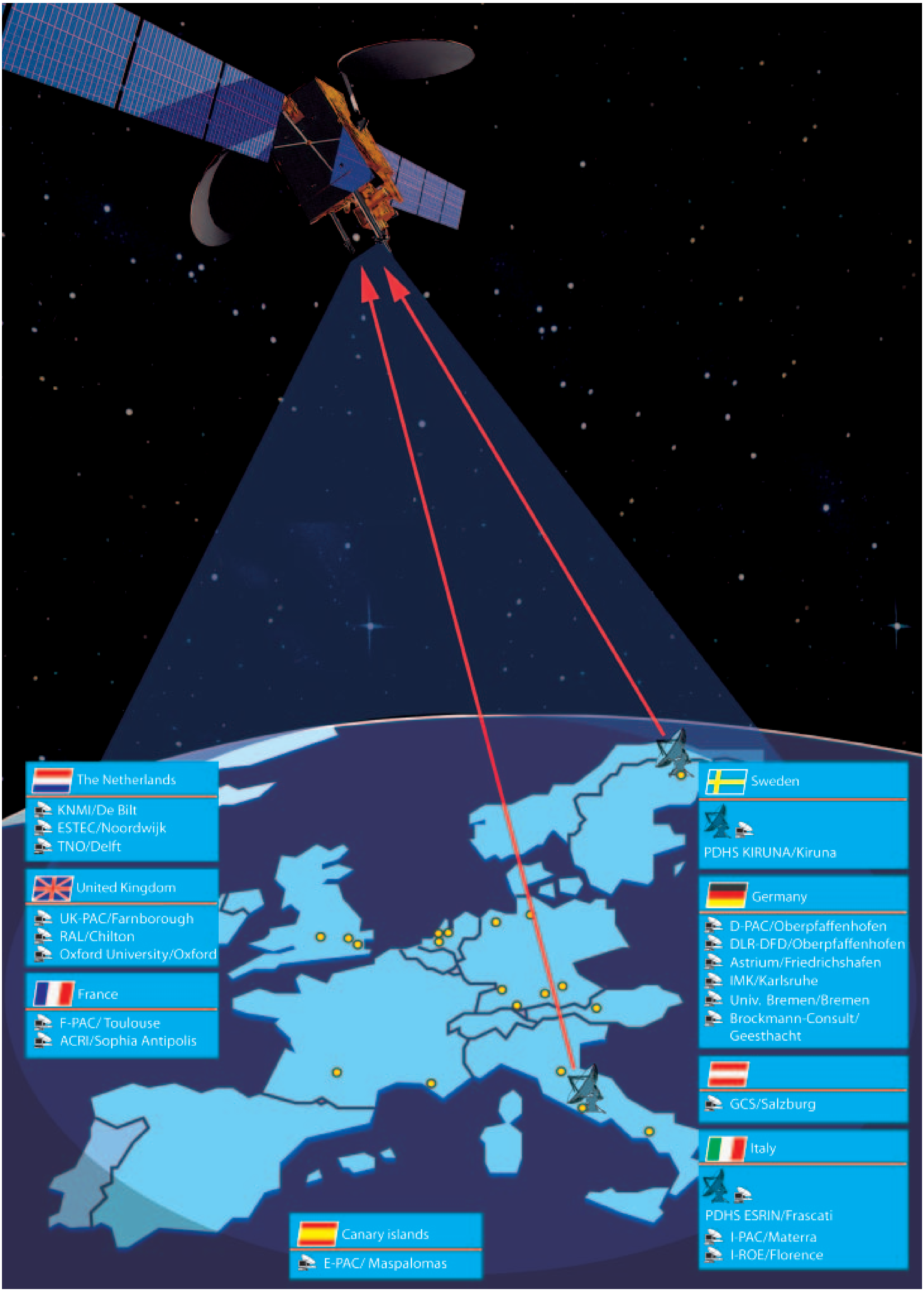


The Netherlands
KNMI/De Bilt
ESTEC/Noordwijk
TNO/Delft
United Kingdom
UK-PAC/Farnborough
RAL/Chilton
Oxford University/Oxford
France
F-PAC/ Toulouse
ACRI/Sophia Antipolis
Canary islands
E-PAC/ Maspalomas
Sweden
PDHS KIRUNA/Kiruna
Germany
D-PAC/Oberpfaffenhofen
DLR-DFD/Oberpfaffenhofen
Astrium/Friedrichshafen
IMK/Karlsruhe
Univ. Bremen/Bremen
Brockmann-Consult/
Geesthacht
GCS/Salzburg
Italy
PDHS ESRIN/Frascati
I-PAC/Materra
I-ROE/Florence

The Envisat Data Dissemination System

S. Badessi
Earth Observation Applications Department, ESA Directorate of Earth Observation Programmes, ESRIN, Frascati, Italy

H.L. Moeller, P. Viau
Earth Observation Programmes Development Department, ESA Directorate of Earth Observation Programmes, ESTEC, Noordwijk, The Netherlands

D. Castrovillari
Intecs HRT, Pisa, Italy

B. Collini-Nocker
Internet Broadcasting Solutions, GCS GmbH, Salzburg, Austria

The Envisat Data Dissemination System (DDS) will allow rapid dissemination of the satellite's data products to users across Europe. The system uses a commercial satellite-based network, which is based on the Digital Video Broadcasting (DVB) standard and is integrated into the Internet. It accommodates low-cost user stations and allows for cost-effective use of satellite bandwidth. It is also suitable for use in support of other missions.

Introduction

The Envisat mission calls for the dissemination of scientific data products to users within hours of sensing. This requires a ground-segment facility capable of distributing each product from the Envisat Payload Data Segment (PDS), charged with acquisition and processing of the scientific data, to one or more user premises.

In 2000, a survey of commercial data-dissemination networks available on the European telecommunications market showed none matching the Envisat dissemination requirements. Solutions based on terrestrial networks were not considered cost-effective for broad- and multi-casting tens of gigabytes per day. Turnkey solutions based on a satellite network lacked an adequate approach to the integration of data sources and satellite up-linking. Furthermore, they offered only limited reliability of transmission, and did not provide cost-effective use of the satellite bandwidth.

In the absence of an adequate off-the-shelf solution, therefore, ESA embarked on the development of a system making maximum use of commercially established elements. This involved the use of commercial satellite capacity, industrially supported subsystems for satellite-bandwidth allocation and data transmission, mass-market data-reception components and, last but not least, well-established digital transmission standards (TV and Internet).

Based on these choices, and benefiting from earlier experience within ESA and its industrial partners, it was possible to complete the development of the Envisat Data Dissemination System (DDS) in less than 12 months (Fig. 1). This included the deployment of all of the user stations that will be required during Envisat's commissioning phase. DDS development and validation has followed an incremental approach starting from a core system, which was gradually integrated with the Envisat PDS and complemented with secondary functions. This approach secured key capabilities at an early stage and allowed a proper review of progress at each stage of development and proper planning for subsequent stages.

Today's DDS architecture (Fig. 2) and functions are scalable in terms of the number of up-links and receivers and can also support a further increase in bandwidth, to allow the accommodation of new data-dissemination requirements emerging during the mission's lifetime. The DDS's design also allows for multi-mission use, i.e. other missions can make use of DDS services in parallel with Envisat. In fact, DDS is already being used to support limited ERS data distribution in parallel with the Envisat rehearsal activities.

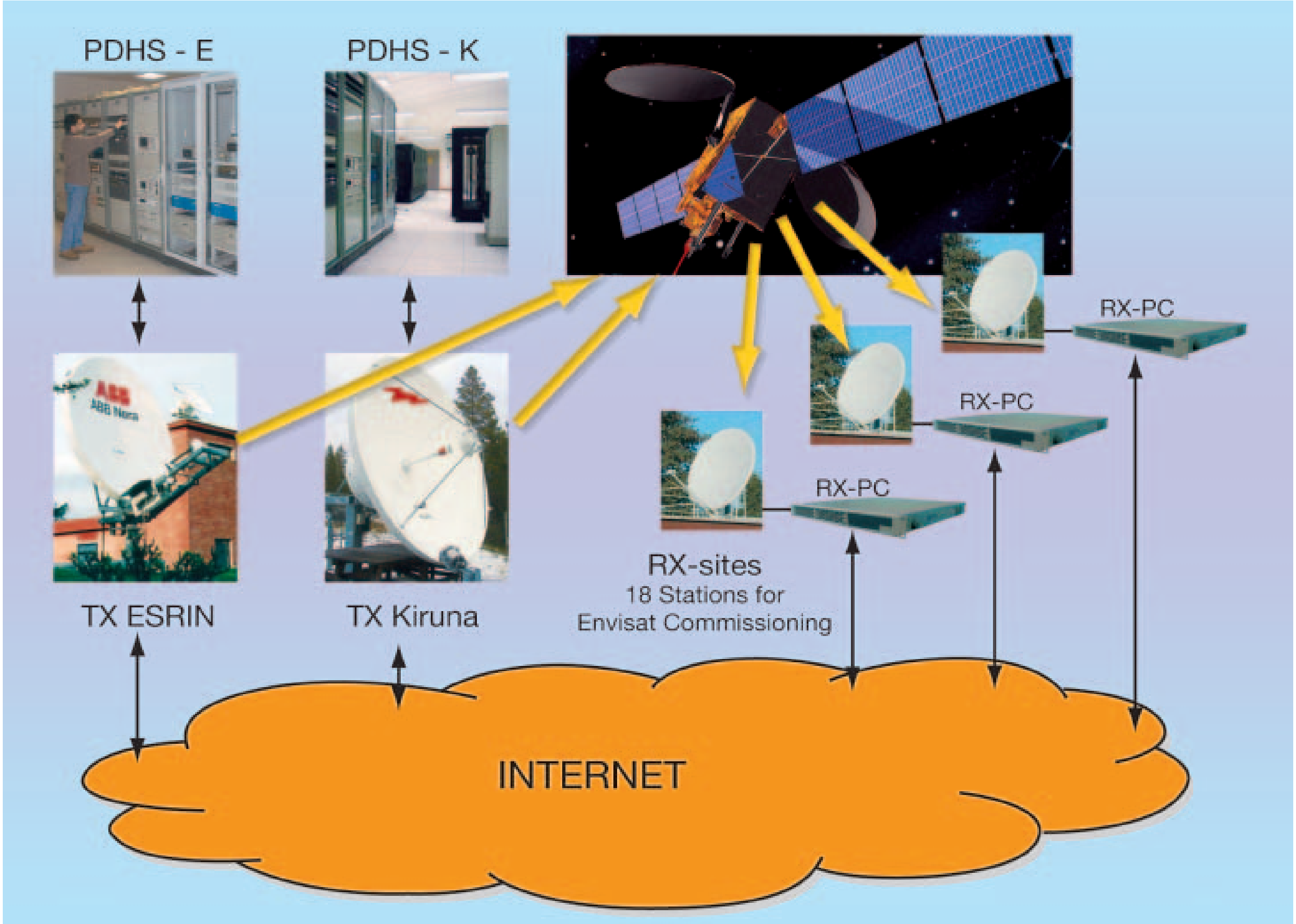


Figure 2. DDS architecture

DDS architecture

The DDS contains the following computing infrastructures and telecommunications networks:

- Two transmitting stations located at the Envisat Payload Data Handling Stations (PDHS) at ESRIN in Frascati and in Kiruna, Sweden. Each station comprises a PC infrastructure for data handling, and an antenna and RF units for data up-linking.
- A multitude of receiving stations located at user premises across Europe. Each station comprises a commercial TV antenna, and a PC with a board for digital video broadcast (DVB) data reception.
- A central monitoring and control system co-located with the Envisat Payload Data Control Centre (PDCC) at ESRIN.
- A satellite network based on dedicated, leased redundant transponder capacity on the Eutelsat W1 spacecraft (Fig. 3).

The DDS also makes use of the following terrestrial networks in order to ensure reliable data transfers:

- The Envisat Payload Data System (PDS) Communication Network (PDS-COMNET) for system-critical links.
- The public Internet for receive-only users.

The DDS interfaces externally with:

- The Envisat Payload Data System (PDS) Dissemination Facility at the two PDHS, which issues dissemination requests to the DDS and provides the data products to be transferred.
- The local networks and computing facilities at user premises, such that users can forward received data products to their computer facilities for further processing.

DDS functions

The principal function of the DDS is the delivery of PDS products to users within three hours or one day of sensing, depending on product type. Products, which can be up to several hundred Mbytes in size, are retrieved for dissemination from the PDS Dissemination Facility at the Kiruna and ESRIN PDHSs and are delivered to receiving PCs at the user premises. In performing this function, the DDS acts as a dissemination service provider to the Envisat PDS Dissemination Facility.

48 hour dissemination planning

The PDS Ground Segment Planning (GSP) issues a dissemination plan that identifies the time windows during which the PDHS transmit uplinks at Kiruna and ESRIN are required to be

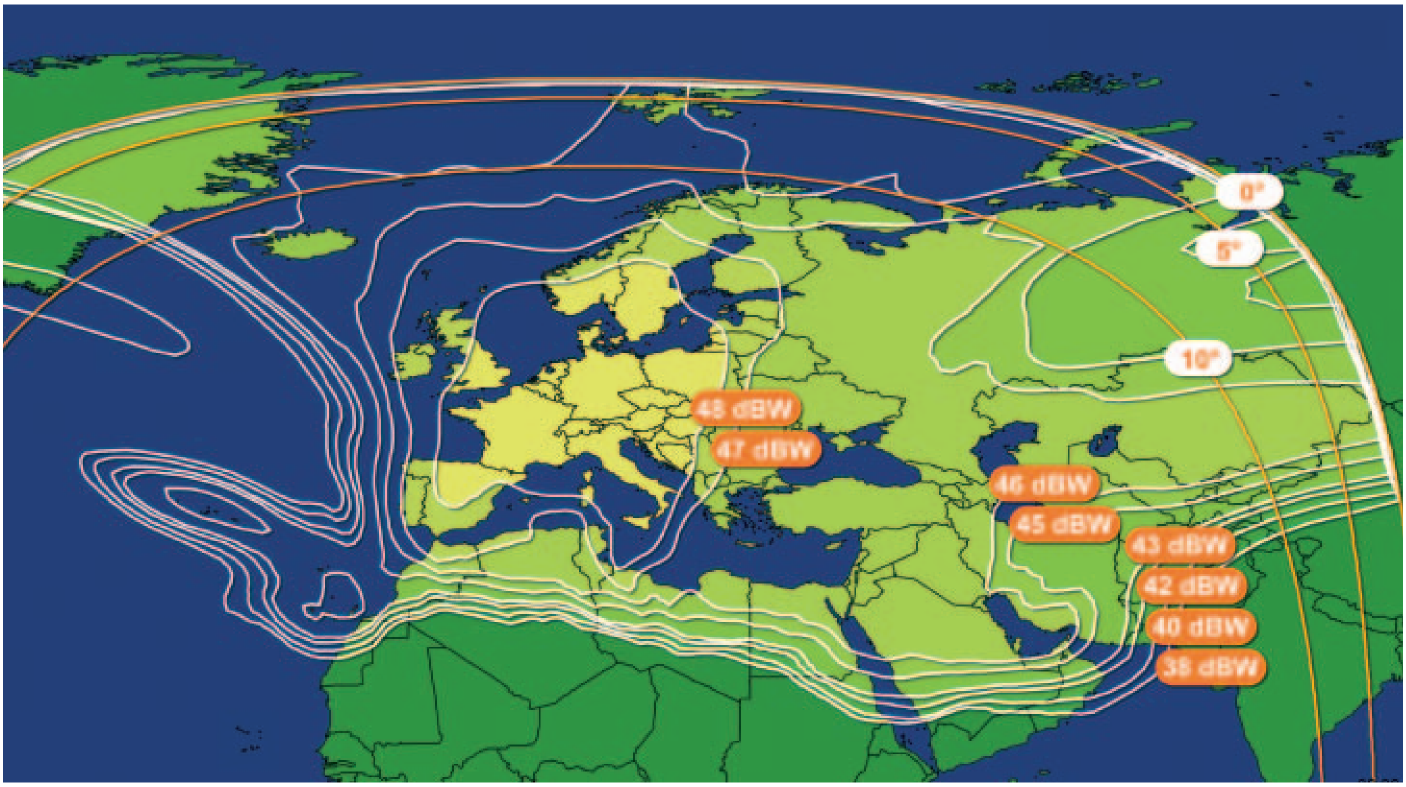


Figure 3. The Eutelsat W1 satellite's footprint from 10°E (courtesy of Eutelsat)

ready for dissemination. It provides a listing for each time window of all product dissemination requests, together with the planned dissemination start and stop times. Plans are elaborated regularly, typically every 24 hours, but can also be issued on an ad-hoc basis.

Figure 4 shows a 48 hour dissemination plan and identifies the dissemination instructions therein. The top lines identify the orbit numbers of Envisat and the time of day. The next line shows the start and stop times allowed for the planned individual dissemination requests originating at Kiruna and ESRIN, respectively. The following line indicates periods during which the TX up-link at either Kiruna or ESRIN is active and can disseminate products. Within these periods the actual time slots for individual product dissemination are identified below.

Individual product dissemination requests
The actual dissemination requests for individual products will be issued by the DF at the respective PDHS, once the product has been acquired, processed and is ready for dissemination. This happens shortly before the planned start time for the particular product in the dissemination plan. Each dissemination request identifies the product data file location at the DF, the list of receive destinations (one or more), and the planned time window for the dissemination of that product.

Data handling
The DDS provides for the data handling associated with each individual product dissemination request. Once a new request is identified, the related product is transferred locally from the DF to the DDS. The products are forwarded for dissemination via the satellite link. Urgent requests for dissemination can be inserted manually, bypassing the DF interface. Only one transmission is necessary, even if more than one user is destined to receive the product, since the transfer protocol takes advantage of the inherent broadcasting nature of satellite links. Reliable dissemination is ensured by immediate retransmission of lost packets. At the end of a dissemination, the DDS collects all dissemination reports from the addressed receivers and provides them to a central reporting point.

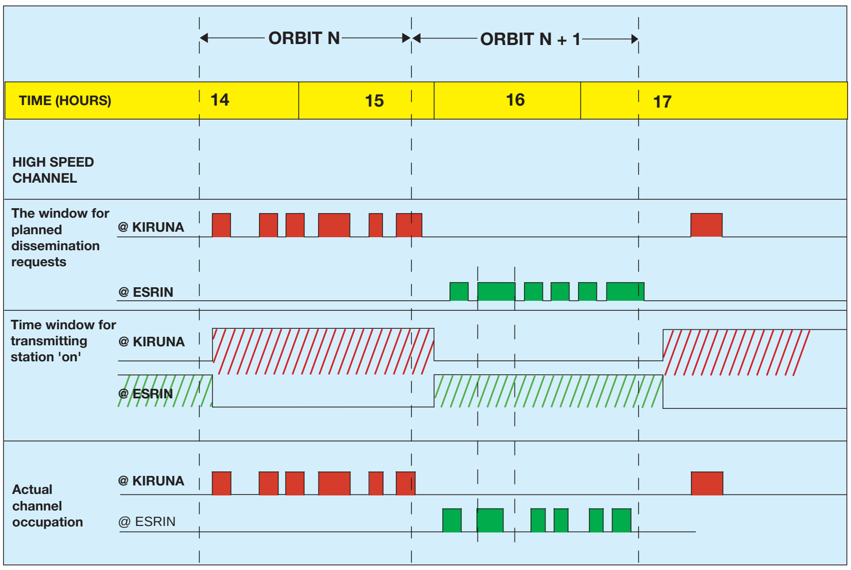


Figure 4. A 48 hour dissemination plan

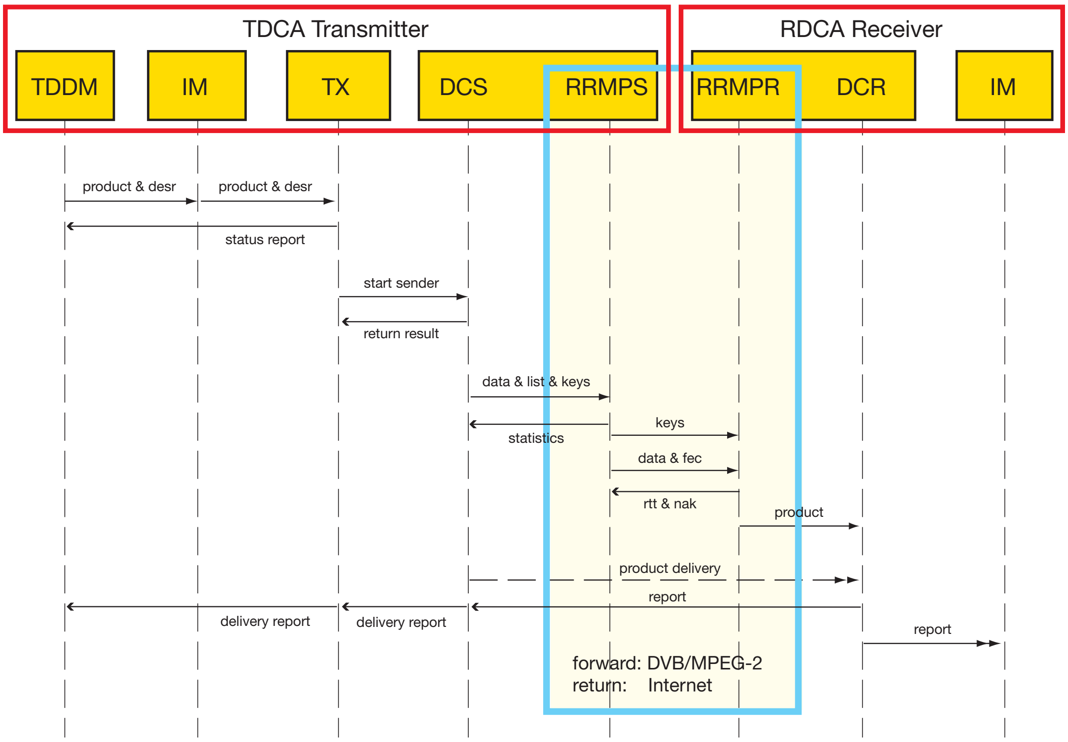


Figure 5. Dissemination protocol

Dissemination requests can be addressed to two different logical channels sharing the same satellite link. The two channels, configured as high-speed (several Mbps) and low-speed (several kbps) channels, can be used in parallel and are optimised for large and small data products, respectively. Only one product can be disseminated per channel at a given time.

DVB/IP dissemination protocol

Products forwarded for dissemination via satellite are handled using the MPEG-2/DVB-S based Datacast protocol. MPEG-2/DVB has become widely accepted as the means of transport for both digital television and Internet Protocol (IP) packets (Fig. 5). MPEG-2 uses fixed-size packets (188 bytes) each with a packet identifier (PID) to discriminate between logical channels. The Multi-Protocol Encapsulation is used to carry IP packets. DVB-S, where S stands for satellite transmission, provides sophisticated error-correction with Viterbi and Reed-Solomon coding.

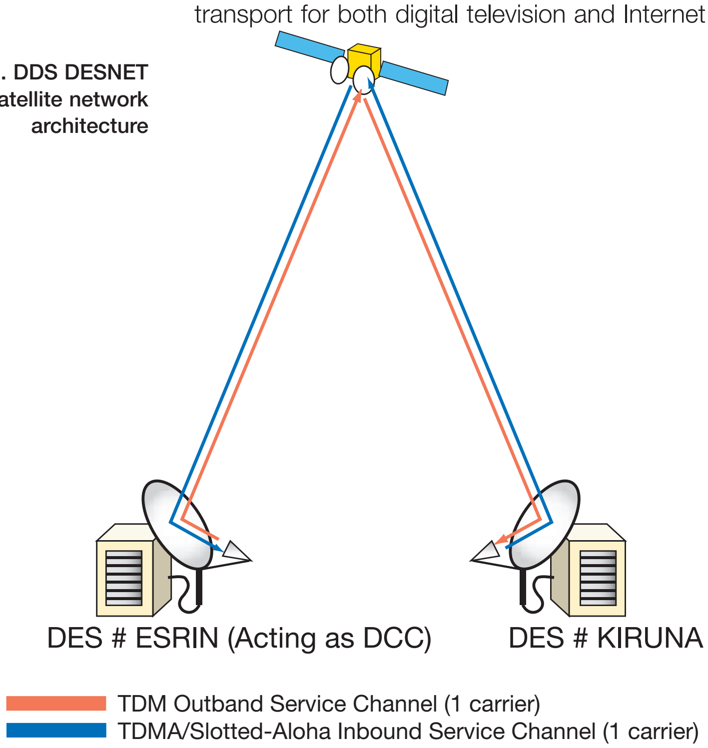


Figure 6. DDS DESNET satellite network architecture

Management of satellite capacity

The DDS allocates the satellite capacity to the transmit stations according to the active periods declared for the respective PDHSs in the dissemination plan. Only one transmit module can use the satellite capacity at any one time. The capacity assignment can be performed automatically or manually and makes use of a commercial subsystem (DESNET).

The DESNET network architecture (Fig. 6) comprises two logically overlapped sub-networks, the Traffic Data Network and the Service Data Network. DESNET is fully self-standing and does not require any special additional telecommunications infrastructure.

The Traffic Data Network (TDN), which provides for the actual product dissemination, is characterised by a fully meshed topology with DAMA/PAMA access schemes for DDS transmit modules. It employs continuous, SCPC (Single Channel Per Carrier), variable-bandwidth satellite carriers.

The Service Data Network (SDN) provides for the allocation of the Eutelsat W1 bandwidth to the transmit modules according to the

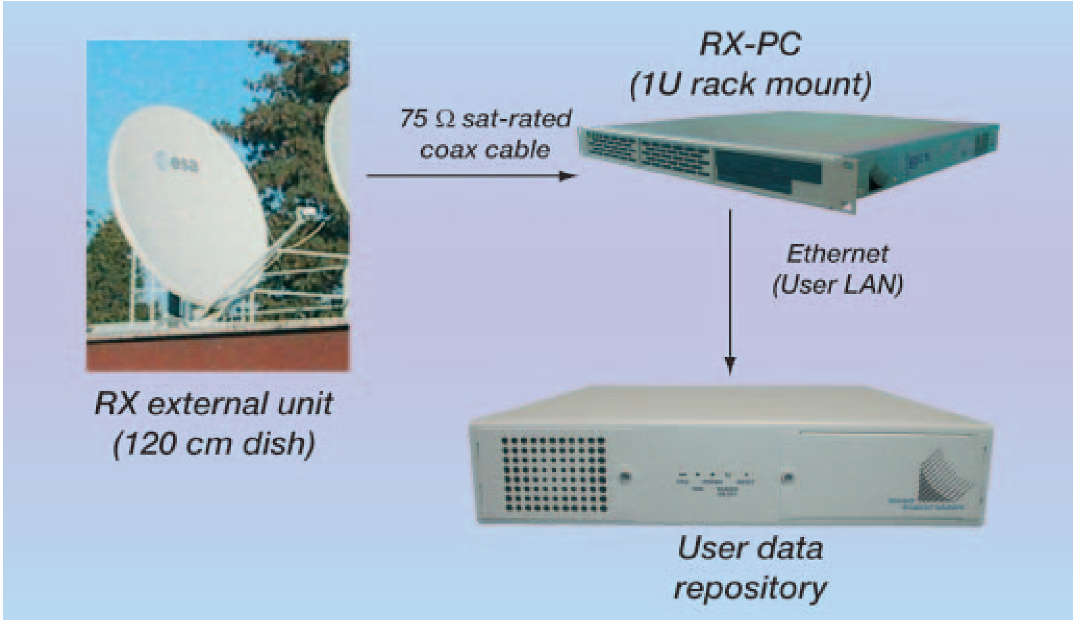


Figure 7. DDS receiver infrastructure

dissemination plan. It is star-meshed with a designated DES configured as the DESNET Control Centre (DCC) at ESRIN acting as the centre of the network.

A DESNET session corresponds to a time window allocated to a DDS transmit station. The session classification priority can be 'normal', 'priority' or 'emergency'.

DDS receiving stations

The DDS infrastructure at user premises comprises an antenna, a coaxial cable with a maximum length of 30 m, the receiver PC and a user LAN (Fig. 7).

The receiving stations are equipped with a Pentium-based PC running the Linux operating system, with hardware chosen to provide sufficient speed at moderate cost:

- 1U chassis with an 800 MHz Pentium-III
- 256 MB of RAM
- Intel EtherExpress 10/100
- 36 GB UW-SCSI hard disk.

It integrates the Broadlogic 2030-16 Satellite Express DVB receiver card, which performs the deconversion/decapsulation of DVB data streams into IP packets. This card has been shown to be the one best suited for low-rate SPCP carriers, starting from 2.222 Msymbol/sec (corresponding to 2.048 Mbps). The Linux driver is able to receive data at up to approximately 7 Mbps per logical channel.

User interface

The Envisat receiver PC provides a WWW user front end, offering maximum ease of use. The header frame shows the system information, the navigation bar provides access to one-shot information and sub-menus, and the content frame always shows the current system status (DVB link, disk usage, LAN forwarding and/or disk cleanup activated).

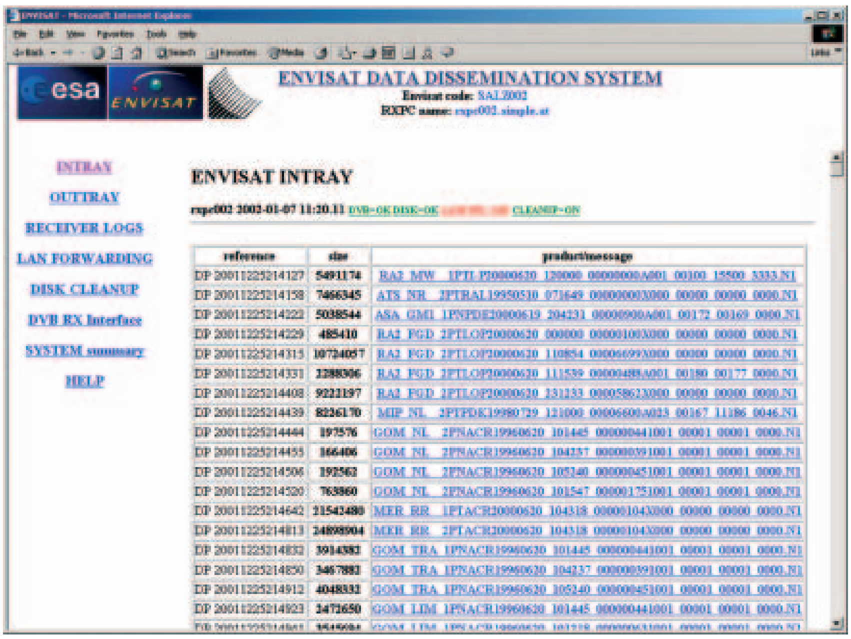
Figure 8 shows the in tray, which lists all of the data product files, with their reference codes and sizes, that have been received successfully and are still stored on the local PC, ready to be downloaded via the LAN. The 'LAN forwarding' menu (Fig. 9) allows one to configure for and activate manual or automatic forwarding of products from the PC to a user workstation.

The System Summary display gathers on one screen all of the parameters that are important for smooth operations, such as the disk usage of all file systems.

DDS operations and quality of service

DDS operations are integrated into the scheme

Figure 8. DDS receiver interface – in tray



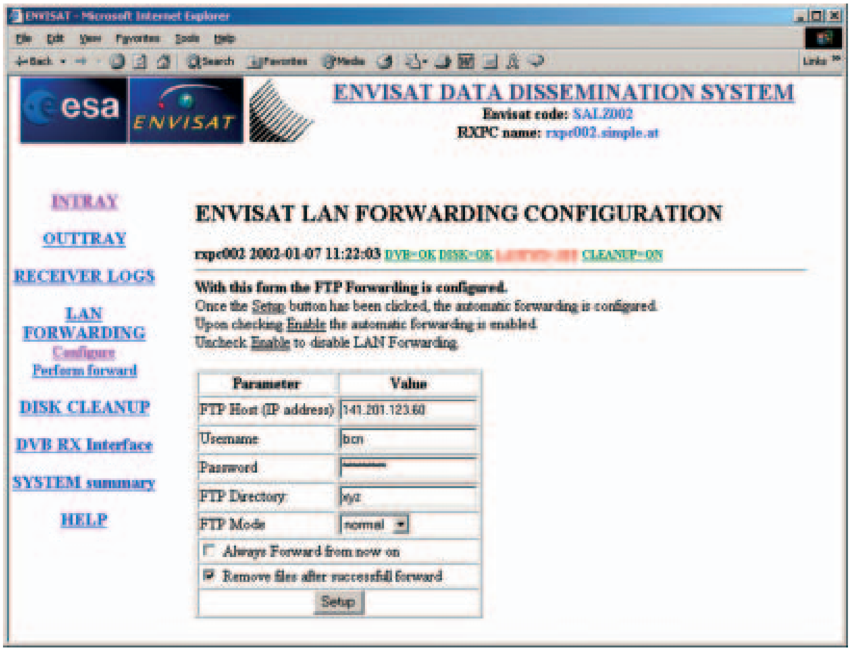


Figure 9. DDS receiver interface – LAN forwarding

Figure 10. The EO Help Desk staff

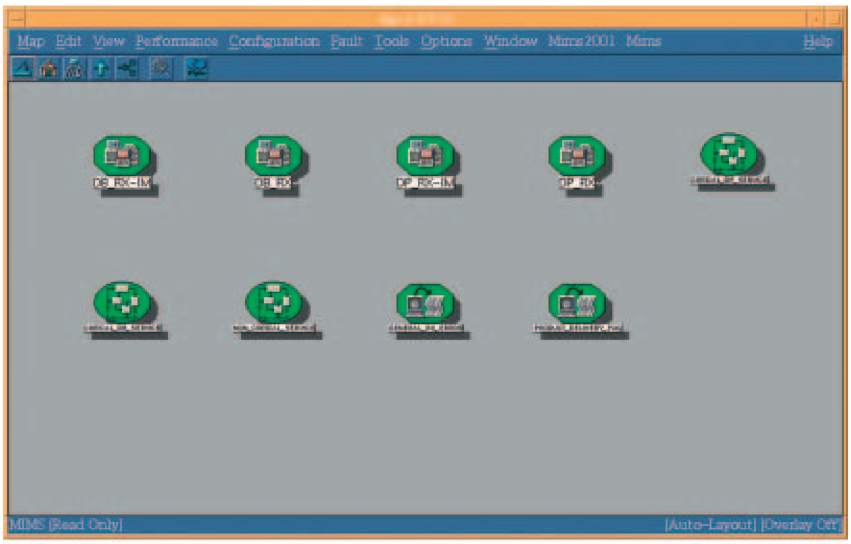


Figure 11. DDS MIMS monitoring interface

currently used at ESRIN for ERS and Earthnet/Third Party mission operations. The DDS Operations Team is responsible for the correct configuration and maintenance of the system. The shift operators will respond outside normal office hours to occurrences where a prompt intervention is required (e.g. switching to a DDS redundant chain). DDS operations will also be supported by the EO Help Desk (Fig. 10) in terms of interfacing to the users, and by the Multi-Mission Integrated Monitoring System (MIMS) as far as the DDS network and system monitoring are concerned.

ESA central monitoring and control

Two types of communications are foreseen for the monitoring: remote access from the central MIMS, whereby a file containing the current system status is read periodically, and asynchronous communication (traps) from the monitored system, generated when one of the controlled functions changes its status, e.g. an alarm is raised at a user station. Monitored-object statuses are then presented to the operator/user via graphical displays (Fig. 11).

Under each icon there is a tree of functions that can be monitored (Fig. 12); for example, parameters such as satellite link status, user interface configuration (e.g. LAN forwarding active) and use of resources (e.g. available disk space). In the case of a failure, the central operator responsible can initiate all of the required maintenance and recovery actions. For example, the DDS operator can intervene remotely to free disk space for new disseminations. MIMS provides for continuous 24 hour per day, 7 day per week monitoring of critical DDS elements.

As a complement to MIMS monitoring, DDS generates performance reports for each receiving and transmitting station, allowing the quality of service for individual users to be monitored. These reports cover both the transmit activity in terms of how may files have been transferred, the throughput, the start/stop time of the satellite session, and the receive activity for each station in terms of the number of products acknowledged as successfully received, the actual success percentage (against the number of products actually sent to the reception station), and the overall number of retransmission requests issued by the station.

Redundancy

The DDS up-link stations are fully redundant in all their components, mainly via ‘hot’ elements that can be activated immediately following predefined procedures, e.g. emergency operations initiated by MIMS. Redundancy of the satellite capacity has been ensured through a contract scheme with Eutelsat, which guarantees equivalent capacity in the event of an unrecoverable transponder failure.

Cost aspects of DDS

The major cost objectives for DDS development have been to minimise the investment in user infrastructure needed and to allow low operating costs. This goal has been achieved through:

– A user infrastructure making use of a standard PC, custom built into a rack unit with commercial DVB receiving board and commercial TV outdoor equipment at a total cost of about 5kEuro per receive module.
– A commercial satellite bandwidth with redundancy scheme, leased at a monthly flat rate corresponding to a cost of about 50 Euro per gigabyte of up-linked data, or 1kEuro per day.
– The integration of a large part of DDS operations and monitoring and control into the framework of Envisat operations, resulting in a marginal cost.

The up-front investment in DDS was mainly for the two transmitting stations and the local-area networking at PDHSs. These investments can be seen as Earth-observation infrastructure investments in support of multi-mission requirements.

DDS status and possible evolution

Status

At the time of writing, the development effort has been concluded and DDS is being operated in support of the Envisat rehearsal phase. It comprises two up-link stations (TX) and 20 receiving stations (RX), including receivers at all PDS Processing and Archiving Centres. DDS uses a satellite bandwidth of 5 MHz and makes available about 2.5 Mbps of effective throughput for reliable multicasting and broadcasting. Additional capacity has been reserved with Eutelsat. Operations are managed as part of the Envisat operations, with all central tasks being handled at ESRIN.

By design, DDS is capable of supporting other missions in parallel with Envisat, interfacing with additional data sources beyond the PDS-DFs to provide dissemination handling also to users outside the Envisat community. This capability is currently being used for the rapid repatriation of ERS calibration data from Kiruna to ESRIN. The DDS architecture is scalable to increase the number of transmitting and receiving stations, even allowing for the addition of other transmitters at other European locations, within the limits of the Eutelsat W1 footprint. Overall DDS capacity can be upgraded to 8.5 MHz/4.25 Mbps by exploiting already reserved additional capacity on Eutelsat W1. The system is dimensioned to support up to 8 Mbps.

Operations outsourcing

Some areas of DDS operations are candidates for outsourcing once the satellite-services market for data communications has matured. In particular, the leasing and access management of the satellite capacity and the provision and maintenance of the receivers could soon benefit from market offerings. The satellite resources could be managed from the service centre of a satellite network operator as part of its overall operations. ESA's New Media Service Centre (NMSC) may support such transfers. However, the actual data-handling aspects of DDS will remain closely linked to the PDHS operations and locations, at least for the duration of the Envisat mission.

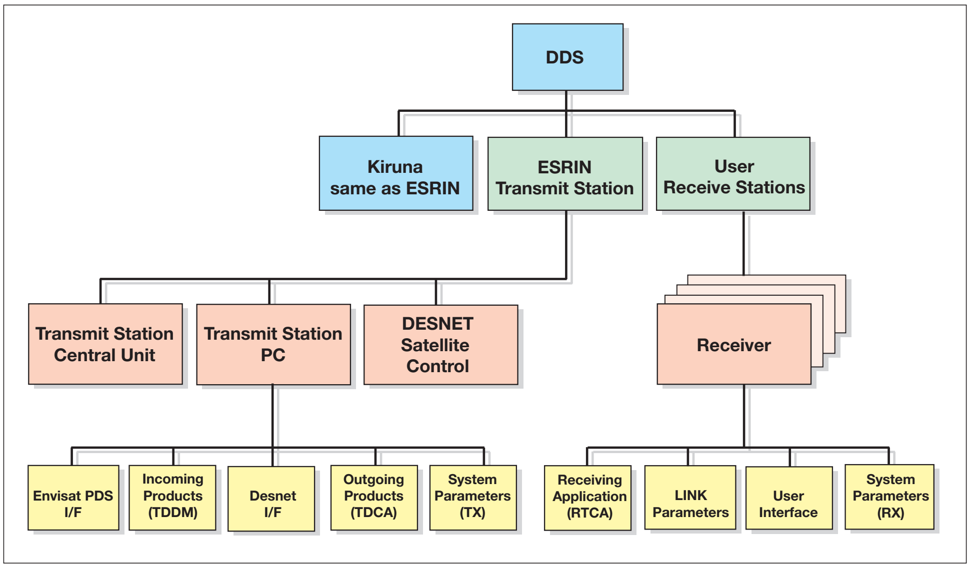


Figure 12. DDS MIMS monitoring tree

Conclusion

Ten years after the development of the ERS Broadband Data Dissemination System (BDDN), a new state-of-the-art data-dissemination system has been put in place for Envisat. It represents a decade of technological evolution in the Internet age, supported by ESA through its Telecommunications Programme. A number of ESA-sponsored trials have supported the technology transfer from digital satellite TV into the domain of Earth-observation applications. The experience gained in this process has been fundamental to conducting the DDS development so quickly. The result is a cost-effective dissemination service based on future-proof standards and commercial offerings, to the undoubted benefit of the user.