ESA'S ACTIVITIES AND PLANS FOR REMOTE SENSING DATA SYSTEMS

Dr. Livio Marelli
ESA/ESRIN
Frascati
Italy

1. INTRODUCTION

The European Space Agency (ESA) is involved in Earth Observation from space since the mid 1970s. This has been through the Meteosat programme, operated now on behalf of Eumetsat, and through the Earthnet programme, which up until now have acquired, archived, processed and disseminated data from non ESA remote sensing satellites like Landsat, SPOT, MOS-1, TIROS-AVHRR (Advanced Very High Resolution Radiometer) plus, in the past, Seasat, HCMM (Heat Capacity Mapping Mission) and Nimbus-7.

At present ESA is building ERS-1 which is an ocean and ice monitoring satellite due for launch in 1990. The Earthnet programme is upgrading its facilities to meet this new challenging mission. It will guarantee service not only to the science and research community, but also to global and regional weather and sea state forecasting organisations, offering near real time sea state information.

Recently, the Long Term Plan of ESA has been approved (up to the year 2000) and within the plan, a comprehensive Earth Observation programme is included. The plan involves, in particular, a second flight unit of the ERS series and the participation of Europe to the Polar Platform complex developed in the framework of the International Space Station (ISS) programme.

Within each one of the phases of ESA's activities in remote sensing mentioned above, the problem of data systems have, and will be, central and will involve major technical and operational challenges.

This paper outlines the programmatic approach followed so far, and describes the evolution planned for the coming generation of ERS satellites as well as the preliminary end-to-end system concept envisaged for the Polar Platforms later in the 1990s.

2. THE PAST EXPERIENCE

Up until very recently remote sensing has been mostly an area of research and proof of concept: missions like Seasat, HCMM, Nimbus-7, and to some extent Landsat Multi Spectral Scanner (MSS) and Return Beam Vidicon (RBV), were aimed at demonstrating the feasibility of specific sensing techniques for a number of research/application domains.

The satellites mentioned above were not developed by ESA and had no assurance of continuity: in fact, Landsat is the only service which has maintained practical data continuity over the years.

Another aspect of the series of satellites launched towards the end of the 70s was the fact that they relied mostly on regional ground stations to collect data since only some had on-board recorders, the vast majority of which proved rather unreliable.

ESA's philosophy for the data systems associated with the above missions can be summarised as follows :

- Decentralised network of ground stations covering the major areas of interest for the European users (e.g. Europe, Scandinavia/Greenland and the Arctic region, North Africa and the Sahel).

- Each regional station charged with data acquisition, archiving and pre-processing (bulk correction) on request.

- Centralised network management and users interface service including catalogue, quick-looks, order handling and quality control.

- Dissemination system, exclusively off-line, delivering digital and photographic products through mail and/or special delivery to nominated centres in participating countries or to individual users.

The archiving task is restricted in preserving the original raw data recorded digitally on High Density Digital Tape (HDDT) (one should bear in mind that Seasat Synthetic Aperture Radar (SAR) and Landsat RBV were transmitting in analog form) or on Computer Compatible Tape (CCT) for HCMM/Nimbus-7.

Data received was screened systematically to generate quick-looks and catalogue entries primarily to obtain reliable cloud cover information, although the cloud cover assessment was assigned by operators with computer support.

The catalogue of such missions as Landsat was assessable on-line from low speed land lines or packet switching networks.
A full set of quick look prints of data available was set up at the centralised user services facility (ESRIN, Frascati) as well as at most of the national centres which act as points of contact for their national user community.

Products were generated exclusively upon user request in view of the large difference between data collected and data actually exploited: it should be mentioned that, in the case

of Europe, up to 70% of acquired data are cloud covered for a good part of the year. As regards acquisition strategy, two approaches were adopted :

a) Landsat data was acquired systematically over the coverage of member states and to a lesser extent over the Arctic due to swath overlap.

b) The experimental satellites were handled instead according to an agreed science plan defined between Principal Investigators (PIs), NASA and Earthnet.

So far the system has provided an acceptable service and the large archives have proved accessible longer than expected though the old Landsat data ('75-'78) cannot be guaranteed any longer as the rest.

All attempts of purging the data sets of cloud covered passes have demonstrated that the exercise doesn't pay off because, transcriptions are labor intensive and strain the old HDDTs which are difficult to maintain after so many years.

On the other hand, user demand for very old data is so modest that it doesn't justify major investments.

For several years, quick-looks for Landsat MSS were compacted on microfiches but also this exercise proved costly and of limited value to users due to long delays between sensing and the availability of the microfiches.

In the specific case of Meteosat, the handling of the archive on HDDT proved infeasible and it was decided to transfer data on 6250 bpi CCTs: the volume of data involved and the importance of the data set for such projects as FGGE made the exercise worthwhile. Figure 1 gives some general indication on volume of data handled so far by Earthnet.

3. THE PRESENT GENERATION OF REMOTE SENSING MISSIONS

Starting with the launch of Landsat 4/5 in the early '80s and later with the launch of Spot 1, a new generation of pre-operational/commercial missions have become available.

Furthermore, the remote sensing user community became more fully aware of the value of the AVHRR of the TIROS-N series which though designed originally for polar meteorology, proves very valuable for a number of other applications (vegetation index etc.).

Lastly NASDA, in Japan, launched their first remote sensing satellite MOS-1 which Earthnet is acquiring with its network of ground stations.

The peculiarities of the mission mentioned dictated some evolution in the system used with ESA which will be briefly reviewed here after.

The overall philosophy adopted for Landsat Thematic Mapper (TM) and MOS is not significantly different from the one quoted in the previous chapter with few exceptions :

- The quick-look system is undergoing modifications to allow generating of colour masters which are expected to improve users ability to determine suitability of images for their applications.

- The network of ground stations is permanently linked via leased lines to the Central User Service (CUS) facilities which allows daily updates of the catalogue and reception of stations logs including information about data acquired, quality assessment reports on products generated etc.

- Experiments were successfully carried out disseminating within 6 to 8 hours from acquisition MSS full resolution scenes over areas of interest to a number of pilot/demonstration projects using high speed satellite link.

Spot operations in Maspalomas (Canary Islands) are carried our with the same basic philosophy, however, since the access fee is linked to the number of scenes requested acquisitions are not systematic but scheduled to match resources and user demands.

At present, Maspalomas can only acquire and record data while processing, when requested by users, is carried out by Spotimage in Toulouse. Later on this year a standard Spot processing chain will be installed at the station which will then serve users directly.

The TIROS-N/AVHRR and TOVS (Tiros Operational Vertical Sounder) data are part of a newly started activity of Earthnet aimed at preserving those data which are widely used in Europe for meteorological purposes but are thereafter not usually kept for long term exploitation.

The approach adopted here is somewhat different: having recognised that many stations are already in existence, Earthnet has negotiated agreements with national High Resolution Picture Transmission (HRPT) operators to host at their premises a data archiving subsystem which extracts the data to be preserved, derives catalogue parameters including cloud cover, sunglint etc. generates a more advanced quick-look and evaluates, based on specific criteria, whether or not data should be preserved in a long term archive. In view of the more manageable volume of data involved, archiving is carried out on optical disks (12", 2Gbytes disks). The optical disk generated at the various HRPT stations will

eventually converge onto a centralized archive where historical products requested by users will be generated when required.

A central computerized catalogue connected with the archival stations is available on-line from ESRIN. Another feature of interest in the TIROS system is that the archival strategy is decided centrally and the system, based upon the planned HRPT operations and on actual cloud cover evaluation, results will automatically direct station to or not to archive data so that specific cloud free data sets over area of interest be secured.

The option of generating automatically at the stage of data archiving, level 2 products like vegetation index over land, sea surface temperature over sea etc. is being evaluated in cooperation with major user groups.

4. THE ERS-1 PAYLOAD DATA SYSTEM

ERS-1 is the first major remote sensing mission developed by the European Space Agency.

ERS-1 has scientific and application objectives: for this reason ESA is committed to provide, within three hours from sensing, geophysical parameters associated with global sea state (wind fields, wave high and wave image spectra etc.) plus high resolution regional data over Europe derived from the SAR.

ERS-1 payload data system has been designed as an end-to-end complex which includes the following main components :

- a number of Real Time Acquisition stations charged with the task of acquiring data from the on-board recording system over an orbit and processing it to geophysical level and make it available for dissemination.

- a number of SAR acquisition stations capable of generating few SAR scene in near Real Time. This service is exclusively available for the European coverage.
- a centralized user services centre (based at ESRIN, Frascati) in charge of handling all interfaces with the users, cataloguing, order handling, quality assurance network management and, upon delegation, mission management.

- a number of archive and processing facilities in charge of preserving data generated by ERS and generate products for the users either on request or by retrieving relevant products which had been generated by systematic processing.

- a wide band data dissemination system ensuring the distribution of near real time data products to users in nominated centres of member states.

- a number of national or foreign acquisition/processing centres having signed agreement with ESA to have access to ERS-1 data.

The salient feature of the ERS payload data system are :

- all ERS raw data are going to be preserved for at least 10 years after the lifetime of the satellite. Figure 2 summarizes the anticipated data volumes involved.

- global Low Bit Rate (LBR) data will be systematically processed and disseminated in near real time while SAR products will be generated and disseminated exclusively upon user request.

- the archival task will be carried out in a decentralized way separately from the data acquisition facilities. Processing and Archiving Facilities (PAFs) have been selected as centres of expertise in different application domains of ERS. These PAFs shall, in particular, support the Agency in the calibration and validation of the mission, its sensors and products, in the definition of novel or improved or additional products to be extracted from ERS either off-line or in near real time as well as in the definition and validation of quality assessment methods and procedures.

- the central catalogue shall provide information about data already acquired as well as on acquisition plans: likewise the users shall have the capability of placing orders for products from the archive but also for data yet to be sensed and for products to be made available in near real time as well as off-line.

The catalogue shall contain reference to all data collected for ERS-1 including those acquired by foreign stations and users will not be bothered to know where physically data they need is kept or production is carried out.

At present it is not anticipated to generate the equivalent of Landsat or Spot quick looks: it is possible that such a service might be developed for the Along TRack Scanning Radiometer (ATSR) which is an experimental sensor provided as an instrument of opportunity but it is not planned for the SAR.

ERS-1 will represent a major challenge as regards the payload data system and will allow development and validation of a number of novel features which will be applied for the Polar Platform complex.

5. THE POLAR PLATFORMS

The polar platform complex is a part of the international space station programme which is being finalized between ESA, Japan, Canada and Europe.

The polar platforms will carry on-board a very large number of sensors of scientific and application nature and they are aimed at a long term earth monitoring system lasting well into the next century.

The polar platforms will rely on a complex space infrastructure developed as part of ISS which will greatly enhance the system and will also impose significant changes to the payload data handling design and implementation: typical examples are the Data Relay satellites (TDRSS, European DRS and Japanese DRS) which will allow real time world wide access to data from the platforms.

At present ESA is only studying the Polar Platforms' (PPFs) end-to-end data systems. Therefore, only very preliminary considerations on its final set up can be provided to date. We anticipate that in a number of aspects the PPF payload data system will be similar to the one presently in place, or that foreseen for ERS-1 e.g. :

- the system will be decentralized making use of several regional facilities as well as of specialized centres in charge of specific services along the lines of ERS PAFs. Such facilities however, will not be operated necessarily just off-line but could receive global data through data Relay channels.

- specialized user community like meteorology could and probably shall set up dedicated facilities to handle sensors data of specific interest.

- the centralized user services will offer information about data available for the PPF complex rather than for individual missions.

- near real time as well as off-line services will be ensured with systematic and "on request" operations according to the product type and associated user requirements.

Conversely, a number of new aspects will have to be addressed and solved with novel approaches :

- the central user service for Europe will have to integrate user requests for instrument operated on non-European platforms and liaise with the relevant mission management centres to ensure their feasibility and actual implementations.

- Data collected in the United States or in Japan needs to be transferred to Europe when required, either in near real time or in an off-line mode, be processed and delivered to the requesting users. This data traffic may well prove to be complex and expensive and needs therefore to be optimized.

- the data dissemination systems of the major partners covering NORTH AMERICA, EUROPE and Japan might need to be interconnected.

- standardization and intercalibration of products will become an essential requirement to allow users to handle indifferently data generated by different sensors operating on different platforms and received and processed by different partners in the system.

- the different nature of the sensors operated on PPFs being either scientific/application or commercially orientated will imply complex problems of data allocation, protection, accounting etc.

The challenge is major but this path appears the only viable one to address the complex issues of environmental monitoring or global change studies.

6. CONCLUSIONS

Remote sensing systems seems to change generation every 5 to 6 years: Landsat-1 in 1972, Landsat-3, Seasat, Nimbus, HCMM in 1978, Landsat-5/Spot in 1984/86, ERS, JERS, TOPEX 1990-92, PPFs in 1995-97.

Within such a time span two major aspects evolve :

1) User requirements

2) Technology available

We have attempted to describe how in Europe the transition from experimental to pre-operational space remote sensing system is taking place, and its impact on data systems.
The technology evolution is obviously playing an equally important role but unfortunately, each generation of remote sensing systems operates approximately with the technology prevailing during the previous generation and little can be done to modify this pattern.

So far the most glamorous evolution in remote sensing payload data handling is in the area of available computing power and on-line storage.

High speed recording technology has not yet evolved at the same pace.

Archival technology based on optical recording is reaching maturity only in these last years and has a long way to go before adequate standardization is enforced.

High speed data dissemination and networking are becoming increasingly available and are likely to impact on traditional remote sensing services in a significant way.

Remote sensing is on the move to become a major resource management tool in the next decade and beyond.

Future is indeed a big challenge in this area.

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Figure 1

SCENES ACQUIRED BY THE EARTHNET STATIONS UP TO SPRING '88

	MSS	TM	MOS-1	TIROS	NIMBUS
FUCINO	247366	63447	8600	-	-
KIRUNA	177657	68472	17300	-	-
MASPALOMAS	29089	3896	13600	1998	2134
TROMSOE	-	-	7300	465	-
LANNION	-	-	-	-	1291
T O T A L	**454112**	**135815**	**46800**	**2463**	**3425**

				Total Gbytes
One MSS scene	equals	35 Mbytes	MSS	15894
One TM scene	equals	256 Mbytes	TM	34760
One MOS-1 scene	equals	16 Mbytes	MOS-1	748
One TIROS pass	equals	70 Mbytes	TIROS	172
One nimbus pass	equals	90 Mbytes	NIMBUS	308
		T O T A L		51882

Figure 2

ERS-1 YEARLY DATA VOLUMES

EXPECTED GLOBAL VOLUME PER LBR INSTRUMENT PER YEAR

Instrument	Raw Data	FDP + IP
Wave	870 Gbyte	302 Gbyte
Wind	472 Gbyte	3 Gbyte
RA	72 Gbyte	2 Gbyte
ATSR	600 Gbyte	-
T O T A L LBR	**2014 Gbyte**	**306 Gbyte**

POSSIBLE TOTAL VOLUME FOR SAR PER YEAR FOR ALL REGIONAL STATIONS

Instrument	Raw Data	FDP
SAR	28000 Gbyte	990 Gbyte