TOPSAT Data System

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INTRODUCTION

The need for a Global Topographic Mission able to fulfill a wide range of scientific application is worldwide accepted. Synthetic Aperture Radar (SAR) Interferometer is undoubtedly the most suitable instrument to supply a precise Digital Elevation Model (DEM) of the Earth Surface including polar regions for ice dynamic studies.
A joint USA and Italian study of a global topographic mission is taking place. This mission, TOPSAT, is based on two horizontally separated spacecraft operating as an L band Interferometric Synthetic Aperture Radar system.
This paper describes the whole system (Ground and On-board Systems) relevant to the data flow from the "On-board Data Handling" to the final DEM Processing.

1. SYSTEM OVERVIEW

The first objective of the TOPSAT mission is to acquire global, high resolution topographic data of the Earth's land masses between ± 65° latitude with 30m x 30m horizontal resolution and vertical accuracy in the range of 2m ÷ 5m, depending on the surface slope. These data would be acquired in less than 6 months in such a way that the data set would be synoptic and uniform. The second objective of the mission is to acquire high vertical resolution topographic data of the polar ice sheets and other low relief areas up to 85° latitude.
In order to meet the first mission objective it has been proposed the Interferometric SAR (INSAR) Altimeter technique be implemented by a twin satellite system where two spacecraft work together as a L Band INSAR antenna system. The system is also equipped with a Global Positioning System (GPS) receiver to get a very accurate relative baseline knowledge.
The second mission objective would be accomplished by using a multibeam laser altimeter.

In TOPSAT system then three main data streams can be identified:
Command data are the information uplinked from Ground to the spacecraft to manage the on board operations.
Engineering Data which mainly consist of telemetry on spacecraft and payloads health and status.
Science Data are composed of the SAR and Laser science data and of the GPS and engineering data.
Figure 1 shows the TOPSAT data flow diagram in which are indicated where the data are originated, what processing has to be done and where the results are used.
The following description of the TOPSAT mission Ground and Space segments shows the operations on the data streams and their main requirements.

2. TOPSAT GROUND SEGMENT

Figure 2 shows a preliminary configuration for the TOPSAT Ground Segment.
The Mission Operation System (MOS) is responsible for Mission Planning (i.e. for translation of the acquisition request into payload programming according to operational information held in a dedicated database), satellite Control and Monitoring (i.e. command spacecraft, monitor subsystems, management payloads and on board records, resolve anomalies and analyze spacecraft trends), distribution of auxiliary information like orbit and attitude data and for supplying "Production Schedule" to the Production Centers.
MOS is also in charge of supplying the acquisition schedule information to the Science Data Acquisition stations and of controlling the Tracking, Telemetry and Command (TT&C) stations.
Connected to MOS is an analysis task. This task is carried out by project engineers/scientists wich produces updating control algorithms for on board and ground operations.
The Tracking, Telecommand and Command station performs spacecraft tracking, MOS telecommands uplink,

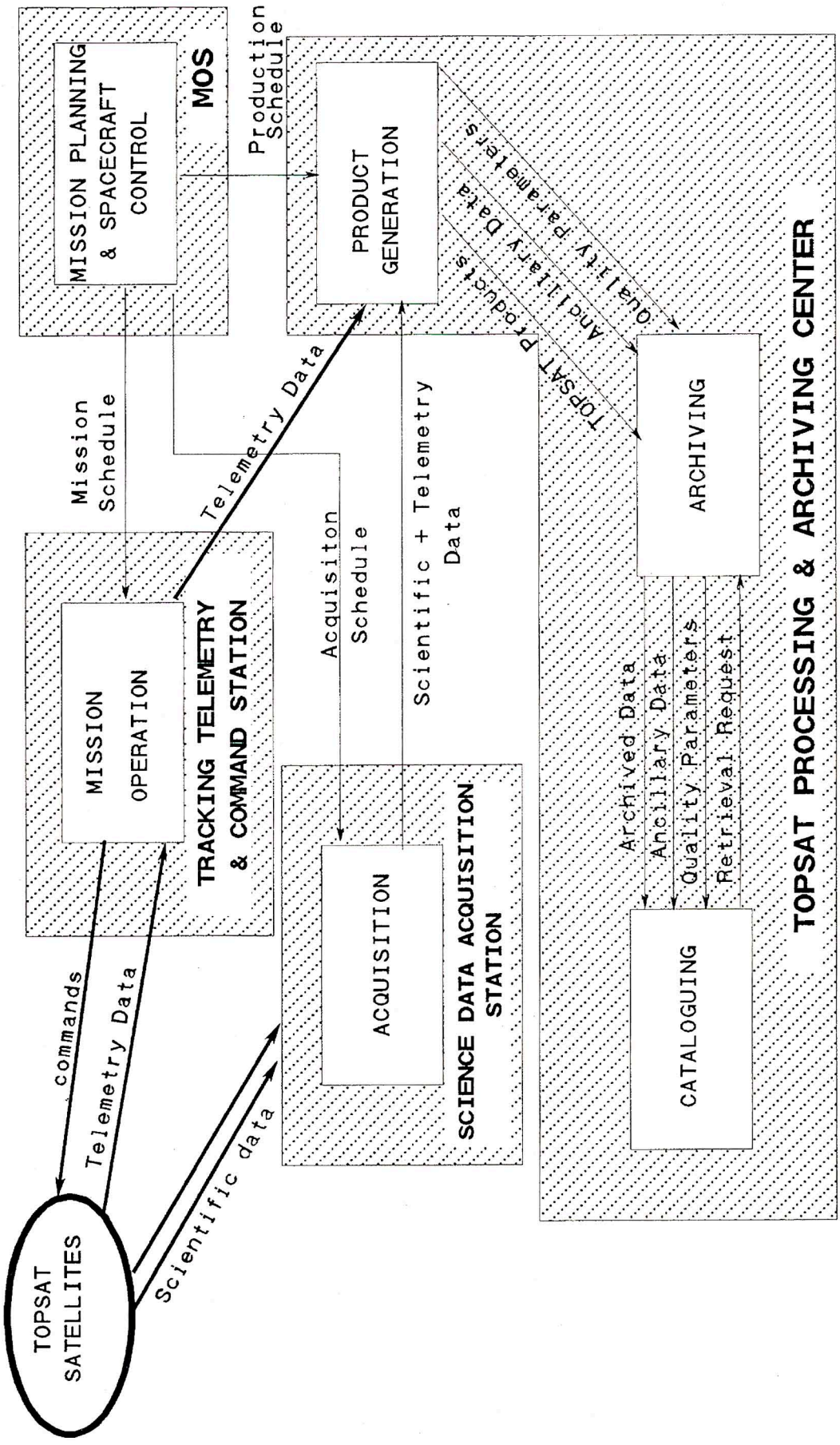

Fig. 1 - TOPSAT - Data Flow Diagram

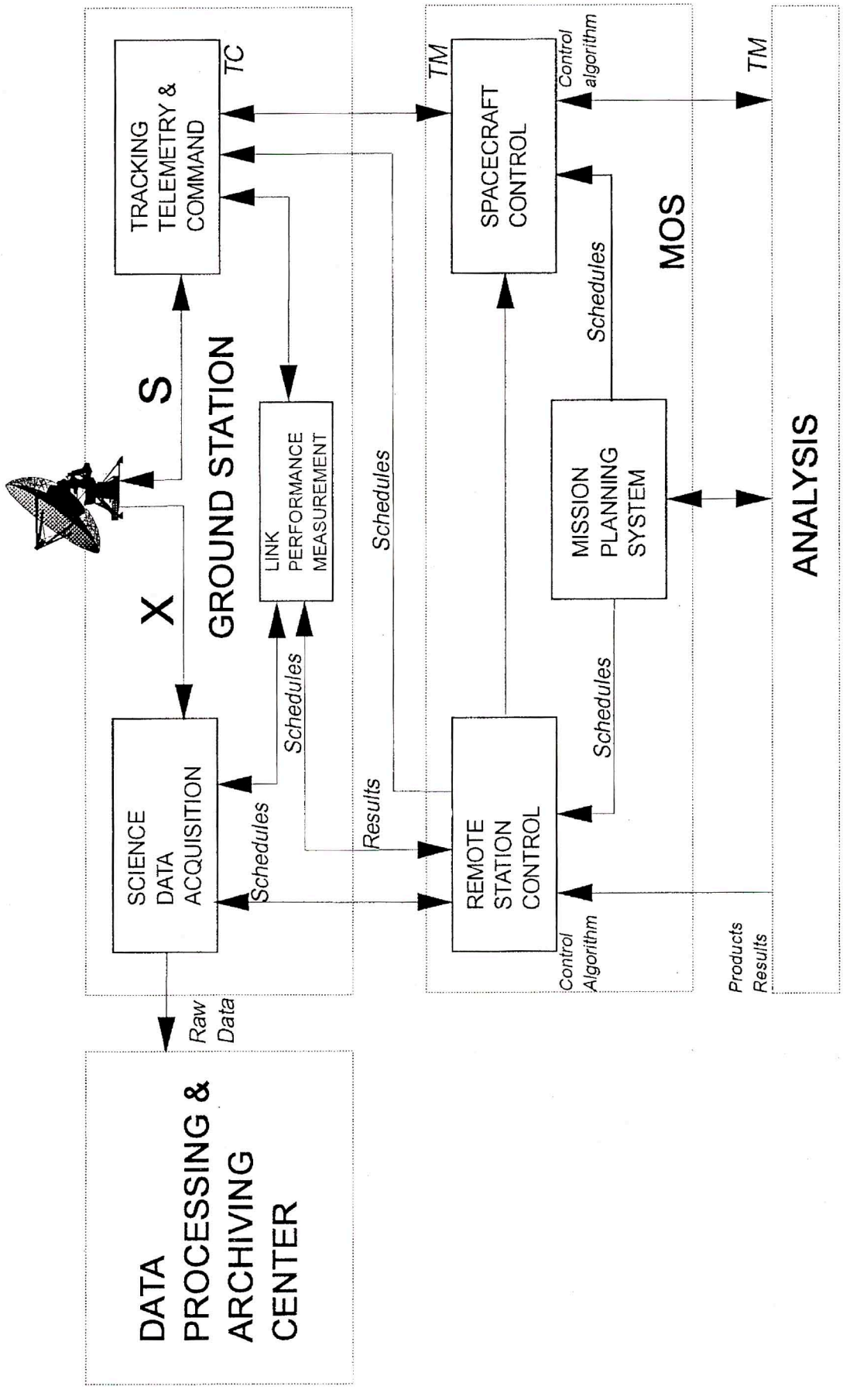

Fig. 2 - TOPSAT - Ground Segment Configuration.

housekeeping telemetry reception and their routing to the MOS.
Uplink and Downlink of engineering data use a S-Band channel, estimated data rate for uplink is 2 Kbps and for downlink is 512 Kbps (including GPS data), requirement for BER is 10e-5 for both the channel.
Science data are sent to the Science Data Acquisition stations.
Two X-band links are foreseen to downlink data from the two satellites.
The Data stream will be the same for both satellites and will include:
SAR data, Laser Altimeter data and GPS data.
The science data will also include a copy of the telemetry data already available on the S-band link.
The estimated data rate is about 52 Mbps per channel.
The use of CCSDS telemetry formats is being considered.
A Science Data Acquisition station, shown in figure 3, is in charge of receiving, demodulating and recording the analog data streams on a High Data Density Recorder (HDDR) for shipment to the Data Processing and Archiving Center.
If a local processing capability for Real Time Processing of SAR and Laser data for sensor monitoring is required, a feedback link to the MOS shall be established through a dedicated high speed link such as 2 Mbps leased line.
The Science Data Acquisition station can be also connected through an ordinary network link (e. g. X25) to the MOS for commands and status reports exchanging.
The TOPSAT Data Processing and Archiving Center is in charge of Product Generation, Data Archiving and Cataloguing.
After the deformatting operations the data enter the Data Processing and Archiving Center through the Data Ingestion and Communication facility. Data Ingestion is in charge of reading data from the received media, quality checking of the data themselves and routing data either directly to the Processing Subsystem or to the Temporary Archiving.
As depicted in figure 4, processing and archiving subsystem in the Data Processing and Archiving Center are connected by mean of a High Volume Data Path.
A dedicated Processing Subsystem is required for SAR, LASER, and GPS data.
A separated Subsystem is required for DEM production.
GPS processing will supply Interferometric Baseline Estimation.
Each processing subsystem not only shall perform the required data processing but also shall generate the suitable metadata information file for cataloguing information.
Products will include DEM products (High Resolution 30 m maps), SAR Image Products and Laser Track Final Products.
Quick Look Products shall be supplied for SAR and DEM, with a low resolution 300 m, for browse purpose.
Finally processed data shall be routed to the Product Generation Subsystem to be formatted and recorded on the suitable media to be supplied to the users. Product Generation is also in charge of deriving cataloguing information from the metadata relevant to each product.
The Facility Management and Control (M&C) is responsible for the proper integration of all the facility system and handling interfaces with other external facility such as MOS.
The facility management and control is also in charge of product ordering handling.
A key issue within the facility management and control is the facility status monitoring where through a LAN connection all the subsystem report their status.
Level 0 data, Final High Resolution and Browse products shall be archived together with the relevant metadata information.
Catalogue and Browse Service is in charge of Data Inventory, Browse Service including catalog entry handling, catalogue storing, catalogue retrieval handling, browse image ingestion and browse image retrieval.
Processing and Archiving Subsystems shall use, where possible, off the shelf hardware and software.
The TOPSAT Data Processing and Archiving Center may be implemented as a single center or may be performed at different processing centers where each center may not have all the functions described above.
For Telemetry, Tracking and Command together with Science Data Acquisition the McMurdo Ground Station has been chosen for this study.
Due to the fact that the TOPSAT mission has to provide a global coverage and the McMurdo station doesn't cover all the orbits an other station, for example Canberra, has to be used as an additional ground station for X-Band data reception.
For the same reason at least another TTC Station S-Band 26m antenna is needed.
In addition data capture may be also performed at Fairbanks, Alaska SAR Facility (ASF).
Moreover an Italian Facility is foreseen for regional Science Data Acquisition and Processing.
A preliminary set of possible TOPSAT Ground Stations is depicted in figure 5.

3. ON BOARD SYSTEM

A functional block diagram of the On-board data flow is shown in figure 6.
The telecommunication subsystem links the spacecraft to the ground stations. Information flowing to the spacecraft (uplink) consists of commands. Information flowing from

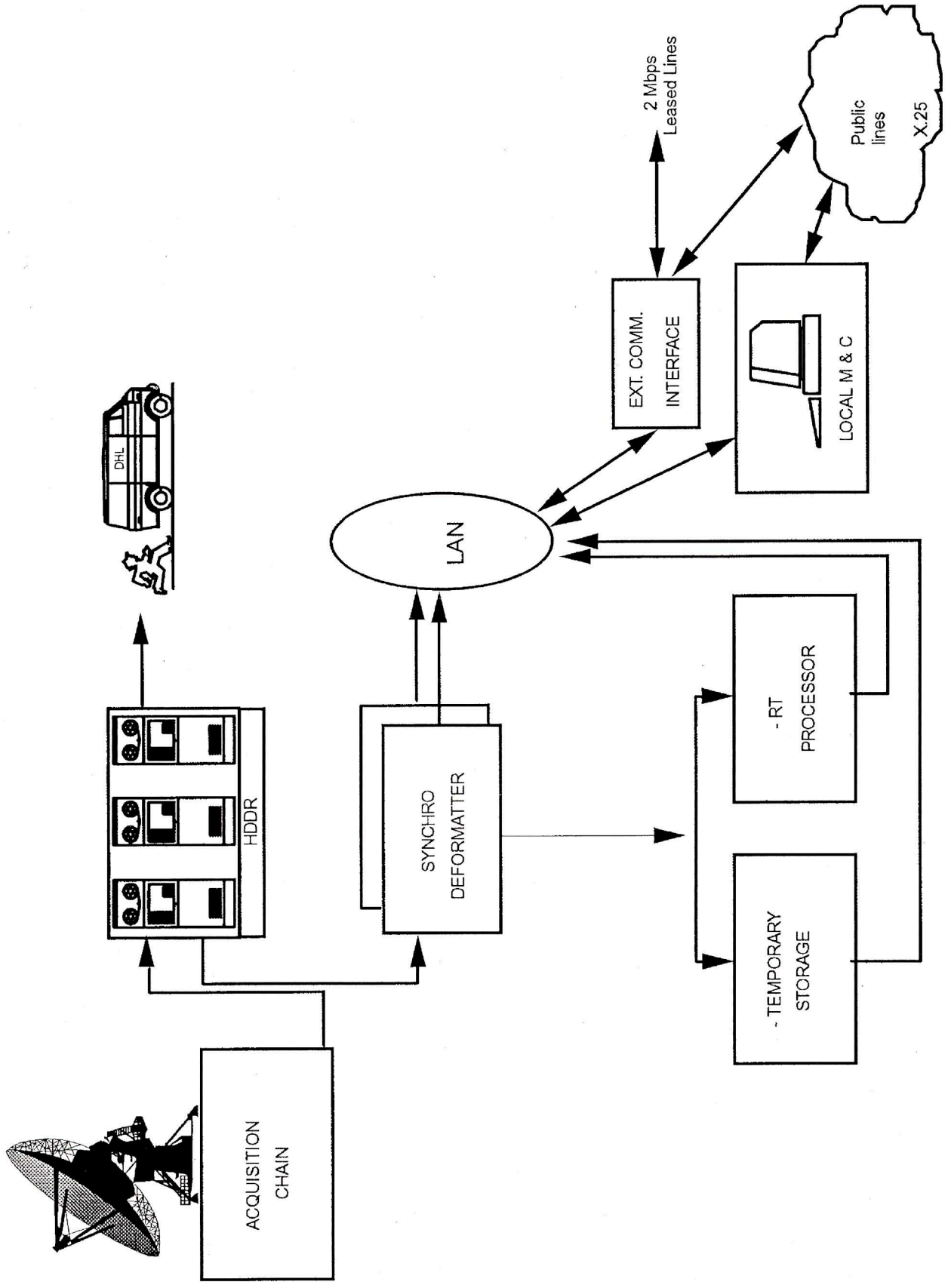

Fig. 3 - TOPSAT - Science Data Acquisition Station

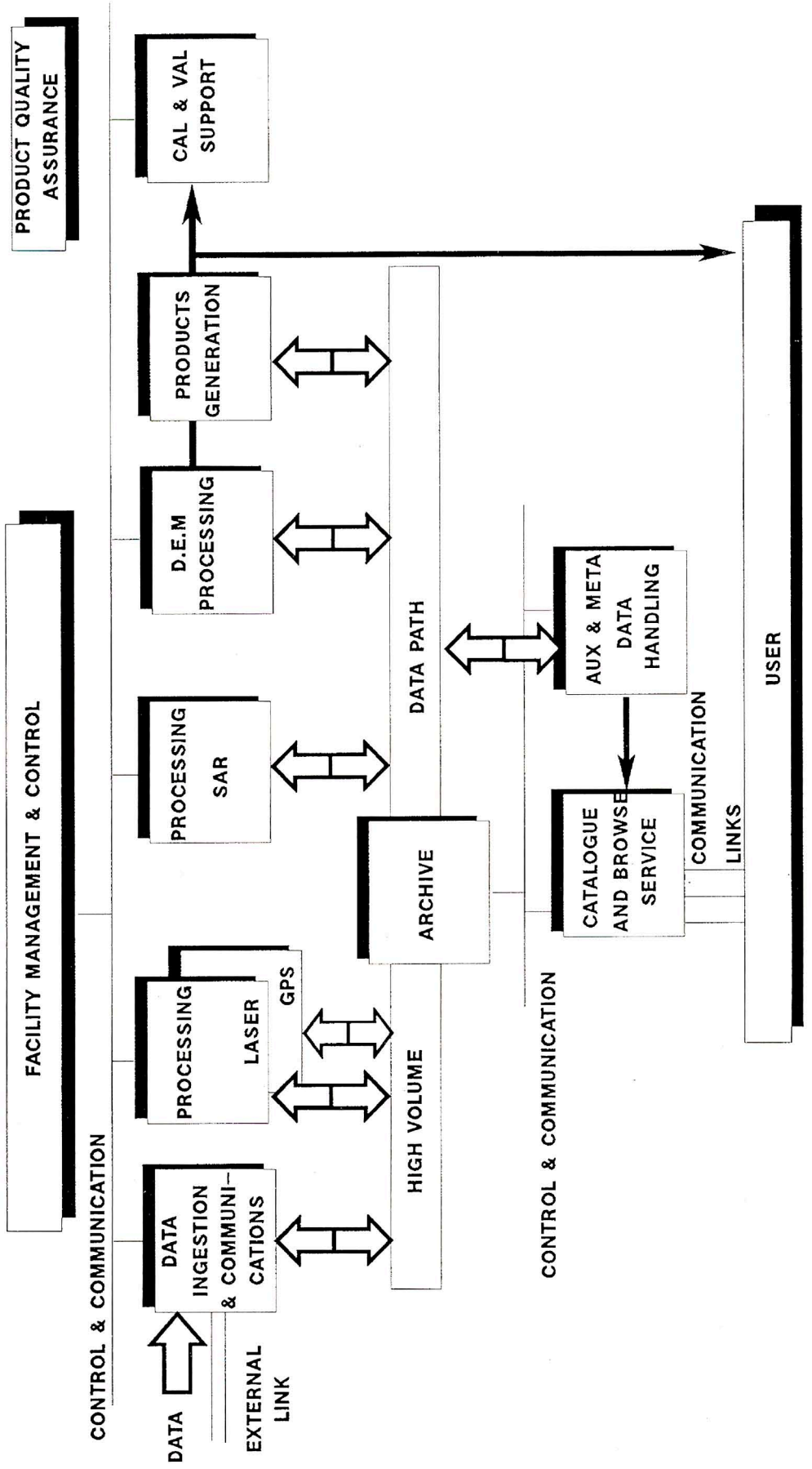

Fig. 4 - TOPSAT - Data Processing & Archiving Center Configuration.

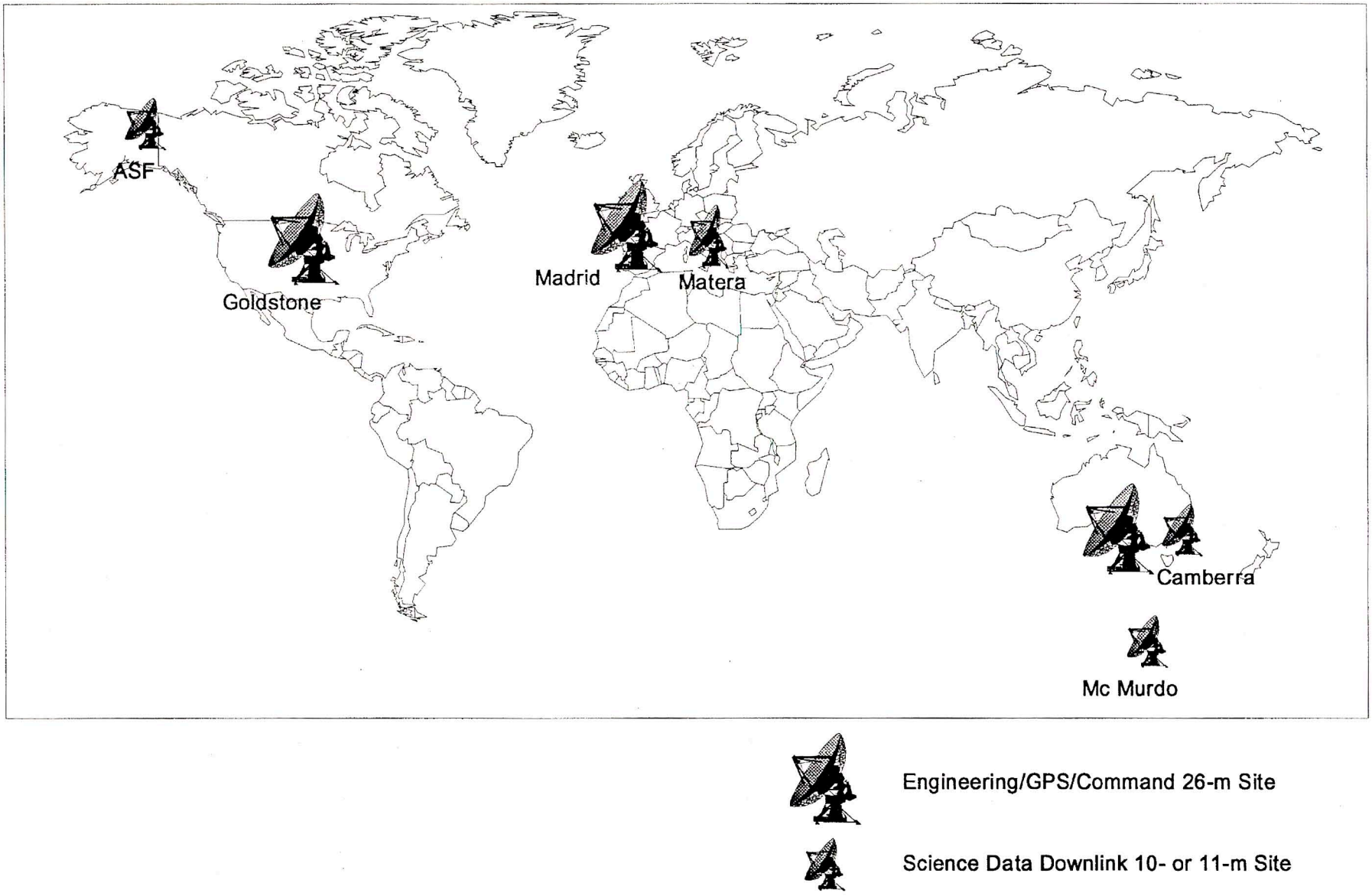

Fig. 5 - TOPSAT - Potential locations of Ground stations.

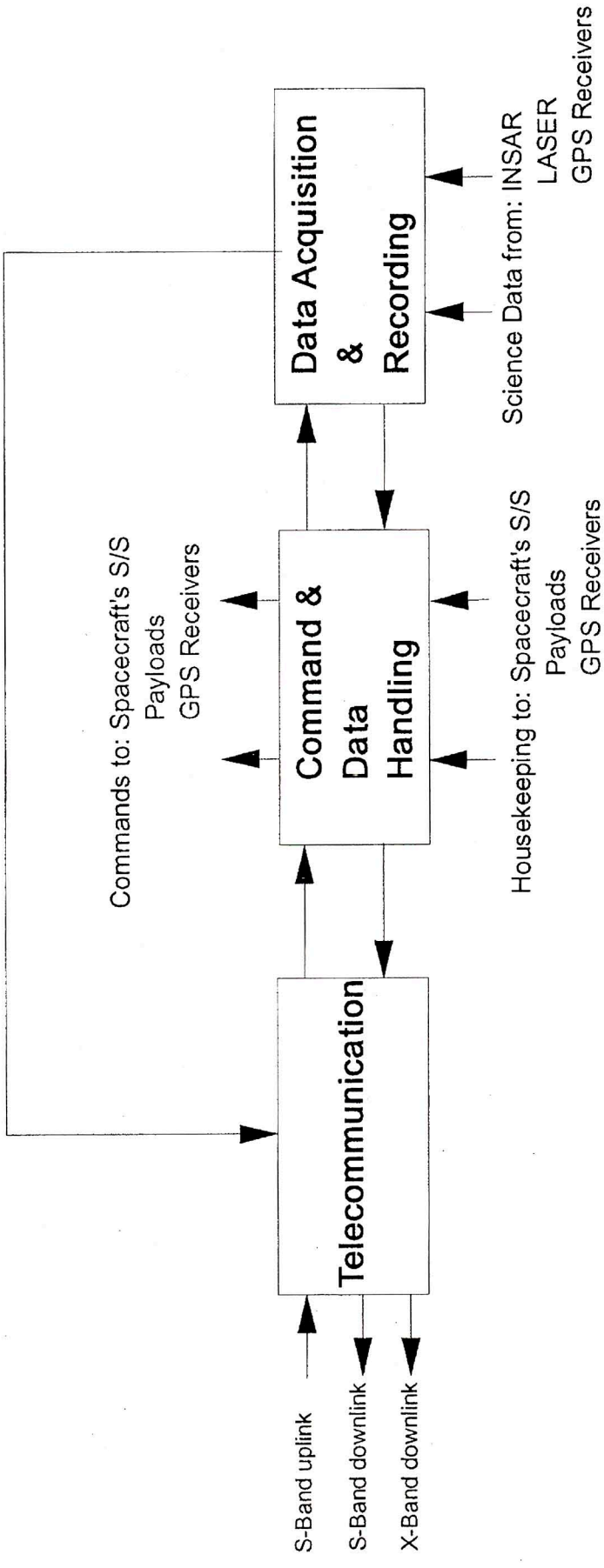

Fig. 6 - TOPSAT - On Board Data Flow.

the spacecraft (downlink) consists of engineering telemetry at S-band and scientific data at X-Band.

The uplink signal enters the subsystem through the antenna, the diplexer routes the signal to the receiver where it is demodulated; the digital command bit stream is then sent to the Command and Data Handling Subsystem (C&DH).

The telemetry packets formatted by the C&DH are passed to the S-Band exciter solid state power amplifier and then transmitted to ground by the S-band omni antenna.

In the same way the science data together with engineering telemetry, either from recording (playback mode) or directly from Data Formatter (Direct mode) are sent to exciter and then transmitted to Ground by the X-Band omni antenna.

The Command and Data Handling subsystem distributes commands and accumulates, stores and formats data from spacecraft and payloads.

The architecture proposed for TOPSAT C&DH S/S is composed of:

- An On Board Computer Unit (OBCU) which gathers the processing and memory capacity for Software Code and-Data, the Telemetry and Telecommand video interface and the necessary devices for failure detection, isolation and recovery. The decoder is also contained in this unit as the interface for High Priority Command distribution.
- A data bus complying with ESA OBDH Bus standard TTC.-B-01. The possible bus frequency is 524 kbps.
- An interface unit named Remote Unit (RU) which provides standard and non-standard interface between the OBDH bus and the AOC sensors and actuators.
- Another RU connects the data bus to all the different spacecraft equipment, including the power subsystem, the pyrotechnics firings and related realys arming, the solar array drive electronics, S Band transponder and the ion propulsion package.
- A further RU provides the interface between the OBDH bus and payloads (SAR, Laser), GPS and Data Acquisition and Recording equipment.

The RU devoted to the SAR Payload may use a microprocessor.

The C&DH subsystem coordinates the transfer of information between the satellite and the Ground Station as well as between the various units on board the satellite.

Each payload (SAR, Laser Altimeter) and the GPS receiver are directly connected to the Data Acquisition and Recording equipment by a dedicated link where the data are buffered, formatted and then routed to the on board recorder: Finally the data at 85 Mbps rate are transmitted to Ground Station by the X band transmitter.