THE SPACE OPERATIONS AT CNES

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This paper presents an overview of current space operations performed by the French space agency at the Toulouse Space Centre. The missions are briefly presented and a description of the architecture of the ground facilities involved in the space operations is provided. The improvements subject to current activity are presented and the associated methods and tools are listed.

INTRODUCTION

The Centre National d'Études Spatiales (CNES) is responsible for the implementation of French space policy. It is a government scientific and technical organization run on a commercial and industrial basis.

CNES facilities are sited in the Paris area, at Toulouse, and in French Guyana. The Toulouse Space Centre is the main engineering and technological facility and is responsible for developing and operating French space missions.

The Toulouse Space Centre is in charge of operating scientific and application space systems covering four domains of activity:

- Earth observation satellites
- Geostationary telecommunication satellites
- Mobile search and rescue
- Science

A ground network and multimission facilities are operated to support these activities.

EARTH OBSERVATION SATELLITES

The SPOT concept is a standard spacecraft that can accommodate various payloads for Earth observation. The main payload comprises two high-resolution visible radiometers.

The SPOT system has been operated by CNES since February 1986. The space segment comprises the SPOT 1 and SPOT 2 satellites. The SPOT 3 satellite will be launched in September 1993. A new family of SPOT satellites is under development and, with SPOT 4, will extend the Earth observation mission.

The SPOT satellite orbit is polar and Sun-synchronous, with an altitude of 832 km. This orbit is maintained in such a way that the satellite local time is always the same, allowing for constant lighting conditions.

The ground segment for SPOT includes the following:

- The telemetry, tracking, and command (TT&C) S-band ground station network, comprising the CNES S-band network complemented by the Kiruna (Sweden) station.
- Image receiving stations associated with image processing centres.
- The Mission and Control Centre responsible for satellite monitoring and control, orbit control, and management of the payload work schedule.

GEOSTATIONARY TELECOMMUNICATION SATELLITES

MISSIONS

The first Franco–German geostationary experimental satellites, Symphonie A and B, were launched in 1974. Since then, three major programs have been pursued:

- Telecom 1A, 1B, and 1C
- Telecom 2A and 2B
- TDF1 and TDF2

The Telecom system comprises the Telecom 1C, the Telecom 2A and 2B satellites, and the associated ground control facilities. Since 1984, this system has performed two main missions: business communications service and telephone and television service.

The business communications service uses the 14-/12-GHz band. The Telecom 1C satellite provides six transponders, while each Telecom 2 satellite provides 11 transponders. The telephone and television service establishes links between the French mainland and its overseas territories, using the 6-/4-GHz band. The Telecom 1C satellite provides four transponders, while each Telecom 2 satellite provides five transponders.

France Telecom is in charge of development and operation of the French public telecommunications network. On behalf of France Telecom, CNES is responsible for the control of the satellite.

The TDF1 and TDF2 satellites are part of a Direct Broadcast Satellite family developed cooperatively by Germany and France under the responsibility of TéléDiffusion de France (TDF). TDF is responsible for broadcasting and transmission for public and private television and radio stations. Collocated at 18.8° West, the TDF satellites operate at 18/12 GHz and provide four channels for high-power TV broadcasting.

Concerning the operation of the national satellites, the Toulouse Space Centre is in charge of

- Developing, testing, and running the ground control facilities.
- Performing the station positioning operations.
- Performing the stationkeeping operations.

The Toulouse Space Centre also provides station positioning services for external entities.

STATION POSITIONING

Since the launch of Symphonie A in 1974, CNES has successfully brought 14 operational geostationary satellites onto station. Peak activity occurred between December 1991 and September 1992, when six satellites were put on station. The 14 satellites are listed below.

Telecom 1A	August 1984
Telecom 1B	May 1985
TDF 1	March 1988
TELE-X	October 1988
Telecom 1C	April 1989
TDF 2	July 1990
Inmarsat 2 F1	October 1990
Inmarsat 2 F2	March 1991
Telecom 2A	December 1991
Inmarsat 2 F3	December 1991
Arabsat 1C	February 1992
Telecom 2B	April 1992
Inmarsat 2 F4	April 1992
Hispasat 1A	September 1992

Station positioning operations are planned for Hispasat 1B in April 1993, Turksat 1A in December 1993, and Turksat 1B in December 1994.

Station positioning operations are characterized by

- Short duration (less than one month).
- Use of a worldwide network.
- Involvement of many entities.

The typical ground segment architecture for station positioning is illustrated in Figure 1.

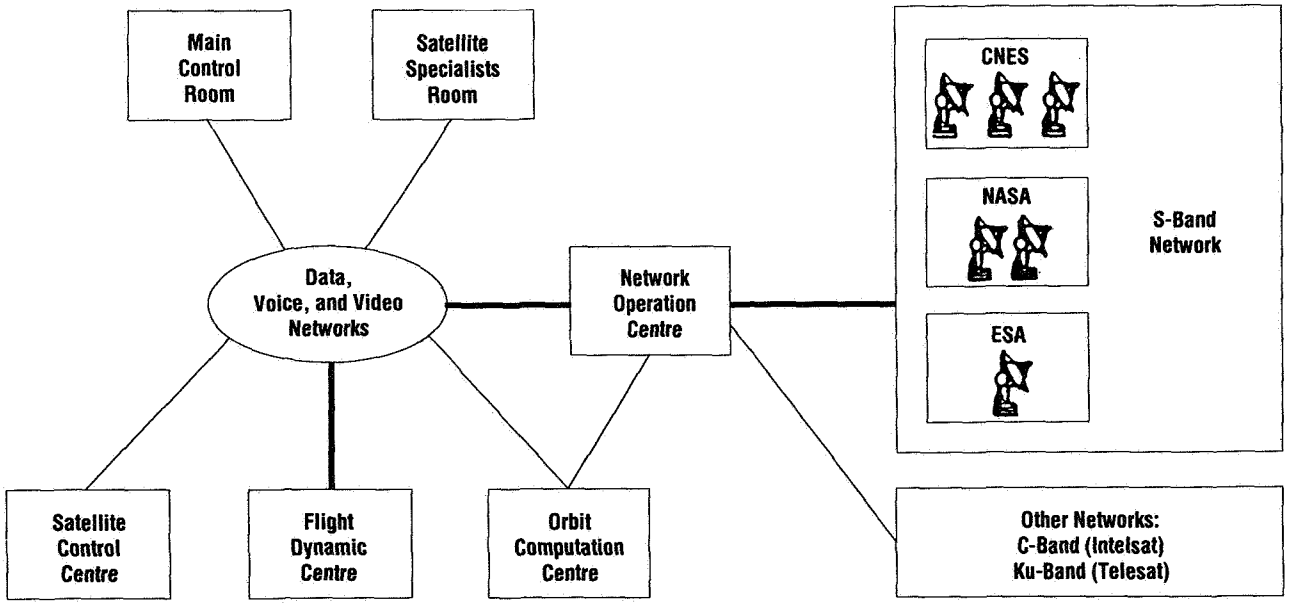

Figure 1. Satellite Positioning Ground Architecture.

The functions of the ground facilities involved in satellite positioning are as follows:

- The Main Control Room provides access to information produced by the other entities that is necessary for coordinating and managing the operations.
- The Satellite Specialists Room hosts satellite manufacturer staff responsible for monitoring the various satellite subsystems.
- The Satellite Control Centre performs satellite monitoring and commanding according to flight control procedures.
- The Flight Dynamics Centre computes and displays the orbit parameters, the satellite attitude, and the manoeuvres parameters.
- The Orbit Computation Centre (OCC) computes the satellite's orbit and provides pointing data to the ground stations.
- The Network Operation Centre (NOC) provides the interconnection with the supporting network. This network can be either the CNES S-band network complemented by ground stations from the European Space Agency (ESA) and/or the National Aeronautics and Space Administration (NASA), or a C-band or K-band external network.

STATIONKEEPING

The control of national geostationary satellites involves facilities dedicated to each satellite family. The typical ground control architecture is presented in Figure 2. The organization of CNES ground facilities for geostationary satellite stationkeeping is described below.

Dedicated ground stations provide the telemetry and telecommand links with the satellites, using the mission frequencies (C-band for the Telecom 1/Telecom 2 system; K-band for the TDF system). The stations provide the measurements for orbit computation ("turn-around" two-way ranging for the Telecom system; range and angle measurements for the TDF system). The CNES S-band network is used for range and angular measurement calibration or in case of satellite attitude loss.

A data transmission system interconnects the various elements of the ground system.

The Satellite Control Centre fulfills the following functions:

- Telemetry real-time monitoring and control.
- Telecommands preparation and transmission.
- Telemetry off-line processing (trending).
- Ground station remote monitoring and control.
- Orbit and manoeuvre computation.

These functions are distributed on computer systems (shown in Figure 2).

MOBILE SEARCH AND RESCUE

The COSPAS-SARSAT program provides satellite aid to search and rescue operations for maritime, aeronautical, and terrestrial vehicles anywhere in the world. The program interfaces permanently with the International Civil Aviation Organization and the International Maritime Organization.

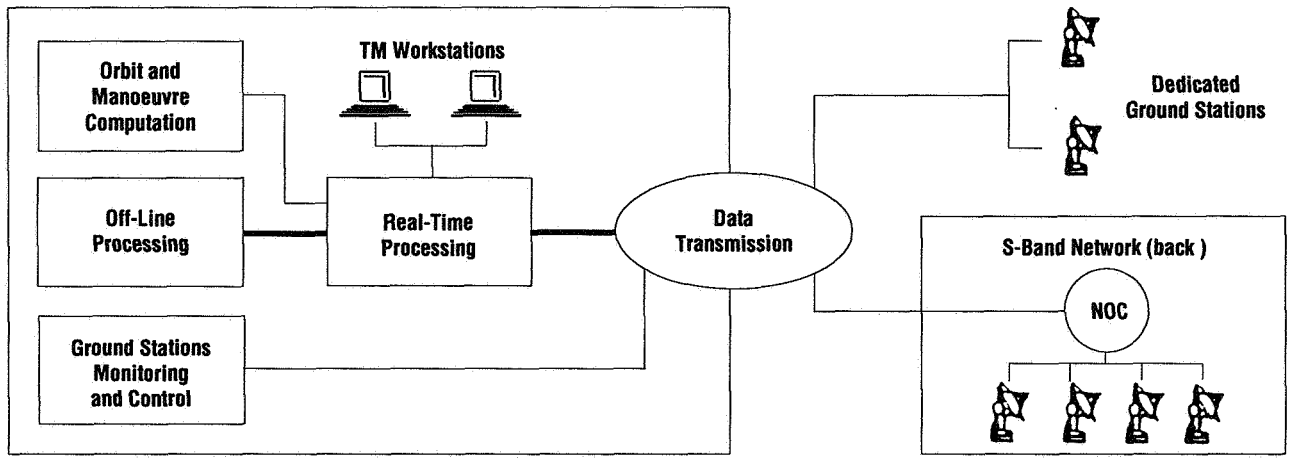

Figure 2. Satellite Control Centre Architecture.

The nominal configuration comprises four satellites relaying signals from distressed units. A local user terminal (LUT) receives the data from the satellites, calculates the position of the activated distress beacon, and transmits the results to the Mission Control Centre (MCC).

The French MCC is operated at the Toulouse Space Centre by a joint team comprising CNES and civil aviation personnel. Its main functions are to collect, store, and sort the data from LUTs, to ensure the exchange within the COSPAS-SARSAT system, and to distribute alert and location data to associated rescue coordination centres.

SCIENCE

The CNES Toulouse Space Centre is responsible for the preparation and operation of French experiments flying on board scientific satellites, as well as the acquisition, preprocessing, and distribution of related data to the scientists.

GROUND NETWORK AND MULTIMISSION FACILITIES

To support space missions, the Toulouse Space Centre operates the CNES S-band network. The function of the network is to provide telemetry and telecommand links with the satellite in orbit. It also performs range and range rate measurements necessary for orbit determination.

The CNES S-band network comprises the following elements:

- Three ground stations located at Aussaguel (France), Kourou (French Guyana), and Hartebeesthoek (South Africa).
- The data transmission system.
- The OCC, which computes the orbit of the supported satellite and provides pointing data to the ground stations.
- The NOC, which monitors and controls all the elements of the network.

The CNES S-band network can be extended with ground stations or ground networks belonging to other entities. ESA and/or NASA S-band ground stations are used during station positioning operations when performed in S-band. The CNES data communications system is fully compatible with the NASA network and a gateway was developed that allows the interoperability of CNES and ESA networks. The Intelsat C-band network was used during the Inmarsat 2 and Arabsat 1C satellites station positioning.

Multimission facilities are operated for the benefit of the missions. These facilities include

- Time distribution
- Video distribution network
- Voice conferences
- Main Control Rooms
- Satellite Specialists Rooms

IMPROVEMENT OF OPERATIONS EFFICIENCY

Besides the development of new ground control facilities (e.g., SPOT 4), emphasis is placed on the improvement of operations efficiency. The goals are to

- Minimize the number and the effects of human errors.
- Improve the capability to react properly to contingency situations.
- Improve knowledge of satellite behavior.
- Improve productivity.

To this end, critical analyses of the organization, the documentation, and the procedures of the various operational entities are conducted by internal and external audits. New tools have been developed or are under development to support these objectives, such as

- Computer-aided operational documentation production.
- Computer-aided report production.
- Satellite simulators used for satellite procedures validation and for training.
- An expert system to be used within the Telecom 2 control centre.
- Telemetry monitoring and processing on personal computers.