SAC-C MISSION AND THE INTERNATIONAL AM CONSTELLATION FOR EARTH OBSERVATION

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MISSION OUTLINE: SAC-C is an international Earth observing satellite mission conceived as a partnership of CONAE and NASA but with considerable additional support in instrumentation and satellite development from the Danish DSRI, the Italian ASI, the Brazilian INPE, and the French CNES. It was successfully launched by a Delta II rocket on November 21, 2000, from Vandenberg AFB, California.

The primary mission of SAC-C is to provide multispectral imaging of terrestrial and coastal environments, measurement of the Earth's geomagnetic field, and studies of the structure and dynamics of the Earth's atmosphere and ionosphere. The primary scientific objectives are to monitor the condition and dynamics of the terrestrial and marine biosphere and environment, better understand the Earth's geomagnetic field and related Sun -Earth interactions, and to develop and utilize new GPS based techniques to globally measure atmospheric phenomena for the study of weather, seasonal, interannual and long term climate change.

The payload of SAC-C consists of: the Multispectral Medium Resolution Scanner (**MMRS**), the GPS Occultation and Passive Reflection Experiment (**GOLPE**), the Magnetic Mapping Payload (**MMP*),*** the Argentine experiment to track the migratory routes of the Eubalanea Australis whale (**Whale Tracker**), the French experiment to study the Influence of Space Radiation on Advanced Components (**ICARE**), two Italian experiments to develop fully autonomous onboard navigation for orbiting satellites (**IST** and **INES**). In addition, Argentina added a High Resolution Technological Camera (**HRTC**) to the MMRS system to improve imaging resolution and a High Sensitivity Camera (**HSC**) to study light intensity in urban areas, as well as a Data Collection System (**DCS**), that will collect environmental data coming from ground stations.

In June 1999, NASA and CONAE created the first International Constellation for Earth Observation (the AM Constellation), in which the NASA satellites Landsat-7, EO-1 and Terra and the Argentine satellite SAC-C will share data in order to enhance the scientific objectives of their individual missions. The four satellites will pass over the same point with a difference of half an hour.

MISSION PROFILE: The SAC-C satellite is an Earth observation mission designed for a 4 year lifetime. It was successfully launched by a DELTA 7320-10 rocket on November 21 2000.

SAC-C is a three axis stabilized, Earth pointing spacecraft. The pointing accuracy required is 1.5 deg, the pointing stability is 0.1deg/sec and the required pointing knowledge is 0.2 deg 3σ on the three axes.

Orbit characteristics:

- Nominal altitude 705 km
- Inclination 98.2 deg
- Type: circular Sun-Synchronous – 10:21 AM
- Track error +/-10 km EOL.

Spacecraft characteristics:

- Spacecraft dimensions: 1.85 mts. X 1.68 mts. X 2.4 mts.
- Spacecraft weight: The maximum SAC-C injected mass was 485kg, including 12.5kg of hydrazine.
- Payload weight: 104 kg.

INSTRUMENT DESCRIPTION AND OBJECTIVES

1. MMRS (Multispectral **M**edium **R**esolution **S**canner): this instrument was provided by CONAE to study the terrestrial and coastal marine environment. The MMRS images will be used to study and evaluate desertification processes and their evolution in time. They will also be used to monitor and predict agriculture production, to monitor flooded areas and to study pollution and productivity in coastal and fluvial areas.

The MMRS is a multispectral camera with 5 spectral bands:

B1: 480-500nm Blue-green
B2: 540-560nm Green
B3: 630-690nm Red
B4: 795-835nm NIR
B5: 1550-1700nm SWIR

The MMRS has two operational modes, a normal mode of 175 meters and a low-resolution mode of 350 meters ground pixel size.

Normal mode: allows to transmit data in real time at a bit rate of 3.774 Mbit/sec and/or store for a later transmission of an image of up to 360km x 12000km depending upon the chosen data compression ratio. Given this swath, every point on the planet can be observed every 7 and 9 days with different viewing angles.

Low-resolution mode: allows for transmission in real time at a bit rate of 0.943Mbit/sec. This lower- bit rate transmission rate will be useful to field programs, research institutes, universities and schools because the requirements of ground reception equipment will be minimized.

2. HRTC: (High Resolution Technological Camera): it is provided by CONAE to acquire high resolution panchromatic images over portions of MMRS scenes to aid in data analysis. It has a ground resolution of 35 meters and a spectral response within the range of 400 to 900nm. The HRTC will record images of size 90km x 1150 km in its own mass memory of 96 Mbytes. A couple of mirrors allow the camera to be commanded to select a defined fringe of 90 km. along the MMRS swath.

3. HSC: (High Sensitivity Camera): This camera has been designed with the objective of performing studies of light intensity in urban areas, the presence of electric storms, fires over forest areas, as well as the dynamics and evolution of polar auroras.

The camera swath is 700 km and it will make observations during the night pass of the satellite (approximately 22 hs 30 m). Spatial resolution for this camera is 300 m and the sensitivity is 0.1 saturation with a point source of 2 Kw, equivalent to 78 W/Dn. The HSC can work in real time and has capacity for storing data. It operates between 450 -850 nm.

4. DCS (Data Collection System): it will utilize ground based Data Collection Platforms provided by CONAE. These platforms will be operated by the users and will permit insertion of ground data upon the collected images. The type of data definition depends on the users needs and the specific applications.

5. MMP (Magnetic Mapping Payload), developed by the Danish Space Research Institute and NASA/JPL, to perform observatory quality measurements of the magnetic field. It consists of a vector (CSC) and scalar (SHM) magnetometers. The vector magnetometer is mounted on an optical bench with a non-magnetic star imager camera head to determine vector field directions.
The MMP requires a magnetically clean spacecraft to achieve the required measurement accuracy. The magnetic cleanliness requirement has been set at a maximum of 1 nT spacecraft field at the position of the SHM instrument, at 8 meters from the spacecraft.

Primary objectives:
1-To perform highly accurate and sensitive measurements of the Earth's magnetic field in order to:

- Determine models of the main magnetic fields and its secular variation.
- Study physical properties of the fluid core.
- Study electrical conductivity of the mantle.
- Investigate correlation between the geomagnetic fields and variations in the length of the day.
- Study lithospheric structure and evolution.

2- To study the interaction between the Earth's magnetic field and the solar wind in order to:

- Study the structure and variability of high-altitude fields and currents.
- Investigate relationships between field-aligned and ionospheric currents in the cleft and cusp.
- Determine the external magnetic fields as functions of local time, season, and solar wind conditions.
- Determine ionospheric signatures of localized processes in the outer magnetosphere.
- Study substorm processes.

6. Gps OccuLtation and Passive reflection Experiment (GOLPE): it consists of one TurboRogue III GPS receiver, provided by NASA JPL, attached to four independent high gain antennae respectively pointed in the zenith, nadir, fore and aft velocity directions. The objective of the instrumentation is to record all of the direct, refracted and Earth reflected GPS signals as received by the low earth orbiting SAC-C satellite. The TurboRogue GPS is capable of providing satellite positioning to better than a decimeter and timing to better than 1 nanosecond when post processed using the IGS global reference network. The precise positioning capability can be used to measure the long wavelength component of the Earth's gravity field augmenting other sources of these data.

The high gain fore and aft antennae will receive setting and rising satellites occulted by the Earth’s limb permitting the use of GPS occultation techniques to determine atmospheric temperature and water vapor at a rate of nearly 500 per day uniformly distributed over the globe. The nadir pointing antenna will be used to determine the utility of GPS signals reflected from the Earth’s surface to characterize the elevation and roughness of the Earth's surface for applications such as the determination of oceanic circulation and surface winds.

7. Whale Tracker: it is a joint project between CONAE and the Secretary for the Environment of Argentina to study the migration pattern and behavior of the Eubalanea Australis. The goal of the project is to learn enough of the migration routes to protect this specie from depredation. It consists basically of a data collection system and will be used also to collect data from ground stations to monitor environment and meteorological data. The instrument is composed of the whale based Data Module and the Satellite Module.

8. ICARE (Influence of Space Radiation on Advanced Components), was developed by the French Space Agency, CNES. The objectives of the instrument are to contribute in :

- The improvement of risk estimation models for radiation effects on latest generations of integrated circuit technologies.
- The improvement of environment models for radiation responsible for degradations and breakdowns in electronic components.
- Real time monitoring of environmental conditions in order to be prepared for possible incidents and to dispose of analysis elements if a breakdown occurs.

9. IST

The **IST** (Italian Star Tracker) was developed by Alenia Aerospazio under funding of the Italian Space Agency, as a technological payload to test a fully autonomous system for attitude and orbit determination using a star tracker.

10. INES: The INES experiment is composed of two separate systems: the GPS Tensor receiver and the Lagrange GNSS receiver. These two receivers have completely different objectives. The INES instruments are developed by LABEN under funding by the Italian Space Agency (ASI).

10.1. GPS TENSOR: The GPS Tensor is used by the SAC-C satellite as a primary AOCS sensor providing navigation and attitude solutions. Although this receiver is part of the satellite bus, ASI and LABEN are interested primarily in validating the attitude determination capabilities and accuracy of the receiver. For this purpose, new filtering methods for attitude determination are developed and will be applied on data collected from the SAC-C mission or directly in flight.

10.2. LAGRANGE: a dual frequency (L1, L2) GPS/GLONASS receiver. The main scope of Lagrange is for applications in the fields of Atmospheric Sounding, Geodesy, Ionospheric profiling and Precise Orbit Determination and Real-Time Navigation using combined GPS/GLONASS constellations. The Lagrange receiver that will be provided for the SAC-C mission will have a reduced configuration with only one antenna mounted with a pointing direction between horizon and zenith. Therefore, the main scope of Lagrange on SAC-C will be on one side a technological validation of the instrument and on the other side the execution of a Precise Orbit Determination experiment.

THE AM CONSTELLATION

The Constellation will increase the synergy between observing instruments of the satellites that compose it, provide new Earth Observation capabilities, explore the utility of coordinated synoptic observational capabilities proposed for future satellite systems and compare new observational technologies, such as formation flying.

The four satellites (Landsat 7, EO-1, Terra and SAC-C) will follow the same path over the Earth surface, and they will orbit at an altitude of 705 Km, with an inclination of 98.21 degrees, the Equator crossing time being 10:00, 10:01, 10:15 and 10:30 hs. respectively (UTM, Universal Time).

The satellites will follow the World Wide Reference System, with a repeat cycle of 16 days, which total 233 revolutions.

More than 200 projects using data from SAC-C and the Constellation have been presented for the Announcement of Opportunity.

The cooperative effort in the Constellation included as well:

- A Flight Campaign of the NASA AVIRIS instrument over the Argentine territory during January and February of 2001, for validation and calibration of the different instruments of the satellites that integrate it.
- The installation of three Aeronet stations in the Argentine territory for the measurement of aerosols components in the atmosphere.
- The installation of jointly operated ground GPS reference site at Cordoba to support GPS atmospheric sounding.
- Jointly sponsored technical workshops.