SAOCOM – 1 ARGENTINA L BAND SAR MISSION OVERVIEW

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ABSTRACT/RESUME

The Argentinian Space Agency (CONAE) decided to built and operate a SAR Mission in 1996, as indicated in the National Space Plan 1996-2007, and subsequent revisions.
During the period 1996-1999, several meetings with potential users from different areas (emergencies, agriculture, ecology, forestry, glaciology, geology, oceanography, etc.) have been organized by CONAE, and the users requirements were processed and refined in an iterative process with them.
The driving concept is to build up a SAR Mission mainly devoted to be used in operational applications, with technical specifications useful also for the development of new scientific developments.

The next section will be devoted to explain briefly the main reasons of a SAR Mission, and of the Band selection, based on envisioned applications and environment constraints.
In Section 2 the specific requirements to the instrument will be explained.
Section 3 will describe the requirements on the satellite to be fulfilled in order to get the necessary information.
Section 4 describes the ground segment architecture being developed to be in line with the Mission requirements, and Section 5 describes the present status of the construction of satellite and associated activities in the ground segment.

1. GENERAL SPECIFICATIONS

The basic concept of this satellite Mission is that it must provide information for natural and anthropogenic disasters prevention, assessment and mitigation, and be also useful for economic activities as agriculture, mining, ocean monitoring etc..
There is a third set of activities as important as the ones described, related with Antarctic monitoring, continental glaciers evolution and global change related indicators monitoring, which must also be satisfied.
Based on the above constraints and requirements, it must ba a day/night observation mission, with a high revisit frequency, and almost immune to meteorological conditions. Therefore, the best solution to those simultaneous demands is a SAR mission.
As one of the most common emergencies is the flooding of extense areas, in most cases heavyly forested ones, the most appropriate band for this purpose is the L Band.
As it also must satisfy the agricultural and oceanic demands, as well as scienece ones, it has been decided to implement polarimetric capability as one operation mode.
To cover extense areas and provide a high revisit frequency, for emergencies as well as for oceanic observations, two ScanSAR modes are available, and the possibility of left (default) and right looking capability.
The list of application areas identified in agreement with the users is detailed in the Mission Requirement Document [1].
In order to enhance the area coverage, two regions were defined in the illuminated zone, the first one, is formed by the standard beams, with a high noise equivalent Sigma0 and high values of ambiguity rejection, useful for studies and applications requiring a good absolute calibration, and a second region of extended beams, with less sensitivity, useful for applications not requiring absolute calibration and with high thematic contrasts.
This double approach has been very useful at the time of the detailed analysis of requirements and needs of different users.
At present we still continue working with the users in refining some aspects, and trying to maximize the applications of the mission.

The Table 1 summarizes the instrument specifications for standard beams (Single Pol. or Double Pol.)

Table 1

Frequency (MHz)	1275
Max. Bandwidth (MHz)	50
Transmit Power (Kw)	4.1
Operation modes	Stripmap & ScanSAR
Antenna looking angle	Leftside (default)
NEσ_0	<-25 dB
Cross Pol. Isolation	> 25 dB
Operation time per orbit	15 minutes
Digitization	8 bits
Strimap resolution	10 meters x 10 meters
ScanSAR resolution	100 meters x 100 meters
Swath width in stripmap	>65 km (each beam)
Swath in ScanSAR wide	>320 km
Transmission	HH or VV

Reception (Single Pol)	HH or VV
Reception (Double Pol.)	HH & HV or VV&VH

Both in Single and Dual polarization modes, the transmitter is set to one polarization (Horizontal or Vertical), and remains so during the acquisition time of a frame (minimum 30 seconds), while the two reception channels are activated in different polarizations (Double), or only one receiver is active in copolar reception (Single mode).
The looking direction can be shifted to right-looking for acquisition of data during a maximum of 5 minutes in one orbit. The manoeuvre takes several minutes, so it cannot be made more than once per orbit. As in that condition the solar power collection is diminished, and probably there is no ground station in visibility of the satellite data downloading antenna, the acquisition in that position will be stored onboard to be downloaded in a future pass over a ground station.

The Table 2 summarizes the instrument specifications for standard beams (Quadpol.)

Table 2

Frequency (MHz)	1275
Max. Bandwidth (MHz)	50
Transmit Power (Kw)	4.1
Operation modes	Stripmap
Antenna looking angle	Leftside (default)
NEσ_0	<-25 dB
Cross Pol. Isolation	> 25 dB
Operation time per orbit	5 minutes
Digitization	8 bits
Strimap resolution	10 meters x 10 meters
Swath width in stripmap	>30 km (each beam)
Available illumination range	> 170 km
Transmission (QuadPol)	Alternating HH and VV
Reception (QuadPol)	HH&HV and VV&VH
Mission lifetime	5 years

In Quadrupole mode (Quadpol), the transmitter power is directed to the Vertical antenna in one pulse, and to the horizontal antenna in the following pulse, continuing this alternate polarization transmission during all the acquisition time.

Simultaneously, both receiver channels are activated, receiving co and cross-pol signal simultaneously.
As each polarization must transmit at an adequate PRF, dictated by the antenna size and nadir echo blocking, the effective PRF of the instrument becomes duplicate, with a duplication of power consumption and halved reception times. This impacts in the time available for echo reception, reducing the available swath width to less than half as compared with single or double pol. Operation.

Even resulting in a very narrow swath for many applications, is of great value for many other applications involving the analysis of polarization rotation depending on the type and topology of the scattering region.

2. SPECIFIC INSTUMENT REQUIREMENTS

As mentioned in the previous section, there are two viewpoints in the instrument specifications, depending on the users needs.

One of them requires high quality radiometric and geometric accuracy (eg. natural resources identification, interferometry, glaciology) and the other needs high revisit frequency for monitoring of a specific operational requirement (eg. Floods , fires, ocean characteristics, ice on sea), perhaps without the extremely high accuracy in the radiometric information needed in the other set of applications.

The satisfaction of both sets of requirements simultaneously, and with the highest set of information quality and resolution specifications implies a dense constellation of instruments, far beyond our possibilities. The adopted decision has been twofold. First to use two identical satellites, looking left or right, depending on requirement, and with a scanning in range high enough to reduce the revisit time to nearly two days at the equator in Single and Double modes. The wide area coverage conspires against the high data quality requirement, then that area is divided in two subareas, with different requirements in ambiguities and NES$_o$ specifications. This approach gives us an expanded capability in revisit frequency, but not enough for a daily monitoring capability of emergencies. The second one is an agreement with the Italian Space Agency (ASI), which is planning the COSMO SkyMED constellation of four X Band SAR satellites, to share information in an operational agreement.

The agreement has been signed in 2000, and since then we are working together to get the maximum from such mixed system. This way, the revisit time reduces to 12 hours, and the monitoring of emergencies is fully covered, and simultaneously both agencies will have two band SAR information, to generate merged X and L band products. In the last four years, we have been working with ASI as a Joint Team, to assess the feasibility of such system, and the set of instruments, satellites and ground segment common requirements for this to be successful [2] and [3].

In our last revisions, which are taking place now, a considerable improvement of the joint system has emerged, with the definition of common observation areas, with similar geometry, for polarimetric, bi-band products[4].

The system so defined is named SIASGE (Sistema Italo Argentino para la Gestion de Emergencias), and is in its final stage of detailed definition.

Under this last configuration, both SAOCOM satellites will cover incidence angles from 20 to 57 degrees, corresponding to an access width of 600 km for the single and double polarization, and a reduced width of 170 km in quadpol modes. In all cases looking left as default, with the option of right looking whenever necessary.

Table 3 shows the set of possible sensing capabilities for Single polarization and Double polarization modes.

Table 3

Stripmap High Resolution	Pixel size < 10m x 10m
Stripmap Mid Resolution	Pixel size > 25m x 25m
ScanSAR Narrow	Pixel sixe 50m x 50m
ScanSAR Wide	Pixel size 100m x 100m
Stripmap High Resolution	Range swath > 60 km
Stripmap Mid Resolution	Range swath > 60 km
ScanSAR Narrow	Range swath > 170 km
ScanSAR Wide	Range swath > 320 km

Table 4 shows the set of possible sensing capabilities for Quadpol polarization modes.

Table 4

Stripmap High Resolution	Pixel size < 10m x 10m
Stripmap High Resolution	Range swath > 30 km
Number of possible beams	6 Beams

3. SATELLITE REQUIREMENTS

As indicated in the previous section, the types and interests of users is broad and diverse. In some cases users are not interested in high absolute calibrated products, but fast availability of the information and useful for the evaluation of a specific type of information as roughness and specific pattern in highly variable environment surface (ocean applications) , in the widest available area and as frequently as possible.
In the other end, the interferometric applications require a very precise orbit control and stability with the lowest possible ambiguity figure.
As this pair of cases, there are several pairs of competing requirements.
The decision has been to adopt the most demanding requirement as baseline for the system design.

Table 5 describes the orbital and satellite control requirements adopted.

Table 5

Orbit type	Polar, Sun-synchronous
Local time Desc. Node	06:00 PM
Repeat cycle	16 days
Coverage	Global in all modes
Orbit Control	Within 25% of baseline
Orbit error determination	< 1 m (GPS) position
Orbit error determination	<1m/s in velocity
Attitude determination	InSAR requirements
Yaw steering capability	+/- 3.5 deg /orbit
Geolocation error	On line: < 7 pixels
Pointing accuracy (3 axes)	< 0.01 degree

Table 5 indicates the satellite control in real time.
Off line, by orbit restitution and telemetry data processing the position and attitude information precision is increased in one order of magnitude.
The data downlink will be channel of 320 Mhz, (two adjacent subcarriers 110 Mhz bandwidth each), in X band, in the frequency slot assigned by ITU for this purpose.
The telemetry, Tele-command and Control (TT&C) channel will be at S Band, as also assigned by international regulations.

4. GROUND SEGMENT

The ground segment, includes all the activities from spacecraft control to product generation and distribution.
The spacecraft control will be done in the Cordoba ground station, as it is being done for SAC-C, and also the Mission Operation Centre will be at the ground station.
The engineering model of the spacecraft and instruments will be on line to perform all tests and commands tests, previous to sending them to spacecraft.

The Data Acquisition Centre, will download the data, pre-process and process the SAR data locally, archive it and distribute to users.
The cataloguing is connected on line with the processing and archiving facility, in order to transfer to the web the information on available information and images almost in real time.
The Mission Operation Centre will have a system and instrument simulator, to perform the following tasks:
Satellite operation planning
Instruments operation planning
Satellite troubleshooting capability
Instrument troubleshooting capability
Generate simulated raw data for satellite and instrument specific conditions.
Process the simulated raw data to detect and fix contingencies.
Instrument and products calibration will be performed at the Mission Operation Centre by means of onboard calibration information as well as sensing over specific calibration areas (deployed corner reflectors, transponders and extended uniform backscatter areas).

5. MISSION STATUS

The present status of the Mission is as follows.
The satellite and the services are all defined and under construction.
The SAR antenna is in its engineering model construction stage, checking the quality and repeatability of antenna units (eight antennas in a single block), and the qualification of tiling process of antenna units.
SAR electronics is in its prototype stage, and engineering units are being tested.
SAR simulation operation and SAR processing software is already built and being tested with a set of prototype operation modes, and will be finished once the final flight configuration be accepted. This task is being done in cooperation with the Centre Spatial de Liege (Belgium), cooperation which includes a SAR Processor and Polarimetric and Interferometric tools.

All the details on applications and project status can be found in the CONAE web page (www.conae.gov.ar) .

6. REFERENCES

1. Giraldez, A. E. *SAOCOM Mission Requirements* CONAE Doc. SOG-SRM-RQ-00100-A. Rev 2003.

2. ASI / CONAE , *ASI-CONAE EO Joint Applications and Products Identification* , June 2003.

3. ASI / CONAE , *SIASGE Mission Requirements,* Doc. RQS /SIA/ 008 /ASI-CONAE

4. ASI / CONAE , *SIASGE System Requirements*, Doc. RQS /SIA/ 0009 /ASI-CONAE.