A SMALL GLANCE TO EARTH FROM SPACE

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ABSTRACT

In 1997 the Italian Space Agency (ASI) started the Science Small Missions (PMS, *Piccole Missioni Scientifiche*) program, fulfilling an explicit recommendation included in the Italian National Space Plan. On a competitive basis, at the end of 1998, ASI selected two missions for the first cycle of the program: AGILE, a light gamma-ray telescope, and DAVID, carrying two experiments for signal propagation at high frequencies. The program foresees a launch every two/three years, making use of the two Italian small standard platforms MITA and PRIMA. ASI decided to issue, on February 2000, a new “Call for Ideas” dedicated to Earth Science. Eighteen proposals were submitted to ASI, covering different topics. On October 2000 six proposals have been chosen for a phase A study. At the end of 2001 the third PMS mission will be selected. This paper will present the PMS program, the MITA platform, and will discuss scientific details of the proposals that are carrying on the phase A assessment.

1. PROGRAM GUIDELINES

The current Italian National Space Plan (1998-2002) strongly encourages the Agency to invest on the growing technological know-how of big and small national industries to attain scientific targets of opportunity needing quick response [1]. The ASI Science Small Missions (PMS, *Piccole Missioni Scientifiche*) program, inspired by the well known “Cheaper, Faster and Better” philosophy, was created for this purpose [2].

The objective of the program is to allow easier access to space for new scientific experiments proposed by the Italian community focusing on astrophysics, fundamental physics, Earth science and engineering sciences. Even if the missions’ objective will cover a broad spectra of areas, the ASI PMS program will not be a mere sequence of prototypic satellites with no links between each other’s. In fact the spacecraft configuration, the ground segment and the overall management structure will be similar, in order to have low recurrent costs, well tested technology and quick development [3].

In this context, Italian space industries are developing, under ASI contracts, multi-use satellite platforms of small dimensions, PRIMA (by Alenia Aerospazio) and MITA (by Carlo Gavazzi Space), optimized to target mission, but carrying standard multi-purpose subsystems and components.

ASI released the first “Call for proposal” on May 1997. The description of the missions proposed by scientific community had to indicate scientific objectives but also instruments design, mission and system requirements, time schedule and costs [4]. The general parameter specified in the first “Call for ideas”, and in particular maximum mass,
power and telemetry rate per spacecraft and payload, were indicative and strictly connected to the requirements of platforms PRIMA and MITA that ASI intend to use for the PMS program [5,6].

From over 60 proposals received, ASI selected and funded 8 missions for further studies (phase A) with payloads that covered widely different areas: high-energy astrophysics, general relativity, geodesy, studies on atmosphere and engineering sciences. At the end of phase A, ASI selected two missions for the first cycle of the program: AGILE, a light gamma-ray (and X-ray) telescope [7], and DAVID, carrying experiments for signal propagation at very high (90 GHz) frequencies [8]. To date they are both under development.

On February 2000, ASI started the second cycle of the PMS program, releasing a new "Call for Ideas" dedicated to Earth Science in order to guarantee a turn over among different scientific areas and to encourage a growing up community. Main constrains had to be the use of MITA platform, a lifetime of two years with launch foreseen in 2006, and a total budget of about 35 M_ [9]. ASI received eighteen proposals in the field of atmospheric physics, geodesy, Earth observation, Earth gravity field, study of magnetosphere and ionosphere, earthquake investigations, climate and meteorology. Among those, six missions were selected for a competitive phase A. At the end of 2001 the third mission of PMS program will be chosen.

2. THE MITA PLATFORM

MITA (Italian Advanced Technology Minisatellite) is a standard, low cost bus, developed to support a wide range of applications for small scientific missions in LEO orbit [6]. The first MITA bus was developed on behalf of ASI by Carlo Gavazzi Space S.p.A. and it was launched on July 15th 2000 by a Cosmos launcher from Plesetsk (Russia) [10]. The spacecraft bus is able to support many different payloads: two way communications, Earth observation, remote sensing, radiolocalization, astronomy, scientific research, microgravity science. This is achieved by a modular design in all the main satellite subsystems: data handling, electrical power, attitude control, mechanical structure. The configuration of the satellite main body is based on a cubic-shaped module, 100 [kg] range, 3 axis stabilized.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>1800 x 1400 x 700 mm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>169.9 kg</td>
</tr>
<tr>
<td>Average power</td>
<td>85 W</td>
</tr>
<tr>
<td>Peak power</td>
<td>120 W</td>
</tr>
<tr>
<td>Attitude control type</td>
<td>3 axis stabilized, Earth pointing</td>
</tr>
<tr>
<td>Attitude accuracy</td>
<td>±1 Deg each axis</td>
</tr>
<tr>
<td>Communications</td>
<td>S-band</td>
</tr>
<tr>
<td>Telemetry</td>
<td>512 Kbps, ESA CCSDS</td>
</tr>
<tr>
<td>Telecommand</td>
<td>4 Kbps, ESA CCSDS</td>
</tr>
<tr>
<td>Mass Memory</td>
<td>64 Mbytes</td>
</tr>
</tbody>
</table>

Table 1 - MITA key features
The satellite platform is based on two fully redundant chains of On Board Data Handling and Telemetry & Telecommand subsystems. The other electrical subsystems are partially redundant, in order to optimize the cost/benefit ratio. The redundancy concept ensures the functionality of the mission even after a failure.

The key features of the MITA satellite configured for the first mission are summarized in Table 1.

3. THE EARTH SCIENCE MISSIONS

The six missions, selected for a competitive phase A study, deal with innovative and challenging scopes. The objectives range from global change detection to earthquake investigations, from bistatic SAR experiment to precipitation measurements, until to sea state detection. The missions selected are briefly summarized as follows.

3.1 BISSAT

A bistatic radar is a system that operates with separated transmitting and receiving antennae. Several scientific activities and new applications are foreseen using bistatic SAR (Synthetic Aperture Radar) data as further input, for example: evaluation of bistatic RCS (radar cross section) of natural and man-made targets, by means of multi-angle bistatic SAR observations; improvement of image classification and pattern recognition procedures; acquisition of velocity measurements thanks to the simultaneous measurement of two Doppler frequencies; high-resolution measurements of components of sea wave spectra.

The BISSAT mission should deal with a bistatic SAR experiment based on a small satellite flying in formation with an already existing main mission (e.g. ENVISAT or COSMO-SkyMed) and equipped with a receiving-only microwave system, with catches the echoes of the main monostatic SAR [11].

3.2 ESPERIA

Seismicity is one of the most important dynamic phenomenon that occurs in the lithosphere. The analysis of these processes is a fundamental step to study forecast and seismical prevention and to foster our knowledge of earthquake physics.

The aim of the ESPERIA proposal is the development of methods and instruments for short-term earthquake prediction by the investigation of lithosphere-atmosphere-ionosphere coupling [12]. The proposal implies the study of perturbations in the atmosphere and ionosphere caused by electromagnetic (EM) waves generated at the preparation earthquake hypocenters. The study includes satellite observations concerning charged particle fluxes, ULF, ELF, VLF, HF, EM waves and ionospheric plasma parameters. The payload consists of four instruments: a Particle Detector Analyzer, a Langmuir Probe and Retarding Potential Analyzer, an Electric and magnetic analyser, and a Global Positioning System (GPS).
3.3 FOURIER

Is the climate of Earth really changing? Science has raised this question related to global warming, and it has reached the political agenda but, up to date, data for making informed decision about the future are not yet available. A way to increase confidence in the predictive capabilities of a climate model is to compare relevant aspects of model behavior, systematically and objectively, with observed data. Appropriate observing systems must be relevant, global, precise, and calibrated against absolute standard.

In this context, the mission Fourier proposes two well-established observing systems, particularly suitable for testing climate projections: a well calibrated interferometric measurements of radiances at a spectral resolution of 1 cm$^{-1}$, in the 1.2-45 micron interval, and radio refraktivites obtained by observing occultation of signals from the Global Position System (GPS) satellites [13].

3.4 IGPM

A major issue we should face in the next decades is water scarcity. Growing demand corresponding to unknown climate changes, that will probably influence precipitation system, will enlarge this problem.

For the above reasons it is important to understand how precipitation systems are influenced by atmospheric and superficial climatologic variables and vice versa, how precipitation processes could influence climate. In this context, following the successful Tropical Rainfall Measurements Mission (TRMM) experience, NASA and NASDA have recently started the Global Precipitation Mission (GPM). The GPM consists in a main satellite, like an updated TRMM, equipped with microwave imager and precipitation radar, and a constellation of six-eight small satellites, called drones. Every drone will carry a microwave radiometric system with three different channels.

The mission IGPM proposes the Italian contribution to the GPM with the realization of one of the small satellites [14].

3.5 REFIR

The far infrared (FIR) outgoing thermal radiation, due to the emission by mid and upper tropospheric water vapour and clouds, represents a substantial fraction of the total planetary emission to space and its importance in the climate system has been recognised as crucial.

The REFIR mission [15] proposes to measure the spectral radiance in the FIR (100-1100 cm$^{-1}$) and will try to address several important issues in field of climate and global change, and of meteorology as well, including: the role of the FIR part of the planetary emission spectrum, which gives an important contribution to the cooling of the atmosphere; the role of water vapour and clouds in modulating the planetary emission to space; the quality of our knowledge regarding the absorption properties of water vapour.
The payload consists of four instruments: a REFIR Fourier Spectrometer, a REFIR Embedded Imager, a REFIR Total Energy Radiometer, a REFIR Add-on Imager.

3.6 VISIR

The VISIR proposal deals with the monitoring of the sea and the coastal water, vegetation and atmospheric variables, using a multi spectral sensor characterized by a reasonable spatial resolution and very high spectral sensitivity.

Several scientific activities are foreseen using VISIR data as for example: color sea measurements in coastal waters, regional scale estimate of bio-geochemistry fluxes, study of energy fluxes and hydrological cycle, aerosol measurements and algorithm definition for atmospheric correction [16]. The payload consists in a visible imaging spectrometer designed for coastal water monitoring with a thermal imager with two spectral channels to retrieve surface temperature and a near infrared imager for cloud and ice discrimination.

4. CONCLUSIONS

The ASI PMS program is now entering in its crucial phase, with the first two satellites being under construction and the selection of the next mission in progress.

The most relevant results achieved in these four years from the kick-off of the program are: the surprising response form the national community, turned out in more than 80 ideas of small missions, covering a wide range of the scientific spectrum; the capability, shown by the Agency, to manage such a serious task of comparing and selecting very different topics; the availability of the national space companies to deal with a new approach, at least for Italy, to space missions, framed in a scenario which foresees a leading role of ASI at system level, a deeper involvement of scientists in the definition not only of the science, but of the mission itself, and a consequent greater flexibility from the industrial side to fulfill the new requirements.

5. REFERENCES

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