NanosatC-BR – Space Weather Mission

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Abstract

The NanosatC-BR – Space Weather Mission consists of a INPE-UFSM Capacity Building Integrated Program on space science, engineering and computing sciences for the development of space technologies through a CubeSat satellite, the first Brazilian Scientific Nanosatellite.

The Capacity Building Program was conceived at the Southern Regional Space Research Center, (CRS), from the Brazilian National Institute for Space Research – INPE/MCT, by Dr. Nelson Jorge Schuch, who is the Mission's General Manager and PI, having technical collaboration and management from Dr. Eng. Otávio Santos Cupertino Durão, the Mission's local Manager at INPE's Headquarter (HQ), in São José dos Campos, São Paulo, with the involvement of undergraduate students from the Federal University of Santa Maria – UFSM.

The NanosatC-BR was specified to monitor in real time the Geospace, the particle precipitation and the disturbances observed at Earth's magnetosphere over the Brazilian Territory, for the determination of their effects on regions such as the South Atlantic Magnetic Anomaly (SAMA) and the Brazilian sector of the Ionosphere Equatorial Electrojet.

Introduction

The nanosatellite NanosatC-BR – Space Weather Mission will be the first Brazilian CubeSat developed with the involvement of university undergraduate students in Brazil. It is a scientific and technological cooperation basically between the Southern Regional Space Research Center, (CRS), from the Brazilian National Institute for Space Research – INPE/MCT with the Santa Maria Space Science Laboratory – LACESM/CT-UFSM and other departments from the Federal University of Santa Maria - UFSM, in Santa Maria, Rio Grande do Sul, South of Brazil, with technical, financial support, and collaboration from other Brazilian and International private and governmental Institutions.

The development of technologies, scientific instrumentation, manufacturing, qualification, launch of the satellite, study of collected data and post analyzes of the NanosatC-BR mission objective accomplishment will provide the Brazilian institutions with technical and scientific base for the development and manufacturing of that class of satellites and associated sensors. The general management and the PI supervision are located at the CRS and the project technical supervision for the mission and payload specification, subsystems design and analysis, ground operations, sensors specification and acquisition, are provided by engineers and scientists from INPE's Headquarter (HQ), in São José dos Campos, São Paulo, Brazil and from the UFSM and the CRS. The UFSM also participates with its undergraduate students (Scientific & Technologic Initiation Students) and faculty members as well.

The major payload consists of a magnetometer to measure the intensity of the Earth Magnetic Field at the South Atlantic Magnetic Anomaly (SAMA) and on the Brazilian sector of the Ionosphere Equatorial Electrojet and a particle precipitation chip dosimeter. Subsystems such as structure, thermal control, power supply, software for data handling and electronic control, onboard computer, TT&C, are under development by INPE's and UFSM's staff with the participation of undergraduate students. Ground operation at the CRS will have the technical supervision from INPE's HQ Satellite Tracking Center.

CubeSats

A CubeSat is a type of miniaturized satellite classified as nanosatellite having a 10x10x10cm cubic format, a volume of one liter and weighting no more than one kilogram (Figure 1).

Beginning in 1999, the California Polytechnic State University (CalPoly) and the Stanford University developed CubeSat specifications to help universities worldwide to perform space science and exploration by using that class of satllites.

The CalPoly published the CubeSat standard in an effort led by aerospace engineering Professor Jordi Puig-Suari, David (2004). In this line of effort Bob Twiggs, from the Department of Aeronautics & Astronautics at Stanford University, has contributed to the CubeSat community with his work focused on CubeSats for educational institutions. In the same scenario of efforts Prof. Bob Twiggs proposed actions to support hands-on university-level space education and opportunities for low-cost space access David (2006). CubeSat has been understood by several researchers as a good new opportunity to investigate the space close to the Earth in specific mission, mainly as a cluster of satellites.

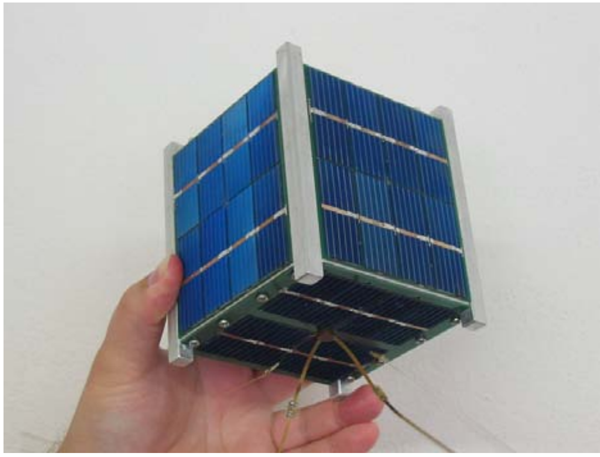

Figure 1: The CubeSat czCube. (http://www.czcube.cz/en/index.html, access on March 26, 2009)

Compared to traditional multi-million-dollars satellite missions, CubeSat projects have the potential to contribute for the participant education in addition of being a reasonable option for the successful implementation of useful space missions in the field of science and industry at much lower costs.

The relatively small size of the CubeSats could each be made with very low costs. The INPE–UFSM CubeSat Program, for the NANOSATC-BR Space Weather Mission, is planed to be made starting with two CubeSats basses and tracking station hardware with an estimated cost for INPE of about US$ 103,000.00. The launch cost is estimated for UFSM to be around US$ 95,000.00. Therefore, the total estimated cost for this Brazilian CubeSat Mission is around US$ 200,000.00 dollars (or about R$ 454.000,00 Reais (**)) which is in did very cheap for its benefits. These prices tag, far lower than most satellite launches, has made CubeSat a feasible option even for Brazilians institutes and universities and others across the world. Because of this, a large number of universities and some companies and government organizations around the world are developing CubeSats — more than 113 in August 2008, Cal Poly reported (Figure 2).

CubeSat payloads and experiments are often new and unique, and project timelines are typically 9-24 months from inception to launch. CubeSat missions still require considerable planning and many man-hours of work to maximize the chances for success. Since launch opportunities are scheduled well in advance, it is critically important that a CubeSat project adhere to its schedules and stay on time and under budget.

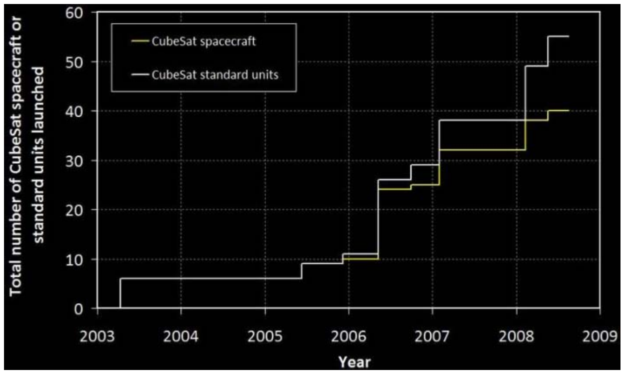

Figure 2: Growth in CubeSat launches since 2003. (http://www.clyde-space.com/resources/introduction_cubesats, access on March 26, 2009)

Scientific Payload

The NanosatC-BR payload consists of a particle precipitation chip dosimeter, which is been specified and a low power three-axis magnetometer, the Mag566, produced by Bartington, shown in Figure 3.

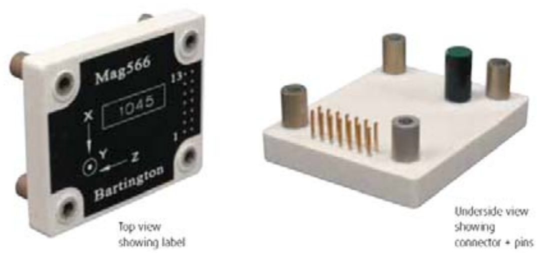

Figure 3: Mag566 Bartington. (http://www.bartington.com/products/Mag566threeaxislowpowermagnetometer.cfm, access on March 23, 2009)

The Mag566 magnetometer the following technical parameters: full-scale range of ±100µT; operates from a ±5V supply; provides three analog outputs of 0 to ±4.5V with a bandwidth of 0 to 35Hz; has a 20mW power consumption and low self-noise.

The main objective of the Mag566 magnetometer is to measure the total intensity of Earth Magnetic Field at the South Atlantic Magnetic Anomaly (SAMA), see Figure 4, and the Brazilian sector Ionosphere Equatorial Electrojet. It is expected to collect data from the magnetometer to search for the variability of the geomagnetic conditions at Earth's surface and low Earth orbit over the Brazilian Territory through monitoring and measuring the Earth Magnetic Field.

The effect of the South Atlantic Magnetic Anomaly is of great significance for satellites and other spacecraft that orbit the Earth at altitudes of several hundred of kilometers. Those orbits take satellites through the Anomaly periodically, exposing them to several minutes of strong radiation each time. When it occurs the communication of the satellite with Earth is affected by interference or loss of signal and all electronic systems can be exposed to damage.

Most of the events associated with mal functioning or damage occur over the SAMA, affecting mostly the Polar Orbit satellites.

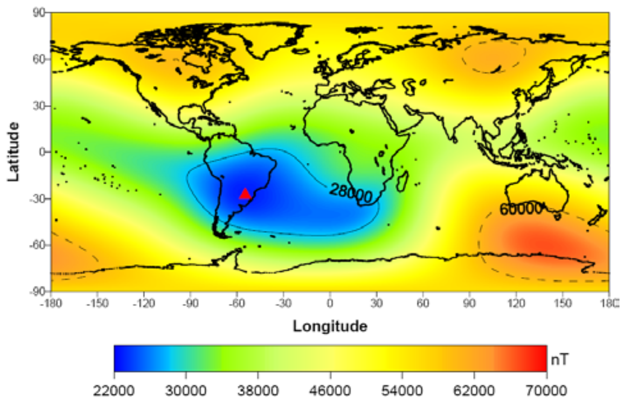

Figure 4: Magnetic Field from year 2000. 28000nT shows the region of SAMA. Heirtzler (2002).

The MODIS, NASA's premier remote sending instrument, was made inoperative on June 15, 2001. See Figure 5 for illustration (red star spot). The smaller yellow dots show the regions where the TOPEX had problems during the years 1992-1998. The field strength is a minimum over the South Atlantic Magnetic Anomaly. It was possible to get MODIS back in operation only after 16 days.

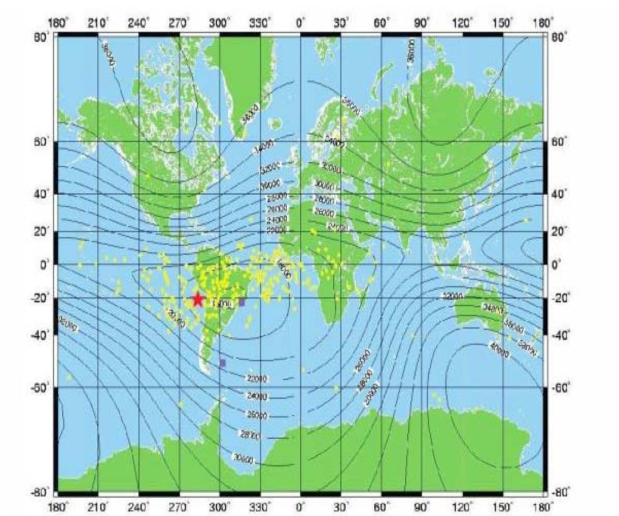

Figure 5: Near Earth spacecrafts problems over the South Atlantic Magnetic Anomaly.
(http://core2.gsfc.nasa.gov/terr_mag/saa.html, access on March 23, 2009)

The South Atlantic Magnetic Anomaly is the region where Earth's inner Van Allen radiation belt makes its closest approach to the planet's surface (Figure 6). Thus, for a given altitude, the radiation intensity is greater within this region than elsewhere. The Van Allen radiation belts are symmetric with the Earth's magnetic axis, which is tilted with respect to the Earth's rotational axis by an angle of 11 degrees. Additionally, the magnetic axis is offset from the rotational axis by 450 kilometers. Because of the tilt and offset, the inner Van Allen's belt is closest to the Earth's surface over the South Atlantic Ocean and farthest from the Earth's surface over the North Pacific Ocean. (Stassinopoulos; Staffer (2007)).

Therefore, due to these phenomena, it is necessary to develop integrated programs for research and monitoring in order to determine the dynamic and more accurate forecasting of the radiation environment over the southern Brazilian Territory.

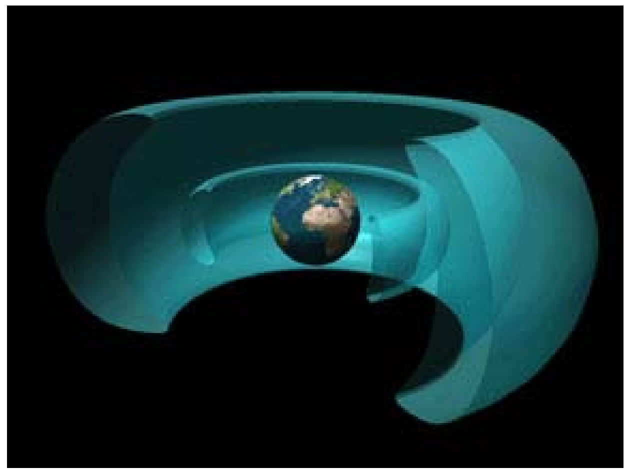

Figure 6: Representation of Van Allen radiation belt. (http://www.windows.ucar.edu/tour/link=/glossary/radiation_belts.html&edu=mid&back=/search/search_navigation.html, access on March 23, 2009)

The study of the dynamics of radiation and its correlation with the Terrestrial Magnetosphere will undoubtedly contribute to satellite project decision making and the spacecraft protection optimization against the radiation phenomena, promoting the increase of satellite lifetime.

Human Resources

Another major objective of the Mission NanosatC-BR is the Human Resource Capacity Building through the training of undergraduate students in their respective areas, mainly Engineering, Computer Sciences and Physics from the UFSM. It is the student's task to participate in the development of the project including the search for and adaptation of equipments of various systems and subsystems on the platform and payload of the satellite. Therefore it is necessary to get background information about all contexts involving Space Technologies, engineering tools for project and Systems to develop Space missions. Students should also get involved with activities of research in the areas of Space Science, mainly those students responsible for the mission scientific objective and the nanosat Payload.

The students are organized into two teams: a technical team to participate of the satellite design at subsystem level, and scientific one, to participate of the scientific aspects of the payload database definition, architecture and of the general objectives definition and formulation.

It is expected that the NanosatC-BR Mission contributes to aggregate technology and science capability into the institutions involved in the nanosat project, improving their capability in technological and scientific areas such as Engineering, Space Technology and development of scientific space Instrumentation. Additionally, it is also expected an increase on the scientific research area related to the space weather phenomenology in general, and on global aspects of space region over Brazil.

Conclusions

The development of the Brazilian NanosatC-BR is feasible and will be the first Cubesat of the Country involving human capacity building of undergraduate students in a real space project. The nanosat launching is planned for the second half of 2010. However the mission depends on the success of the Brazilian bureaucracy bidding processes, which is complex and may delay the Mission schedule. The mission will contribute to a better understanding of the Earth's magnetosphere processes and phenomena such as the Southern Atlantic Magnetic Anomaly – SAMA – and the Ionospheric Equatorial Electrojet.

Acknowledgments

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(**) Euro – Dollar - Reais reference values on March 22nd , 2009: 1 Euro = 1.355 US Dollar, 1 US Dollar = 2.264 Brazilian Reais.