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A PROPOSAL FOR ITASAT SATELLITE CONFIGURATION AND ITS PRELIMINARY MISSION ANALYSIS

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Abstract. *This paper describes a proposal for ITASAT university satellite configuration to meet its mission requirements related to Brazilian Environmental Data Collection System continuity and to present the preliminary mission analysis results. The proposed satellite configuration is based on its launch restriction as a secondary payload. The preliminary mission analysis considers some simplified scenarios related to orbit selection, attitude control, data collection platforms and receiving ground stations locations, as well as satellite antenna radiation patterns. The mission analysis was performed using integrated simulation tools. As a main conclusion, the simulation results show that the proposed satellite configuration can meet its mission requirements related to its main payload and to other experimental payloads.*

Keywords*: ITASAT satellite, university satellite, mission analysis, dual spin stabilization, environmental data collection system*

1. INTRODUCTION

The ITASAT system is an effort to develop a university satellite within the scope of the Small Technological Satellite Development Program, funded by Brazilian Space Agency (AEB) with technical coordination of INPE and academic coordination of ITA. Other participating universities on the development of ITASAT university satellite are: EESC-USP, UFRN, UEL, UnB and UNICAMP.

The Small Technological Satellite Development Program main objectives are to improve, develop and validate space technologies as well as to prepare and qualify human resources for the National Program of Space Activities.

ITASAT is a technological satellite with an operational payload for the continuity of the Brazilian Environmental Data Collection System. It will carry some selected experiments such as a Digital Data Collection Transponder with on-board processing and data storage, a novel experimental computer for evaluation, a GPS receiver for orbit estimation, attitude determination using Micro Electro Mechanical System (MEMS) devices, and a setup for evaluating radiation effects. Thermal and Structural experiments are also being considered.

This paper describes a proposal for ITASAT configuration to overcome budget restrictions with respect to contract a dedicated launch, and benefit of a possible launch as a secondary payload - usually made available for polar orbit missions. The proposed configuration could also operate in a low inclination orbit, with some restrictions with regard to the launcher capabilities and procedures in early orbit phases.

The mission overview is described in section 2. Section 3 describes the proposed satellite configuration. Section 4 presents the scenarios and conditions used during the simulation with STK tools. Section 5 presents the preliminary mission analysis considering orbit selection, attitude control, antenna location on the satellite and its radiation patterns, tracking, telemetry and commanding functions, data collection service performance, and preliminary results related to the experimental payloads. Section 6 describes the main results and conclusions.

2. ITASAT MISSION OVERVIEW

The ITASAT Mission comprises the development, launch and operation of a small university technological satellite for use in a Low Earth Orbit (LEO). The satellite shall be capable of providing data collection services as offered by the Brazilian Environmental Data Collection System, besides offering a mean to test in orbit several experimental payloads (Yamaguti *et al.*, 2009a).

The Brazilian Environmental Data Collection System space segment currently operates with the SCD-1, SCD-2 and CBERS-2B satellites, and its main goal is to automate the environmental data acquisition by means of several Data Collection Platforms (DCPs) on the ground that acquire, process, and transmit messages in burst mode to those satellites within a repetition period from 40 to 220 seconds. The DCS transponder operates as a bent pipe transponder: the DCP can only communicate with a Receiving Ground Station only when one of the satellites passes over the mutual visibility of that DCP and the Receiving Ground Station. After the pass is over, all the received messages are sent by the latter ground station to the Data Collection Mission Center (CMCD) at Cachoeira Paulista – SP for further processing, data base management and data dissemination to users (Yamaguti *et al.*, 2006).

Today more than 700 DCPs are installed over Brazilian territory, covering applications for hydrology, meteorology, water quality, oceanography studies and many others. Potential applications such as fishing vessel monitoring and animal tracking are very important not only in terms of commercial revenues, but also strategic in terms of environmental monitoring and wild life studies. More than 100 users' organizations are registered to receive the data collected from the installed platform networks (Yamaguti *et al.*, 2009b). Figure 1 depicts the ITASAT System related to the Data Collection System (DCS) composed by the ITASAT satellite (space segment) and the Data Collection ground segment.

As described in the previous section, the experimental payloads planned for ITASAT Mission are: a) an experimental Digital DCS Subsystem consisting of a new Data Collection Payload with on-board message processing and storage capabilities; b) an experimental Computer for in-flight evaluating the computing hardware and data-compressing algorithms; c) a GPS Experiment for orbit determination; d) an attitude determination experiment using MEMS devices, and e) radiation-hard setup experiments. Thermal and Structural experiments can also be included.

3. ITASAT SATELLITE CONFIGURATION

To meet the launching capability of any sort of launcher, any satellite orbit, while maintaining a data collection service performance similar to those of SCD-1, SCD-2 and CBERS satellites, a spin-stabilized configuration similar to that of SCD-2 was initially selected for ITASAT. However, a trade-off resulted between operation performance and robustness to such a wide range of launcher capabilities and orbits. The proposed satellite configuration in this paper started with the objective of defining ITASAT's orbit and its launch strategy. The following restrictions are considered:

a) Launching as a secondary payload, which imposes mass and size restrictions;
b) Launch opportunities as a secondary payload in polar orbit missions;
c) A solar panel area to supply about 100W, using triple junction solar cells;
d) Satellite size to accommodate the satellite subsystems (service subsystems and payloads);
e) Use of a momentum wheel to stabilize the satellite attitude (dual-spin stabilization);
f) Performance of the data collection services compatible with the Brazilian Environmental Data Collection System;
g) Evaluation of the experimental payloads should be feasible.

Figure 2 shows the proposed configuration. The satellite shall support the following functions: a) operational data collection services and technological data acquisition for the experiments; b) payload monitoring and control during in-flight acceptance and routine phases; c) management of payload data related to its processing, dating, data packets generation, on-board recording, and data transmission to the ground stations.

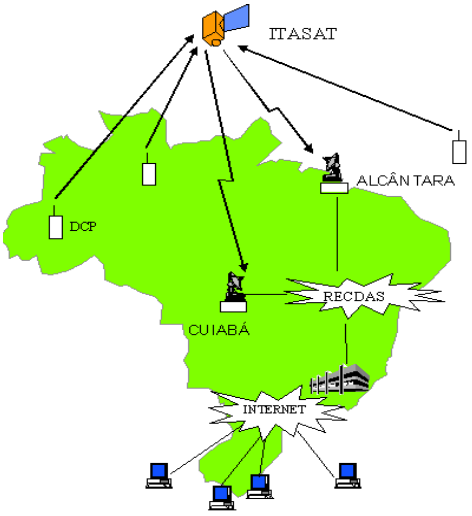

Figure 1. ITASAT System related to data collection services

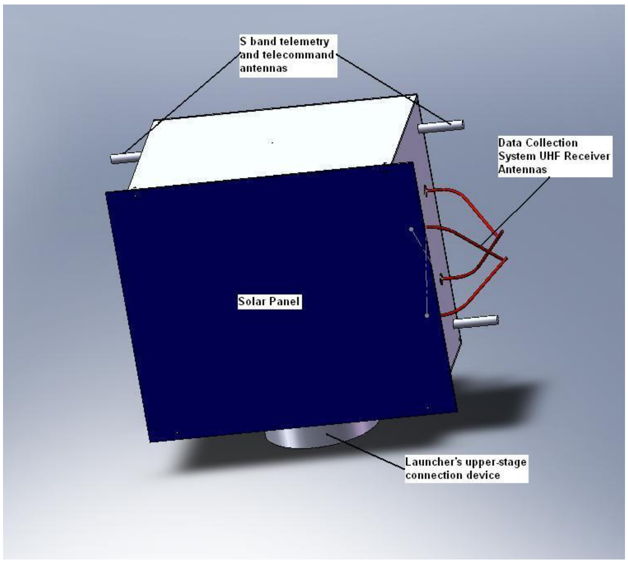

Figure 2. ITASAT satellite configuration

The satellite architecture is based on the following functional chains:

a) An electrical power generation, regulation and distribution function including triple junction solar panel, a Nickel-Cadmium (NiCd) battery and the harness;
b) An attitude control function which includes a momentum wheel to provide satellite stabilization, an attitude determination system based on three sun sensors and a 3-axis magnetometer to provide pointing accuracy better than 5 degrees, during the routine phase, and magnetotorquers for attitude maneuvers;
c) A data handling function which is implemented on a redundant On-Board Computer (OBC) system, with a Consultative Committee for Space Data Systems (CCSDS) interface and redundant S-Band transmitter and receiver chains;
d) A satellite structure to provide a mounting platform for all satellite components and payload instruments and to maintain the alignment required by the payloads and some satellite components;
e) A thermal control function to maintain the temperature of satellite components within safe operating and non-operating ranges. Thermal control can include heaters, thermostats, temperature sensors, radiating surfaces, insulation, and thermal isolators, as needed to control the temperature of the various satellite components and payload interfaces;
f) Operational and technological payloads that includes the following: Operational DCS, Experimental Digital DCS, Experimental Computer, GPS Experiment, MEMS, Radiation-hard evaluation setup.

Figure 3 describes the functional block diagram for the ITASAT satellite.

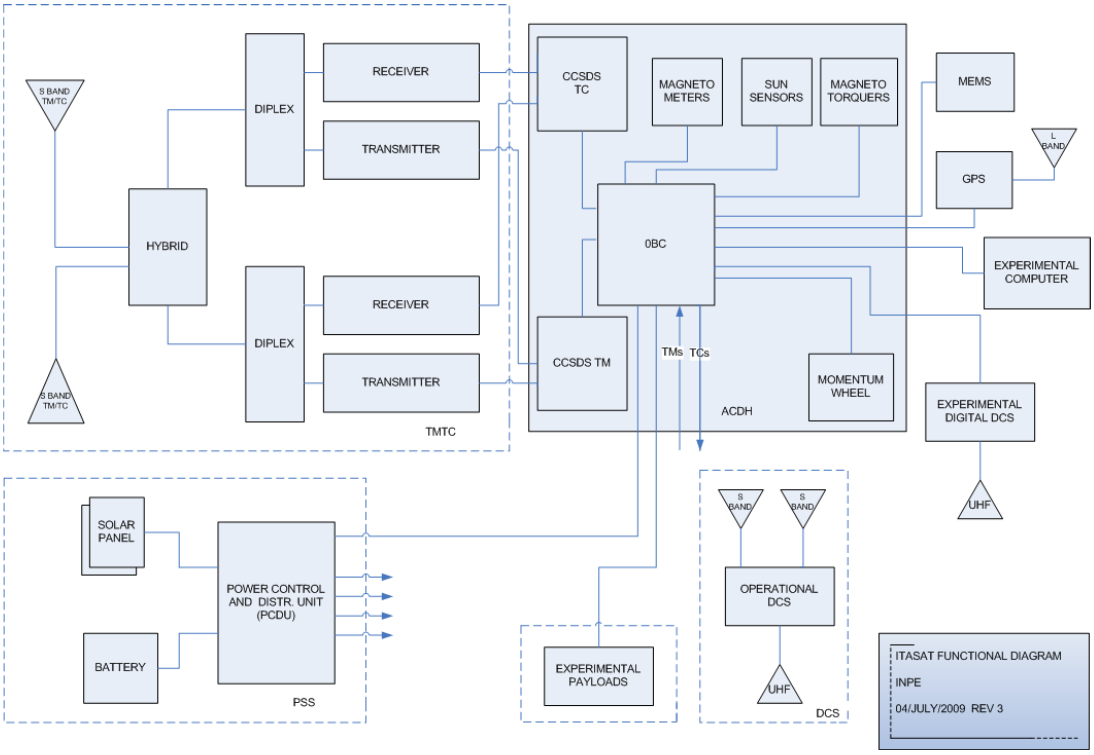

Figure 3. ITASAT Satellite Functional Diagram

The goals in terms of mass, size and power to enable the satellite launch as a secondary payload are: mass less than 85 Kg; size = 700 x 600 x 400 mm, and power generation from 80 to 100 W.

4. MISSION SCENARIO COMPUTATIONAL SIMULATIONS

Some of the previously proposed ITASAT satellite subsystems and its mission scenarios were simulated using the AGI's Satellite Tool Kit (STK) software simulation tool (AGI, 2009). STK is an integrated collection of software suites that provides design, simulation, visualization and analysis capabilities regarding land, sea and space systems. STK is able to perform complex analysis considering all the simulated assets, sharing the results in one integrated solution. It also supports 2-D and 3-D visualization, high-fidelity orbit propagators, complex sensor modeling, terrain analysis constraints and custom data product generation such as detailed reports and graphs.

For the problem described in this work, a simulation solution has been proposed where the ITASAT mission scenario was represented by inserting most of its objects and systems in a STK environment using version 8.1.3. Two types of simulation scenarios were used: one for a polar orbital launch and one for a near-equatorial orbital launch. For the first case, the satellite orbit definition has been derived from the CBERS-2B Two Line Elements (TLE), since it is a viable opportunity for launching ITASAT as the secondary payload for the CBERS satellite series. In the second situation, ITASAT's orbit definition has been derived from the SCD-1 TLE. The scenario analysis has aimed at replacing one of the SCD satellites, or even to improve the DCS coverage network by adding more SCD-like satellites to low-inclination orbits, which have significantly more passes over the Brazilian territory.

Besides satellite orbit, a rough preliminary ITASAT 3-D model has been developed, which was then compounded with the STK simulation tool for visualization purposes. This satellite model was kept in STK simulation tool at a body-fixed attitude, with its solar panel continuously pointing to the Sun. Furthermore, such satellite deployment attitude has been chosen by taking into consideration the last stage's maneuver prior to separation from the Long March launcher and CBERS's solar panel orientation. ITASAT's body-fixed coordinate frame is shown in Fig. 4 as follows: a) the Z-axis pointing to the Sun; b) the Y-axis in the ecliptic plane; and c) the X-axis completing the dextrogerous coordinate frame.

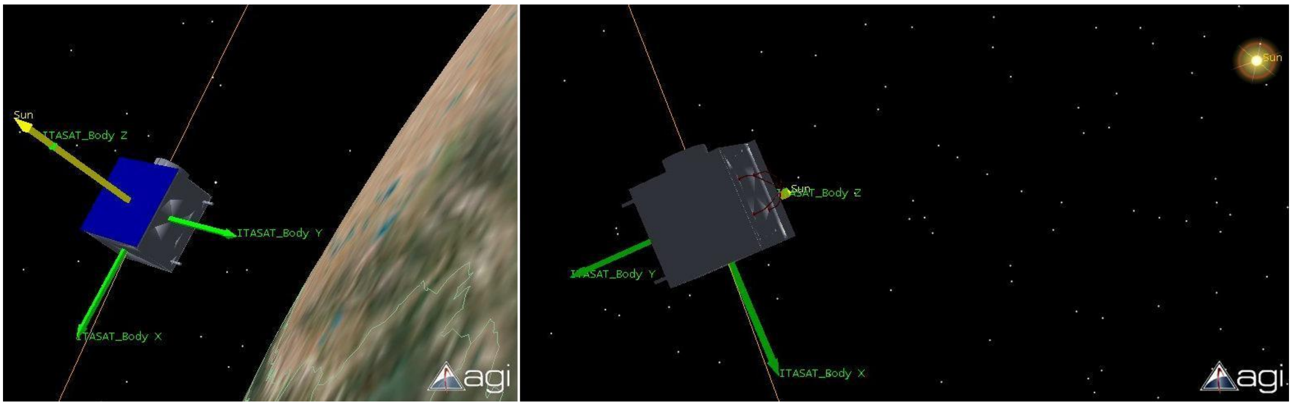

Figure 4. ITASAT sun-aligned body-fixed attitude coordinate frame

The DCPs were inserted into STK by placing facilities objects on the ground respecting their corresponding geodetic coordinates. Five DCPs have been chosen to provide enough valuable data from a wide area over South America.

DCP 001 (Lat: 2.0 deg; Lon: -29.0 deg) has been set to hypothetically represent a location near S. Pedro e S. Paulo islands, the Brazilian most eastern point, covering therefore a portion of the Atlantic Ocean as well. DCP 109 (Lat: 5.186 deg; Lon: -52.687 deg) is located at a point over the French Guiana, a very northern point on South America. DCP 113 (Lat: -12.096 deg; Lon: -77.04 deg) is located at a far-most western longitude and it is actually located at Peru. DCP 32590 (Lat: -15.555 deg; Lon: -56.0698 deg) is situated at the same site of INPE's satellite tracking ground station in Cuiabá, positioned approximately at the center of the Brazilian territory. The last DCP, 9007 (Lat: -10.7167 deg; Lon: -48.4167 deg) has been placed over the Brazilian state of Tocantins, which is a strategic point right in the middle of Brazil between Cuiabá and Alcântara where another satellite tracking ground station is located. The above two Ground Stations (GS) have been inserted in the simulated scenario too.

To increase the fidelity of the mission analysis and to test whether the proposed locations of the DCS UHF receiver antenna on the satellite would provide a good coverage of the surface, all the transmitters and receivers involved on the data link communication chain (both UHF and S-Band) have been also modeled into STK. An UHF source transmitter has been setup at each DCP as well.

At the other side of the link, an UHF receiver antenna has been mounted aboard the simulated ITASAT to receive the DCP signals. The antenna beam has been modeled with an external script containing the angle values off the receiver boresight together with their respective gain values. Those values were obtained from the same SCD-2 radio-frequency model developed and measured at INPE's Integration and Test Laboratory. This antenna has been placed at two satellite distinct locations at each simulation execution, in order to be evaluated.

To retransmit the data collected over the DCPs passes to INPE's Ground Station network, a transmitter has been simulated by positioning an antenna object at one of the four S-Band antennas aboard ITASAT. As the DCS payload is unique in terms of data communication and thus not available in the simulation tools, many parameters have been approximated. In spite of such a limitation, a good overall picture of DCP-to-satellite and satellite-to-ground stations communication chain performance has resulted though.

Values used to model the parameters of the above described objects, as well as the reference parameters to evaluate the simulation results for the data communication chain (DCP-to-satellite and satellite-to-ground station) were obtained from Yamaguti (2005).

Additional input parameters that can be cited are the System Temperature, which has been dynamically simulated by STK. This computation has considered the receiver Noise Figures = 1 dB, the Transmission Line Losses = -0.5 dB, the Transmission Line Temperature = 290 K, and Antenna Noises calculated by factoring in the influence of the Earth, Sun, atmosphere, rain, tropospheric scintillation and cosmic background. Values for these last settings have been chosen as: Earth temperature = 290 K; Gaseous Absorption Model = Simple Satcom (with Water Vapour Concentration = 7.5 x 10^6 kg/km^3 and Temp. = 293.15 K); Rain Model = Crane 1982 (with Surface Temperature = 273.15 K and Rain Outage = 1.0); Computed Tropospheric Scintillation Fade and Deep Fade (with Trop. Fade Outage = 0.1 % and the percent time the refractivity gradient is less than -100 N Units/Km = 10%). Figure 5 depicts a 3D overview of the software simulation scenario.

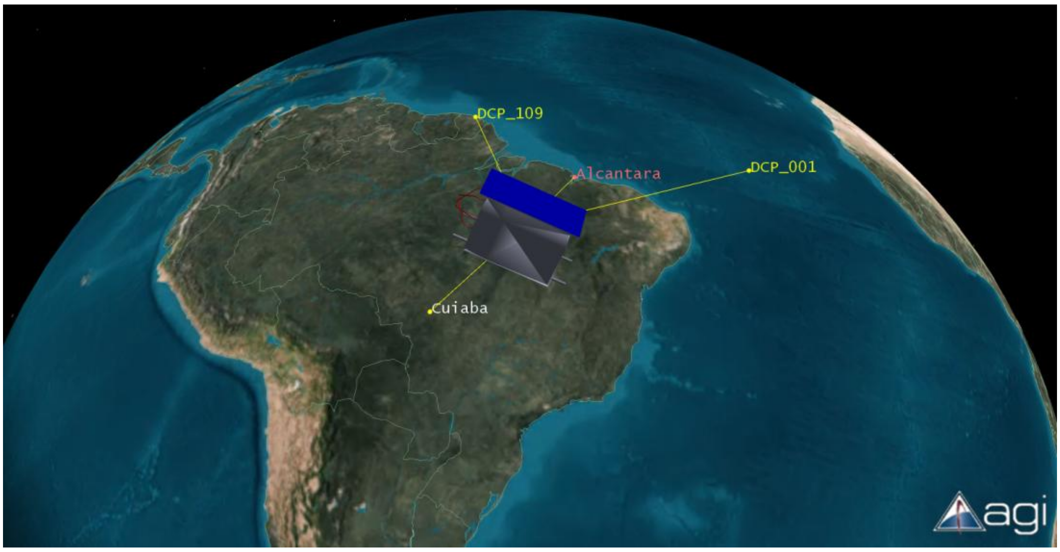

Figure 5. STK 3-D view of the data link chain from DCPs to Alcântara and Cuiabá Ground Stations

5. PRELIMINARY MISSION ANALYSIS RESULTS

This section presents some simulation results as a consequence of the satellite attitude control system configuration that has been chosen and the impact on the data communication links for data collection services as well as on the experimental payloads.

5.1. Launching and early-orbit phases

This satellite proposal considers its launch as a secondary payload to profit from launch opportunities especially for polar orbit missions. Using a momentum wheel to stabilize the satellite will require that the launcher needs to provide telecommand functions to turn on the wheel before satellite separation. Section 5.4 details an example sequence for the case of CBERS satellite series launch and ITASAT as a secondary payload.

Even if launching into a 25 degrees-inclination orbit, the proposed configuration for ITASAT can still meet the mission requirements. For such an orbit the launcher shall deploy the satellite with the momentum wheel positioned orthogonal to the face with the fixed solar panel, at nominal speed, and properly pointed to the Sun.

After separation, the on-board computer is turned on, as well as the telemetry transmitter, initiating the activities related to a safe mode. A telecommand issued by the ground segment can change the operating mode to attitude acquisition mode. If the satellite status is nominal, the subsystem acceptance phase can be initiated, followed by the routine phase.

5.2. Orbit selection

During the simulation, two orbit types were considered. The analysis started by a polar orbit similar to those used by CBERS satellite series, followed by a low inclination orbit similar to that of SCD-1, or SCD-2.

Section 5.5 details the simulation results. Figures 10 and 11 show the number of satellite passes over a ground station for the two scenarios. In terms of data collection services, one notices that the low-inclination orbit is a very adequate choice. Figure 6 shows a comparison between ITASAT flying over South America on both orbit tracks (orange), one based on a CBERS-polar-like orbit on the left, and one at a 25 degrees-inclination SCD-like orbit on the right. The image also illustrates the DCPs included in the simulation (yellow) and both Ground Station cone range projections (white for Cuiabá and pink for Alcântara).

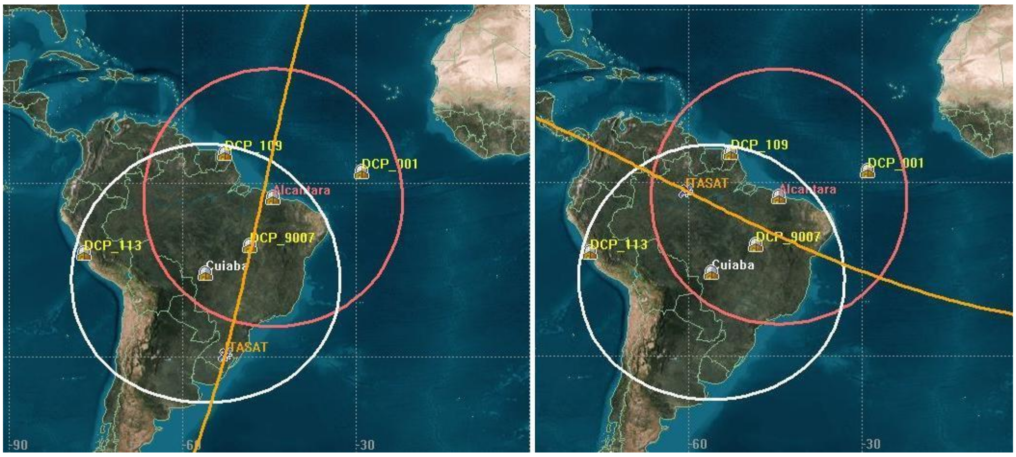

Figure 6. Orbit selection scenarios chosen for simulations. On the left, a polar-orbit satellite pass, and on the right, a 25 degrees-inclination pass

5.3. Satellite attitude

ITASAT´s new configuration focuses on initiating its operations as it is released from a 3-axis stabilized launcher into a polar, 10h30am, 780-km altitude, 100-minute period, and Sun-synchronous orbit. ITASAT´s attitude determination and control system shall rely on 3 2-D solar sensors, one 3-D magnetometer, a triad of air-core magnetotorquers positioned on the satellite payload platform, and an additional, aiding momentum wheel to provide gyroscopic inertia – thus rendering a dual-spin configuration.

To circumvent the need for initial maneuvers to point its sole solar panel face to the Sun and considering ITASAT as a secondary payload with a CBERS satellite launch, ITASAT shall be positioned in its secondary payload bay such that its solar panel face must be parallel to that of CBERS panel after the latter's release from the Chinese launcher and full deployment of its solar panel. Thus, the positioning of CBERS within the launcher´s last stage shall have the role of a compass direction to position ITASAT´s own solar panel face.

ITASAT shall benefit from the gyroscopic inertia of a dual-spin configuration by means of an aiding momentum wheel on board with angular momentum in the 10-20 N.m.s range, chosen to be compatible with the angular momentum magnitude of ITASAT´s previous configuration in spin-stabilized operational mode. The aiding wheel shall be activated to the nominal speed of about 1000 rpm prior to ITASAT´s release, though after the primary payload release from the launcher's last stage. Data concerning approximate inertia properties of the launcher's last stage shall be called for to confirm and ensure that activation of the aiding momentum wheel shall not significantly affect the launcher´s last stage attitude prior to ITASAT's release.

ITASAT satellite shall be 3-axis stabilized with its sole solar panel face pointing towards the Sun. The momentum wheel axis shall be orthogonal to that face. This axis shall provide the highest inertia to allow for stable spin rotation of the satellite in case of wheel malfunction. In such event, the fast-switching, air-core magnetotorquers on board the satellite shall counteract the undesired spin motion to provide 3-axis stabilization with accuracy compatible with the available sensors and magnetotorquers.

Previous investigation on autonomous, closed-loop, recursive 3-axis attitude estimation from magnetometer and Sun sensor measurement vectors and purely magnetic actuation by air-core magnetotorquers indicated the approach is feasible for 3-axis stabilized ITASAT release with an initial pointing error magnitude of 15 degrees up to spin-axis pointing at 40 rpm, and yielding a pointing error below 10 degree-errors in about 3 days for a 25 degree-elevation orbit. Nutation damping role was also concurrently accomplished by that purely magnetic actuation (Waschburger *et al.*, 2009).

In case of proper wheel operation, short-term corrections to maintain ITASAT´s solar panel face pointing towards the Sun shall utilize a 2-D Sun sensor positioned on that face and the air-core magnetotorquers.

The above configuration allows for immediate battery charging, telemetry, telecommand and communications link operations, and an about 8h-period of grace to estimate magnetometer bias as required when injection into orbit is 3-axis stabilized (Santos, D. A. and Waldmann, J., 2009). Upon bias estimation, 3-axis attitude and angular rate estimates from vector measurements of the Sun direction and the geomagnetic field shall be available for magnetotorquer-based control about the Sun’s direction for improved antenna pointing in the short term. Additionally, long term corrections to handle the precession of the sun-synchronous orbit during Earth´s motion about the Sun shall be as described in Washburger *et al*. (2009), and with magnetotorquers located on the stabilized payload platform. The present approach shall update every two weeks a Sun-pointing, constant reference angular momentum vector with respect to the inertial frame, instead of the permanent pointing towards the celestial North pole as previously described in Waschburger *et al.*

(2009). Purely magnetic control for Sun pointing shall be used to reduce power consumption because the aiding wheel - when in torque command mode - expends far much more power than the magnetotorquers. This is a critical issue especially at a moment when the solar panel face is not positioned to squarely face the Sun, and the attitude control system is at the onset of demanding higher power consumption to carry out the Sun-pointing corrections. Hence, the aiding momentum wheel shall be operated permanently in speed mode to reduce its power demand to about 5W.

Therefore, the aiding wheel shall exclusively provide a significant angular momentum to ITASAT´s gyroscopic inertia. Magnetotorquer-only actuation shall damp any satellite nutation, and stabilize rotation about the aiding wheel´s axis. Battery capacity on board shall sustain aiding wheel operation in speed mode during the about 40-minute eclipse in every orbit. The existing 3-axis attitude estimator shall be modified to include the additional aiding wheel angular momentum as the additional state, and its rotating and torquing effects on the previous rigid model embedded in the on-board extended Kalman filter (Santos, D.A. and Waldmann, J., 2009).

5.4. Satellite tracking and control

ITASAT’s attitude and orbit considered in this work and INPE’s existing ground segment for the Tracking, Telemetry and Commanding (TT&C) functions can be used with minor changes. Today, this infrastructure controls the SCD-1, SCD-2 and CBERS-2B satellites using Cuiaba’s as the main ground station and Alcântara’s as the backup ground station. The changes are related to the use of CCSDS protocol in ITASAT and the use of a procedure to compensate the Doppler Effect on the uplink carrier frequency.

The satellite operation will be done at S-Band frequencies. The telecommand data rate is 20 Kbit/s at a 2033.2 MHz nominal uplink frequency, and telemetry data rate is 10 Kbit/s or 400 Kbit/s (switchable by software) at a 2208 MHz downlink frequency. The telemetry is QPSK modulated with differential coding and with +31.5 dBm transmitter output RF power, while the satellite receiver waits a QPSK modulated telecommand with a RF input operating range of -118 dBm to -55 dBm. The orbit determination will be based on Doppler shift measurements of the downlink carrier frequency.

5.5. Data collection services performance

For the analysis in terms of data collection services performance, the goals are to demonstrate that for the existing DCP networks, ITASAT could receive and retransmit the DCP messages for the receiving ground station, e.g. Cuiabá and Alcântara. The UHF antenna radiation pattern is based on the UHF antenna used on the SCD-2 satellite. As an initial configuration, this antenna was installed on the lateral panel, as well as the S-Band DCS transmitter antenna. Figure 7 shows one S-Band transmitter antenna radiation pattern installed on the lateral panel (boresight direction is represented by the white vector) and Fig. 8 presents this antenna received isotropic power over the Earth surface for both the polar and 25 degrees-inclination orbit. Figure 9 also shows the UHF receiver antenna radiation pattern together with its received isotropic power over the Earth (considering the DCPs transmitters) in the case of the antenna installed on lateral panel.

Another important measure for data collection services is the number of satellite passes over the DCPs to provide a good regular sampling of DCP environmental sensors. Figures 10 and 11 show the numbers of satellite passes for a polar and a 25 degrees-inclination orbit. For data collection, a 25 degrees-inclination orbit increases the number of satellite passes over DCP’s installed in the equatorial region but does not cover the poles, whereas the polar orbit has a reduced number of satellite passes in the equatorial region but the polar region is very well covered. Figure 11 shows the contribution of ITASAT to the Brazilian Environmental Data Collection System space segment.

Figure 12 presents, for a polar orbit, two cases regarding the UHF antenna installation on ITASAT and its impact on the quality of reception measured by the carrier power at the receiver input, for the reception of a sample DCP (DCP 9007). Figure 13 shows the same evaluation for a 25 degrees-inclination orbit.

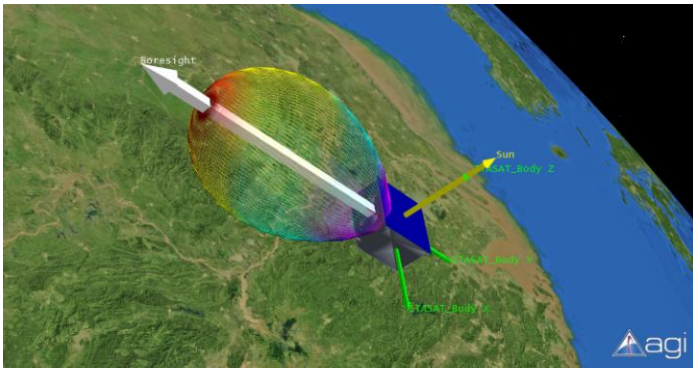

Figure 7. One S-Band transmitter antenna helix beam model aboard ITASAT

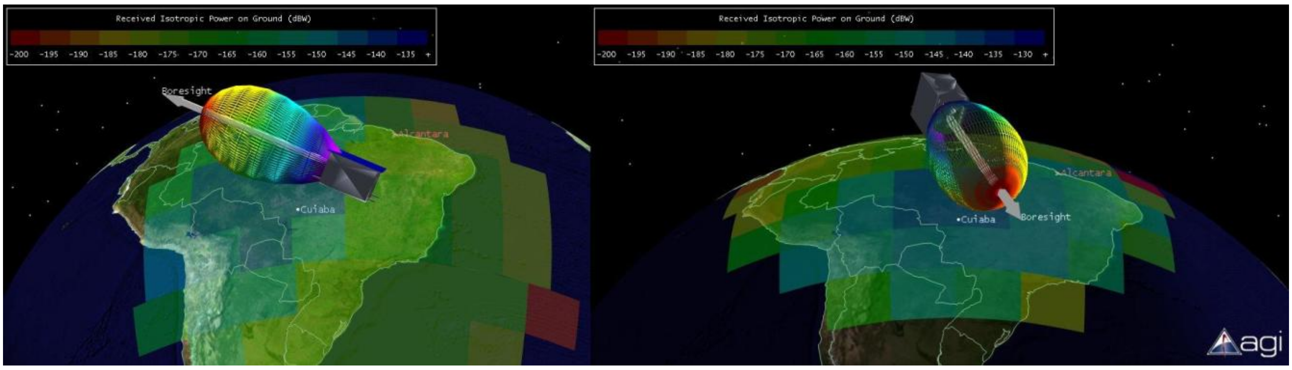

Figure 8. Polar (left) and 25 degrees-inclination (right) orbits showing ITASAT's transmitter antenna received isotropic power over the ground in case of just one S-Band antenna.

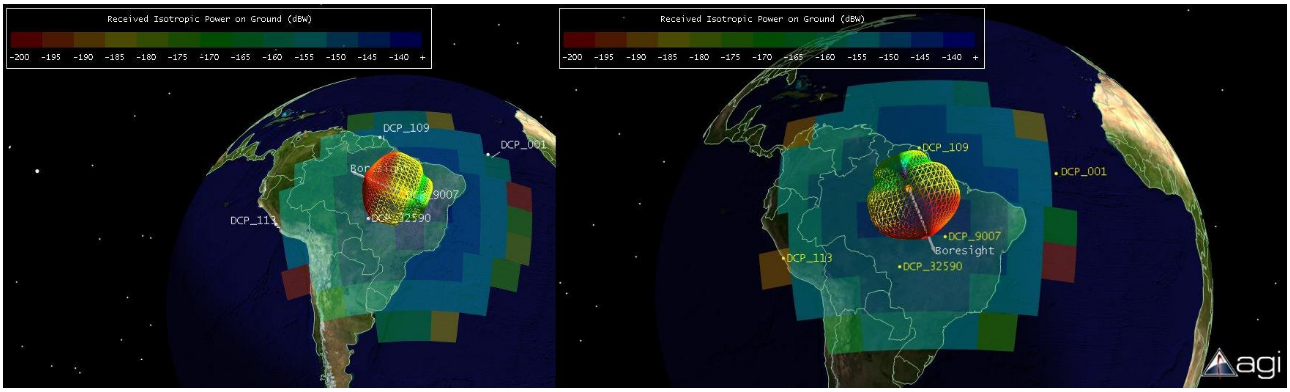

Figure 9. Polar (left) and 25 degrees-inclination (right) orbits showing ITASAT DCS UHF receiver antenna's received isotropic power over the ground

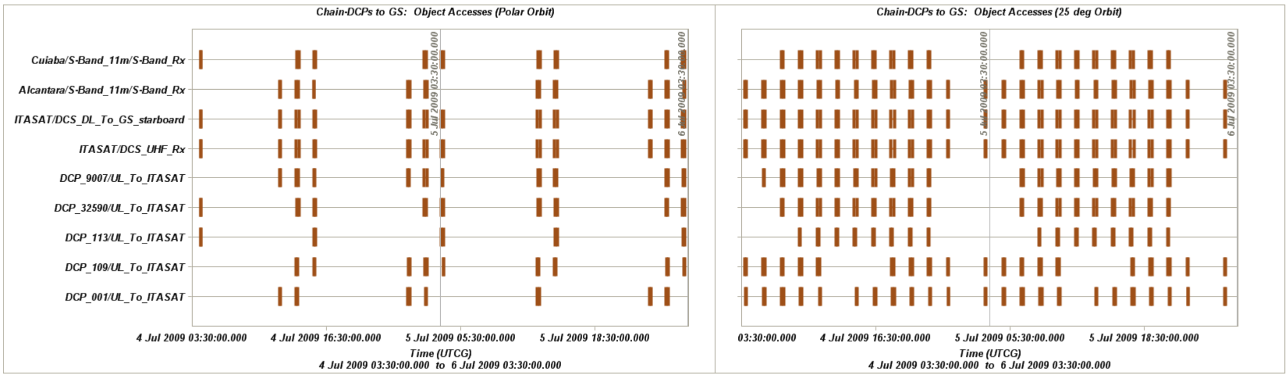

Figure 10. Polar (left) and 25 degrees-inclination (right) orbits showing the individual chain accesses (DCPs → ITASAT → GS) over 2 days propagation

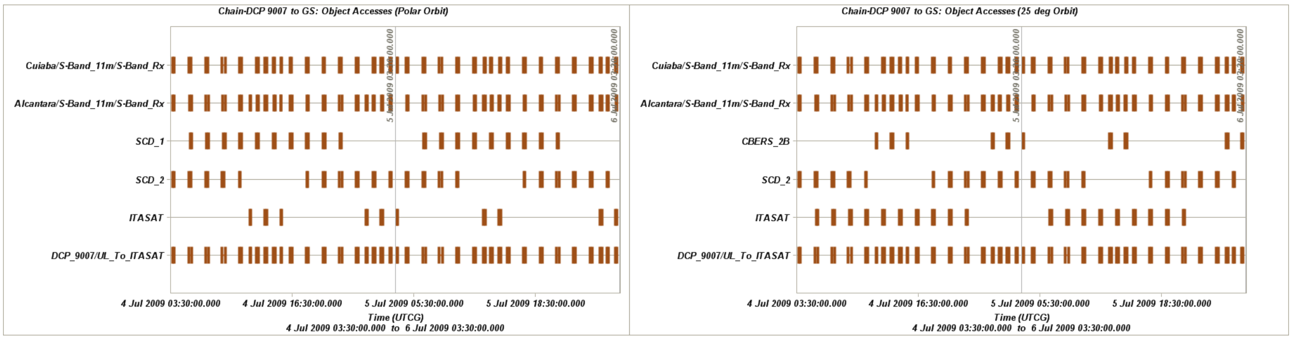

Figure 11. Polar (left) and 25 degrees-inclination (right) orbits showing the DCP 9007 accesses to ITASAT, SCD-1, SCD-2 and CBERS-2B under a complete chain link over 2 days propagation

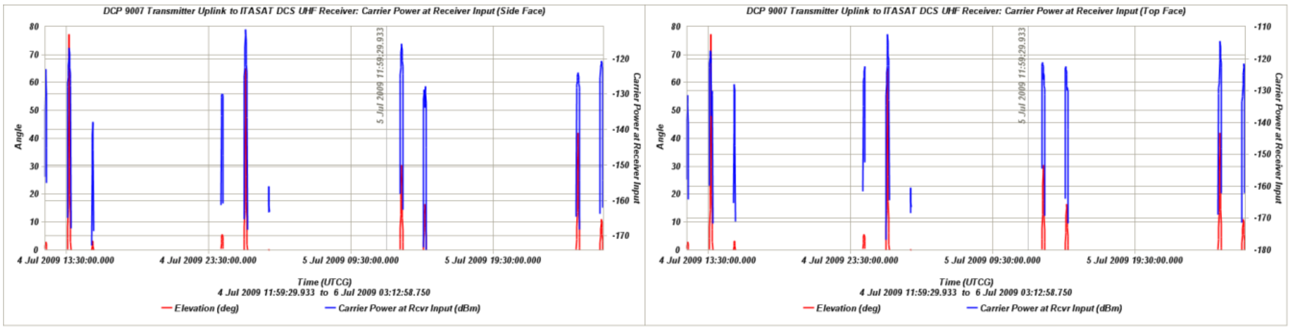

Figure 12. UHF receiver antenna installed on the lateral panel (left) and on the top panel (right) for a polar orbit for the reception of DCP 9007 elevation angle and the satellite carrier power at receiver antenna input over 2 days of ITASAT passes

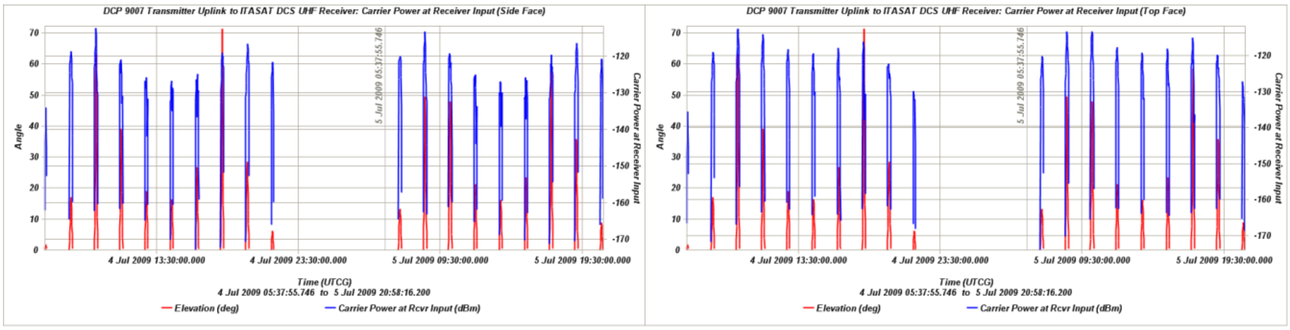

Figure 13. UHF receiver antenna installed on the lateral panel (left) and on the top panel (right) for a 25 degrees-inclination orbit for the reception of DCP 9007 elevation angle and the satellite carrier power at receiver antenna input over 2 days of ITASAT passes.

5.6. Experimental payloads

Regarding the experimental payloads, a quick analysis considering a polar orbit or a low-inclination orbit follows:

a) **Digital DCS:** as this subsystem process the received DCP messages on-board, the reception performance is very good. The acquired DCP messages on board are transmitted to the ground through the telemetry downlink;
b) **Experimental Computer:** no restriction regarding the orbit is foreseen. The acquired data will be downloaded by the telemetry link;
c) **GPS experiment:** independent of orbit selection, GPS constellation signal reception using one antenna should be evaluated. The best place to install the antenna on the satellite shall be analyzed. Acquired data shall be transmitted to the ground for further processing and orbit estimation;
d) **Attitude determination experiment using MEMS devices:** no restriction envisaged with respect to selected orbit. Respective data shall be downloaded through telemetry;
e) **Radiation hard experiment:** this experiment does not impose any orbital restrictions;

f) **Thermal experiment:** the basic idea is to measure additional satellite temperature points to be compared with the satellite thermal model. A detailed specification is not closed yet;
g) **Structural experiment:** the basic idea is similar to the Thermal experiment, and launch is considered an important period to measure structure strain. As ITASAT is to be turned off at launching, the feasibility of this experiment shall be evaluated.

6. CONCLUSION

ITASAT's configuration is at a very preliminary proposal stage to enable satellite's subsystems development and to be an initial reference for systems engineering interaction and discussion among the various teams involved in the design. A lot of work needs to be done to complete a final satellite configuration. For the simulation, some transmission characteristics were approximated, as in the case of antenna radiation pattern used for UHF reception that was based on SCD-2's UHF antenna. Refined antenna simulation and RF satellite model are in need having in mind the proposed mechanical structure, as well as to further investigate interaction among the various antennas (two TM/TC, two DCS S-Band, one or two UHF and one GPS). Another task is to arrange all subsystem equipments inside the satellite. Preliminary simulation results of Receiver UHF antenna on board ITASAT located either on the lateral panel or on the top panel show that top-panel installation is more interesting for Brazil-only coverage than on the lateral panel as initially proposed. UHF antenna installation on the top panel restricts service coverage of the Earth's southern hemisphere. More detailed simulation and distinct scenarios are needed to support the decision concerning the UHF antenna location. As a concluding remark, the simulation results show that the mission can be accomplished with the proposed satellite configuration, but new simulation cases are necessary to support final satellite configuration.

7. ACKNOWLEDGEMENTS

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8. REFERENCES

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9. RESPONSIBILITY NOTICE

The authors are the only responsible for the material included in this paper.