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THERMAL CONTROL OF THE FIRST BRAZILIAN SCIENTIFIC SATELLITE

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Paper accepted as a poster presentation in connection whit Session 12 in the IAA Symposium on Small Satellites for Earth Oservation, Berlin, Germany, November 4-8, 1996

INPE
São josé dos campos
1996

2. GEOMETRIC AND ORBIT CONFIGURATION

The SACI-1 satellite has a shape of square base prism with dimensions of 0.38 x 0.38 x 0.46 m and a mass of 60 Kg approximately. Four solar aluminum honeycomb panels are assembled in the structure and the sun rays hits perpendicularly on them during the operational phase. The internal structure of the satellite consists in pilling of aluminum alloy modules whose sketch showning their localization is presented in the Figure 1.

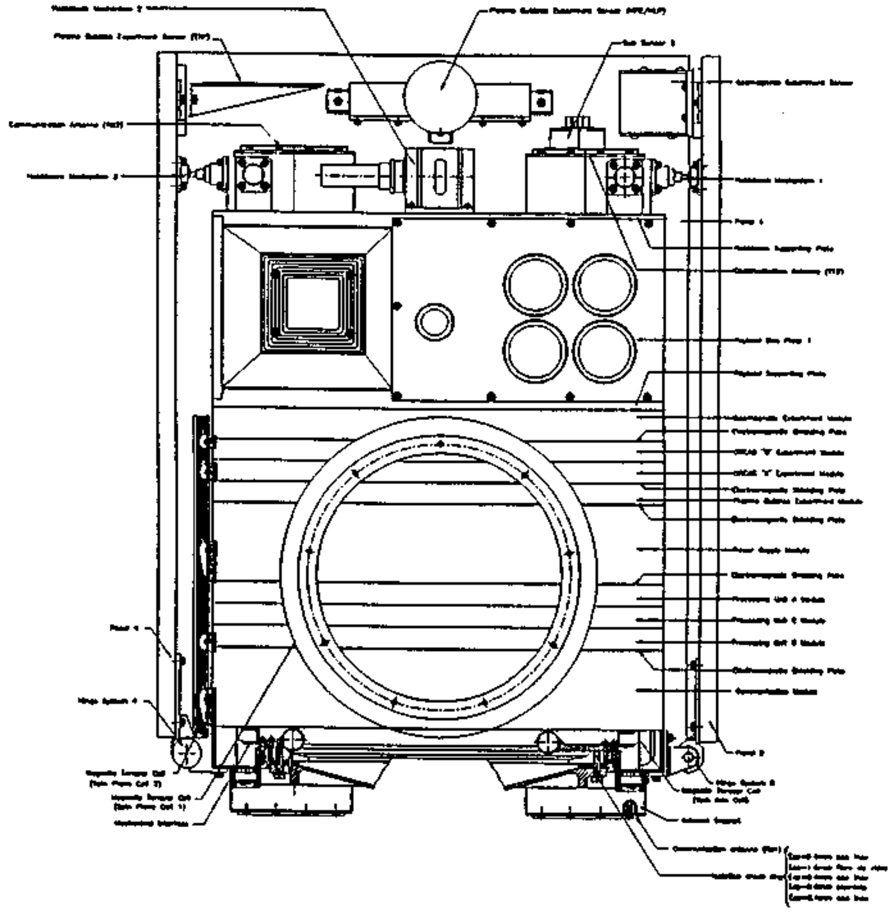

Fig. 1 - Sketch with the localization of the SACI-1 satellite modules

The satellite has a circular and heliosincronous orbit, with an inclination of 98.5 degrees and an altitude of 778 Km. The period of orbit is 100 minutes (eclipse period of 32 to 34 minutes) and the satellite will be spin stabilized with the spin axis pointed to the sun.

The critical thermal conditions of the satellite are determined by the external heat loads and equipments internal dissipation. For the last one the cold case occurs when only the service module are operating (27 W) and the hot case happens when the equipments of service and the payload modules are turn on (68.3 W). In orbital conditions, the satellite is subject to direct solar radiation, albedo and earth radiation. At the nominal attitude, the direct solar radiation hits perpendicularly the sun face. During the acquisition phase, the satellite can have non-nominal atittude.

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ABSTRACT

The small satellites play an important role for the space techonology in general, as demonstrated by the current space programmes being held in many countries. This paper presents the basic concepts of the thermal design for the First Brazilian Scientific Application Satellite (SACI-1), being designed by Brazilian Space Research Institute (INPE).

A passive thermal control technique is used and the thermal analysis is accomplished by the nodal method, using the PCTER thermal software developed at INPE by the thermal group.

The results indicate that the temperature of all satellite equipments can be kept within the specified range for any operation mode and orbital condition using only passive means. An experiment set up is being designed to evaluate the mathematical thermal model by an Engineering Qualification Model (EQM) of the satellite.

1. INTRODUCTION

The thermal design must provide an environment that keeps all satellite equipments within the specified range of temperature for any operation mode and any orbital condition. This work describes the theoretical performance of the Thermal Control Subsystem (TCS) for the SACI-1 satellite that satisfies the critical conditions during the operation and acquisition phase using a passive thermal control technique.The model is based on the nodal method, in which the satellite is divided in a finite numbers of nodes that are assumed isothermal.The satellite equipment temperature are calculated for several attitude configuration taking into account the equipment power dissipation and the orbit conditions. The results are presented for the operation phase and it is indicated possible solutions to manage the thermal critical conditions during the acquisition phase.

3. MATHEMATICAL THERMAL MODEL

The thermal analysis is accomplished by using PCTER thermal analysis software [1] developed at INPE by the thermal group. This software was used successfully in the First Brazilian Data Collection (SCD-1) satellite.

The model is based on the nodal method [2], in which the satellite is divided in a finite numbers of nodes (55 nodes) that are assumed isothermal. These nodes are connected each other by conductive and radiative couplings. They can receive thermal load from external radiations or internal heat dissipation.

The temperature is calculated at each node by numerical method, considering all thermal couplings and loads and the boundary conditions.

4. THERMAL DESIGN CONFIGURATION

The thermal control subsystem (TCS) is expected to use only passive means that include basically the use of thermal control coatings (paints and special fisnishes), thermal blankets (Multiple Layer Insulation - MLI), thermal greases and low conductive materials. Heaters can be used in some critical equipment of the payload.

The Figure 2 presents the external optical properties (infrared emissivity (ε) and the solar absortivity (α)) for the SACI-1 satellite.

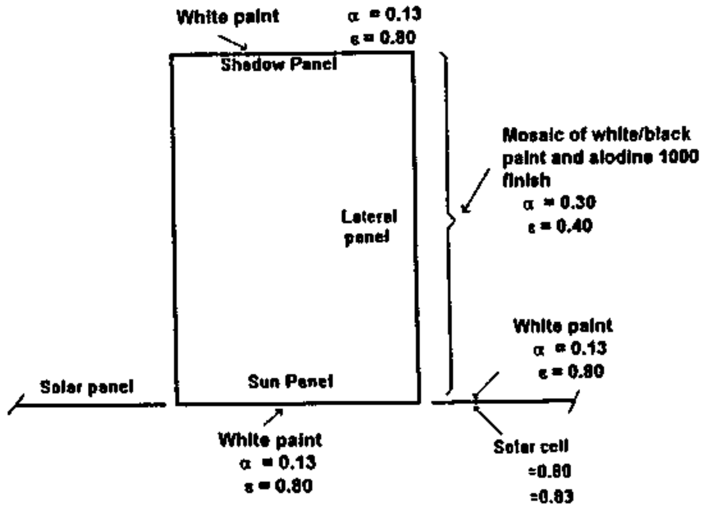

Fig. 2 - Configuration of the external surfaces properties

At one lateral side of each module will be installed connectors for the wires, cables and so on. This region of the modules will be covered by MLI in order to decouple it thermally from the ambient, because it would be very difficult to define a thermal optical property in confidence.

The geomagnetic, HFC and LP sensors that are fixed on shadow face of the solar panel are also radiatively insulated (wrapped) by MLI and conductively insulated by epoxy-fiberglass composite washers at the fixation points.

5. RESULTS AND FINAL COMMENTS

The transient temperature were calculated for each critical case. The maximum and minimum temperatures are presented in the diagram of the Figure 3 for the operation phase for the case of good conductive coupling between the modules. This case represents the closer condition expected to the actual one. The term "radiator" means the border of the module.

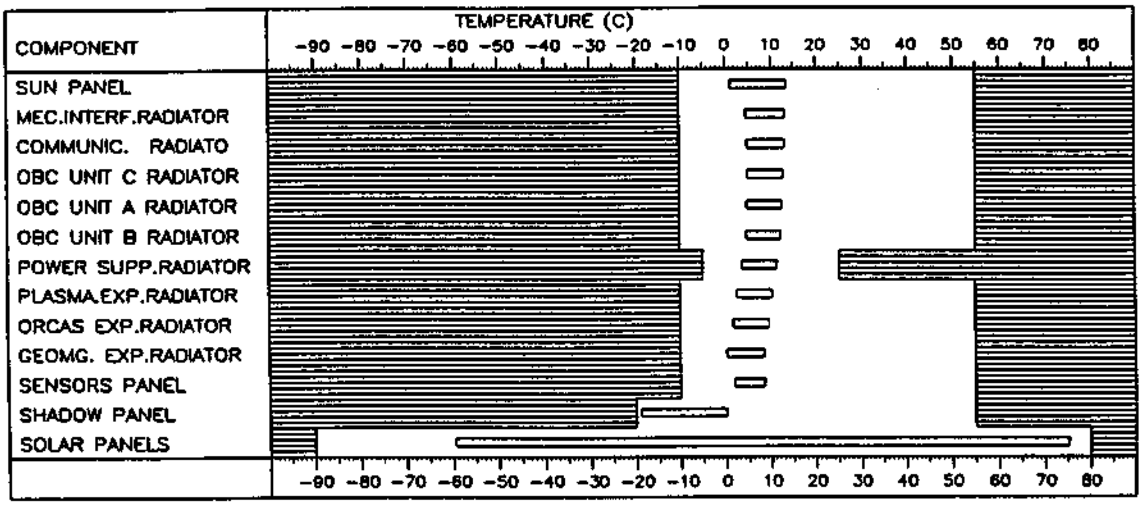

Fig. 3 - Temperature predicted for the operation phase (with good long. cond. coupling)

The preliminary results for this model indicate that the temperature of the modules are within the specified limits for the operation phase. For the acquisition phase we must establish some kind of attitude restriction:

a) The satellite should never be pointed out with the shadow or sun face to the sun for more than 12000 secs (two periods of orbit).

b) The satellite attitude should not be fixed for more than 30000 secs (five periods of orbit) for all other attitude different of mentioned at item a.

Nevertheless, the results and suggestion provided by this model must be checked by a detailed thermal model for the satellite, modules (Battery and PCU, Communication, etc.) and for some equipment such as magnetic torquer coil, sun sensor and so on, that is being performed at the moment.

Finally, it will be necessary to evaluate the mathematical thermal model by testing an Engineering Qualification Model (EQM) of the satellite that will be performed next.

6. REFERENCES

1. J.A. Webelt, *Enginnering Radiation Heat Transfer*, Holt, Rinehart and Wiston (1966)
2. PCTER - Thermal Analysis Computer Program - User's Manual
INPE, São José dos Campos, Brazil (1988)

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THERMAL CONTROL OF THE FIRST BRAZILIAN SCIENTIFIC SATELLITE

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BERLIN, GERMANY

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Symposium on Small Satellites for Earth Observation
Berlin, Germany, November 4-8, 1996

May 15, 1996

Mr. Olavo B. Oliveira F.
Brazilian Space Research Institute (INPE)
Space Mechanics and Control Division (DMC)
C.P. 515
12210-970 - Sao José dos Campos - S.P.
Brasilien

Dear Mr. Oliveira,

On behalf of the Program Committee for the IAA Symposium on Small Satellites for Earth Observation, I am pleased to inform you that your paper entitled

„Thermal Control of the First Brazilian Scientific"

has been accepted as a poster presentation in connection with Session 12 - Spacecraft Subsystems (SU). The poster sessions are currently scheduled for Tuesday, November 5, or Wednesday, November 6, 1996. Please inform your co-authors of the acceptance of your poster.

Reference number IAA-B-1208P has been assigned to your poster. Please, refer to this number on all correspondence and documents relating to your paper.

The extended abstract (short paper on four pages) of your poster will be published in the Symposium digest which will be distributed to registrants at the Symposium.

Camera-ready manuscripts of the short papers should be sent to

Dr. Bernd Kirchner
DLR, Institute of Space Sensor Technology
Rudower Chaussee 5
12489 Berlin
Germany

not later than August 10, 1996. The short papers must be in English. The type instructions are enclosed. The pages should be numbered with blue pencil in the right-hand lower corner.

The posters must fit on tables of size 78 cm by 78 cm.
Please be reminded that there will be awards for outstanding contributions at the end of the Symposium.

Telefax / Telex

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Seitenanzahl/ No. of Pages 1

Dear Mr. Oliveira

This is to confirm receipt of your short paper No. IAA-B-1208P for the IAA Symposium on Small Satellites for Earth Observation, November 4-8, 1996, Berlin, Germany.

Yours sincerely,

MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

July 31, 1996

To
Dr. Bernd Kirchner
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Rudower Chaussee 5
12489 Berlin
Germany

Dear Dr. Kirchner,

I am sending you enclosed the camera-ready manuscripts of the short paper, for the paper with reference number IAA-B-1208P entitled "THERMAL CONTROL OF THE FIRST BRAZILIAN SCIENTIFIC SATELLITE".

I would like also to inform you that I have included as co-authors other two members of my division that helped us to finish this work.

I hope to be able to present it in November in Berlin.

Thank you very much for your attention.

Yours very truly,

Olavo Oliveira
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