NANOSATC-BR2, 2 UNIT CUBESAT, POWER ANALYSIS, SOLAR FLUX PREDICTION, DESIGN AND 3D PRINTING OF THE FLIGHT MODEL FROM THE UFSM & INPE’S NANOSATC-BR, CUBESAT DEVELOPMENT PROGRAM

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Technical Session: Mission
4th IAA Conference on University Satellites Missions & CubeSat Workshop
International Academy of Astronautics – IAA
Rome – Italy
December 4th – 7th, 2017
• Objectives:
  – Scientific
  – Technological
  – Student engagement

• 1U platform and GS purchased from ISIS, through international bid in 2010
  – Delivery 2011

• Payloads
  – Magnetometer – INPE/MCTIC
  – Fault tolerant FPGA - UFRGS
  – IC on/off driver – SMDH/UFSM
NANOSATC-BR1– NCBR1

- It is operational until today; 3 year and 5 months generating data from the payloads and platform subsystems;
- All payloads are with nominal performances;
- Energy power subsystem is with low voltage in the batteries;
- It is not possible anymore to download log files;
- The data is presently obtained by nominal beacon: (165 kbytes of data per beacon); at 30 sec. Interval.
- The World Amateur Radio Network is currently providing data.
NANOSATC-BR2 – NCBR2

Payloads:
- **Langmuir** Probe (INPE/MCTIC);
- **Attitude Determination System:**
  (Cooperation INPE/MCTIC with UFMG - UFABC);
- **Other ICs** – by SMDH and UFRGS with INPE/MCTIC;
- **Two Magnetometers.**

**Launch** – through international bid in 2018
NANOSATC-BR2 – EM Platform

EM Platform

Payload

UFSM

UFRGS
Objective:

Help students better understand the satellite
Satellite Model to be exposed worldwide

Steps:

• Design the Model;
• 3D Print the Model;
• A reliable connection between the CubeSat and the launch vehicle is made through the P-POD

• The P-POD rails measure 227mm, since it is longer than the satellite
The solar cells attached to the structure were designed following Innovative Solutions in Space (ISIS) standard design.
NANOSATC-BR2 – 3D MODEL

• It has a rectangular design, although it has fillets on its corners
The final conception for the Langmuir Probe is attached on 2 sides of the NANOSATC-BR2.
The final model has the Langmuir Probe and the Antennas in the upper face.
NANOSATC-BR2 – 3D MODEL

- 3D Printed Model
Objective:

Obtain Power Balance.

Steps:

• Estimate Power Generation;
• Estimate Power Consumption;
NANOSATC-BR2 – Simulation

- To estimate Power Generation, the NCBR1 orbit is considered for the NCBR2
NANOSATC-BR2 – Simulation

- Orbit
  - Polar: 98° Inclination
  - Eccentricity: 0.00113
  - Velocity: 7.5 km/s
  - Semi-major Axis: 6997 km
  - Orbit Period: 97 minutes
• Umbra estimated for the orbit: 34 minutes

• Angle between sun vector and area vector is determined in each instant of time
• Power Generation in faces +X and -X
NANOSATC-BR2 – Simulation

- Power Generation in faces $+Y,+Z,-Y,-Z$
• **Power Generation**

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![Graph showing power generation over orbit periods.](image-url)
## Power Consumption (Components)

<table>
<thead>
<tr>
<th>Components</th>
<th>Maximum Consumption</th>
<th>Duty Cycle</th>
<th>Consumption with duty cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Power Subsystem</td>
<td>0.249 W</td>
<td>100 %</td>
<td>0.249 W</td>
</tr>
<tr>
<td>Board Computer</td>
<td>0.380 W</td>
<td>100 %</td>
<td>0.380 W</td>
</tr>
<tr>
<td>Receiver (TRXUV RX)</td>
<td>0.237 W</td>
<td>100 %</td>
<td>0.237 W</td>
</tr>
<tr>
<td>Transmitter (TRXUV TX)</td>
<td>0.787 W</td>
<td>4.2 %</td>
<td>0.033 W</td>
</tr>
<tr>
<td>Antenna system</td>
<td>0.040 W</td>
<td>100 %</td>
<td>0.040 W</td>
</tr>
<tr>
<td>2 Magnetometers (XEN 1210)</td>
<td>0.031 W</td>
<td>100 %</td>
<td>0.031 W</td>
</tr>
<tr>
<td>FPGA</td>
<td>0.049 W</td>
<td>100 %</td>
<td>0.049 W</td>
</tr>
<tr>
<td>2 SMDH ICs</td>
<td>0.030 W</td>
<td>100 %</td>
<td>0.030 W</td>
</tr>
<tr>
<td>Langmuir Probe</td>
<td>0.930 W</td>
<td>100 %</td>
<td>0.930 W</td>
</tr>
<tr>
<td>Attitude Determination System SDATF</td>
<td>0.271 W</td>
<td>100 %</td>
<td>0.271 W</td>
</tr>
</tbody>
</table>

**TOTAL** 2.25 W
### Power Balance

<table>
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<th>Duty Cycle</th>
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<td>2 SMDH ICs</td>
<td>0,030 W</td>
<td>100 %</td>
<td>0,030 W</td>
</tr>
<tr>
<td>Langmuir Probe</td>
<td>0,800 W</td>
<td>73,4 %</td>
<td>0,683 W</td>
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<tr>
<td>Attitude Determination System SDATF</td>
<td>0,271 W</td>
<td>100 %</td>
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</table>

**TOTAL** 2,003 W
With the Simulation, Thermal Radiation was determined

**Hot Case**

<table>
<thead>
<tr>
<th>Angular velocity X axis (rad/s)</th>
<th>Angular velocity Y axis (rad/s)</th>
<th>Angular velocity Z axis (rad/s)</th>
<th>Mean Heat Flux Solar Incidence (W/m²)</th>
<th>Mean Heat Flux Eclipse (W/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>454,03</td>
<td>54,24</td>
</tr>
<tr>
<td>0,087</td>
<td>0,087</td>
<td>0,087</td>
<td>518,52</td>
<td>55,91</td>
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<tr>
<td>0,1221</td>
<td>0,035</td>
<td>0,070</td>
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<td>0,5235</td>
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<td>1,57</td>
<td>1,57</td>
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<td>55,92</td>
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<td><strong>Mean Value</strong></td>
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<td><strong>509,88</strong></td>
<td><strong>55,67</strong></td>
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</table>
### Cold Case

<table>
<thead>
<tr>
<th>Angular velocity X axis (rad/s)</th>
<th>Angular velocity Y axis (rad/s)</th>
<th>Angular velocity Z axis (rad/s)</th>
<th>Mean Heat Flux Solar Incidence (W/m²)</th>
<th>Mean Heat Flux Eclipse (W/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>395,41</td>
<td>26,32</td>
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<tr>
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<td>0,087</td>
<td>0,087</td>
<td>452,24</td>
<td>27,13</td>
</tr>
<tr>
<td>0,1221</td>
<td>0,035</td>
<td>0,070</td>
<td>457,21</td>
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<td>0,2618</td>
<td>0,2618</td>
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<tr>
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<td>1,57</td>
<td>1,57</td>
<td>452,07</td>
<td>27,13</td>
</tr>
</tbody>
</table>

**Mean Value**  

444,73  

27,01
• The 3D Model is complete and ready to be used by students and exposed in events worldwide;

• Power Generation and Thermal Radiation were estimated;

• Positive Power Balance was achieved reducing Langmuir’s Probe Duty Cycle for 73.4%. Can operate during solar incidence and eclipse;
The authors thank to the Brazilian Space Agency - AEB, SEXEC/MCTIC, COCRE/INPE-MCTIC, UFSM-FATEC for the support, opportunity and grants for the Brazilian INPE-UFSM NANOSATC-BR Cubesat Development Program, with its CubeSats: the NANOSATC-BR1 & the NANOSATC-BR2 Projects.

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The authors thank to MCTIC-CNPq/(INPE/PCI-PIBIC-PIBIT) and to FAPERGS Programs for fellowships.
The NANOSATC-BR Program site is: www.inpe.br/crs/nanosat/

Thank you

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