



THE BRAZILIAN INPE-UFSM NANOSATC-BR, CUBESAT DEVELOPMENT PROGRAM

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Technical Session:

Best Practices, Lessons Learned and Challenges in Small Satellite Capacity-building

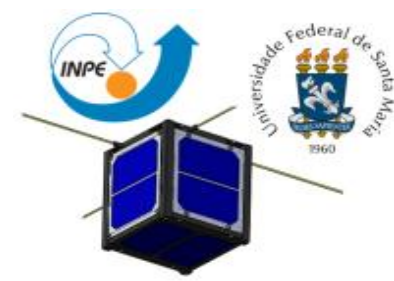
United Nations - Brazil Symposium on Basic Space Technology

"Creating Novel Opportunities with Small Satellite Space Missions"

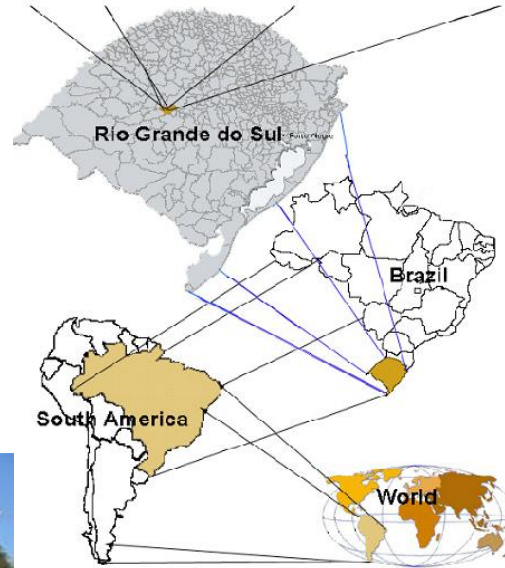
Natal – Brazil

11 – 14 September 2018

NATIONAL INSTITUTE FOR SPACE RESEARCH - INPE/MCTIC UNIVERSITY FEDERAL OF SANTA MARIA - UFSM



Santa Maria, RS – Brazil



**SOUTHERN REGIONAL SPACE RESEARCH CENTER
CRS/INPE – MCTIC
Santa Maria, RS – Brazil**



**TECHNOLOGY CENTER – CT/UFSM
Santa Maria, RS – Brazil**



Background - Development Strategy



Background:

- Decision to create the **NANOSATC-BR Program** and development of the **NANOSATC-BR1** Mission as a 1U CubeSat (**2008**);
- Many papers and presentations by the students since then.
- First missions suggested by INPE scientists.
- Work for the **NANOSATC-BR Program** start in **2009**.

Development strategy:

- To **develop the mission** rather than the platform.
 - Start with **payload development**, software, AIT and operation.
 - **Re-engineering** to develop the platform subsystems.
 - **Bringing technology** from abroad and incorporate it through the industry – joint ventures.
 - Create an industry in Brazil for this class of satellite.
-



The NCBR1 and NCBR2 Engineering Model Platforms



The **NCBR1**, is a 10x10x11.3 cm cube, weighing 0.965 kg. It has name and up and down frequencies link determined by **The International Amateur Radio Union – IARU, in 2011.**

NCBR1 - Science Mission

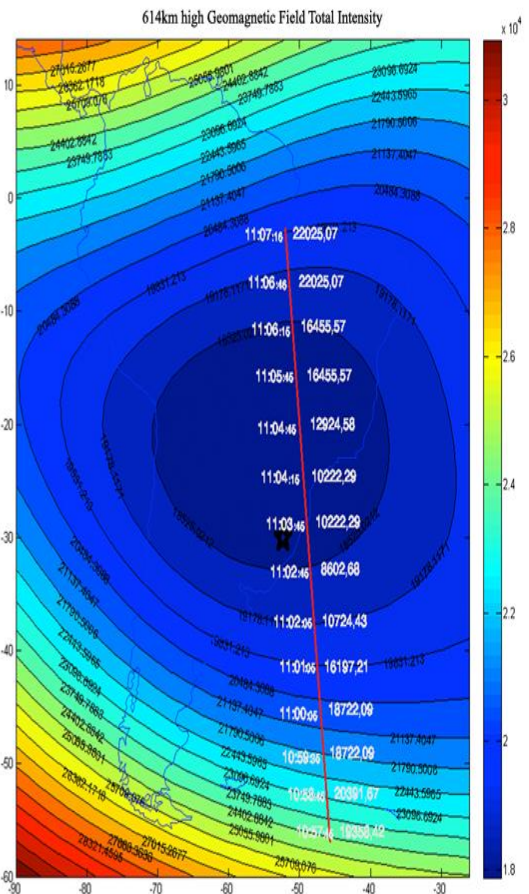
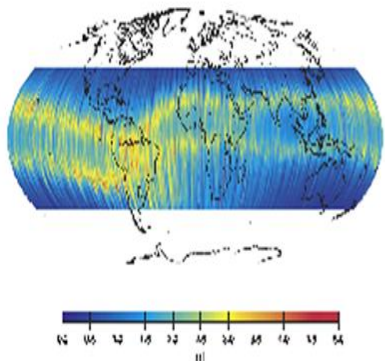
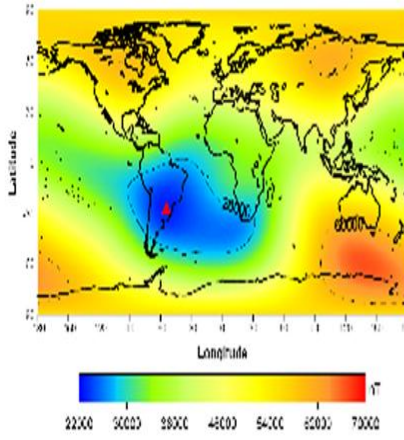


- ▶ **Earth Magnetic Field** intensity measurements.
- ▶ South American Magnetic Anomaly – **SAMA**.
- ▶ Three-axis magnetometer **XEN-1210** with a resolution of **15nT** from the Dutch company XI - Xensor Integration (www.xensor.nl).
- ▶ **Only one payload circuit board** with scientific and technological payloads.



NCBR1

Science Mission Results



➤ SAMA Geomagnetic Field total Intensity (**top left**) and EEJ (**bottom left**) - Ref.[*], [**].

➤ Results from NCBR1 Scientific Mission Payload measurements of the SAMA region (**right**).

➤ It shows an **excellent correlation** of the observed data collected by NCBR1 compared with the International Geomagnetic Reference Field (IGRF/AGA/IUGG) intensity for the same altitude .

References

[*] Heitzler, J. R., "The Future of the South Atlantic Anomaly and implications for radiation damage in space". Journal of Atmospheric and Solar-Terrestrial Physics, pp.1701-1708. 2002.

[**] Lühr, H., S.-Maus, & M.-Rother, "Noon-time equatorial electrojet: Its spatial features as determined by the CHAMP satellite", J. Geophys. Res., 109, A01306, doi:10.1029/2002JA009656. 2004.

NCBR1 - CURRENT SITUATION



➤ The **NANOSATC-BR1** was **launched on June 19th, 2014** as a tertiary payload by **ISIS** in the event **ISILAUNCH 07**, by a **DNEPR**, at **Yasny Launching Base**, Donbarovsky Region, **Russia**.

All **payloads and subsystems**, except the batteries in the power subsystem **continue to operate normally**.

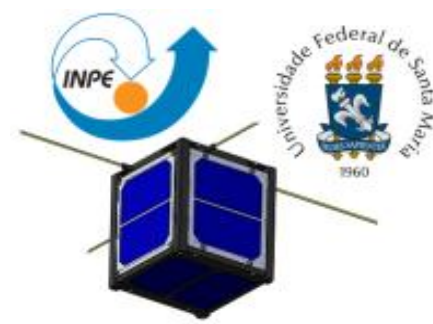
The **battery** can no longer hold electric charge because it was **damaged by magnetic solar storms** in September-October 2014.

Today, the **NANOSATC-BR1** can transmit only when it is in sight of the Sun.

The **World Amateur Radio Network** is currently providing **NCBR1** data.



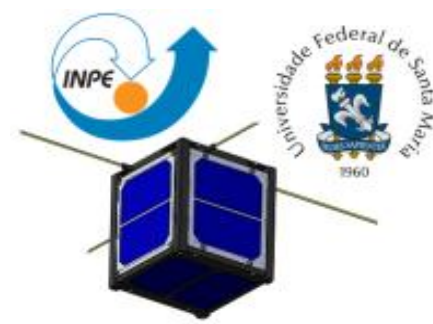
NCBR2 - CURRENT SITUATION



- The **NCBR2** is a **2U CubeSat, (10x10x22.6 cm)**, and has three major objectives: **Capacity Building, Scientific Mission** and **Technological Mission** development.
- The entire **platform flight software was developed in Brazil**, by Researchers and Engineers from INPE/MCTIC, already working in this area (**Determination & Attitude Control and Data Management**).
- **The Control Law for the control software has also been developed in Brazil.**
- The **Project** in May-2018 received specific **budget** from the **Brazilian Space Agency - AEB** for hiring the launch and future operation of NCBR2 in orbit.
- Now the NCBR2 is **planned to be launched in the end of 2018 or in 2019.**



NANOSATC-BR Ground Station & LITN



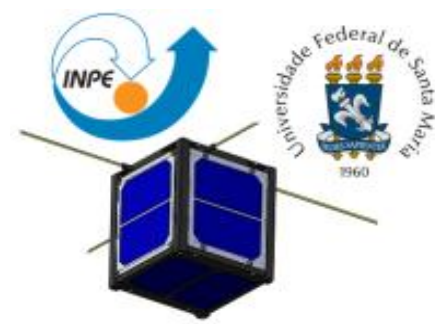
NANOSATC-BR Ground Station – **GS(INPE – CRS)** Santa Maria, RS,

&

NANOSATC-BR **Integration and Tests Laboratory for Nanosatellites - LITN** at
CRS/COCRE/INPE-MCTIC



NANOSATC-BR GS & LITN



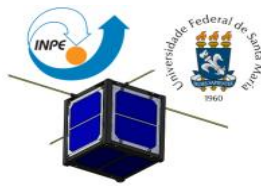
NANOSATC-BR Ground Station – **GS(INPE – CRS)** Santa Maria, RS,

&

NANOSATC-BR **Integration and Tests Laboratory for Nanosatellites - LITN** at
CRS/COCRE/INPE-MCTIC



NANOSATC-BR Ground Stations Network (GS)



GS(INPE – CRS) Santa Maria, RS.

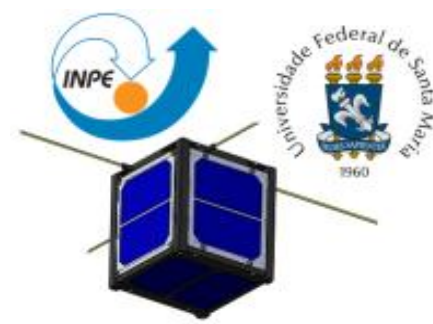


GS(INPE – ITA) São José dos Campos, SP.

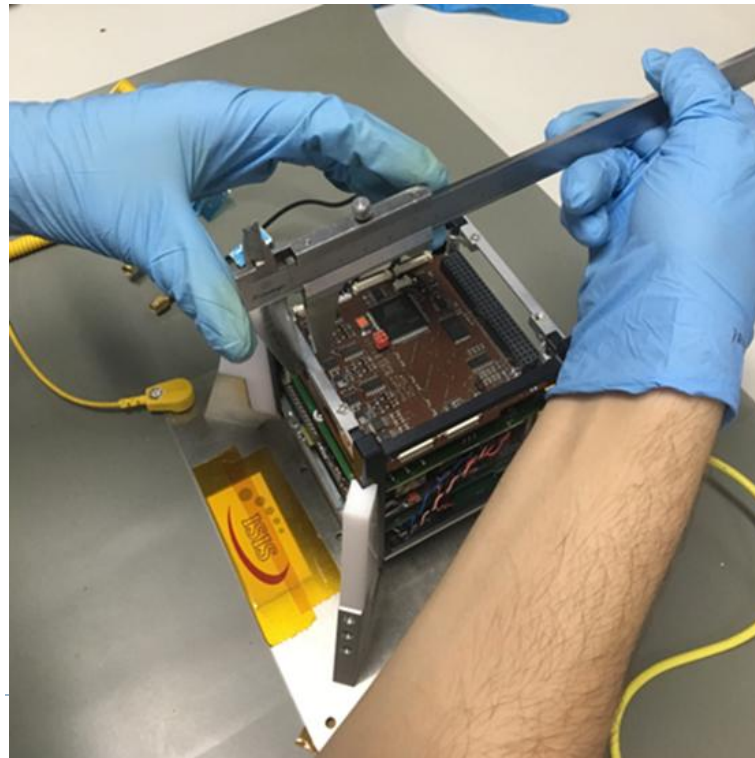
The **NANOSATC-BR's Ground Station Network** (GS) is already installed and in operation: **on left - GS(INPE-CRS)** at CRS/COCRE/INPE-MCTIC, in Santa Maria, RS, and **on right - GS(INPE-ITA)** at ITA/DCTA-MD, in São José dos Campos, SP, in Brazil.



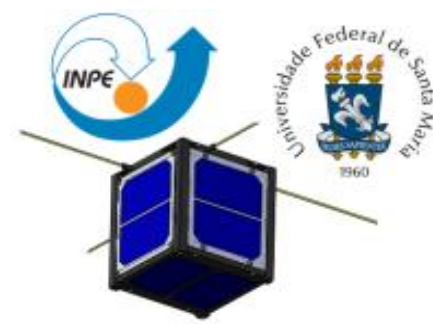
NCBR3 - CURRENT SITUATION



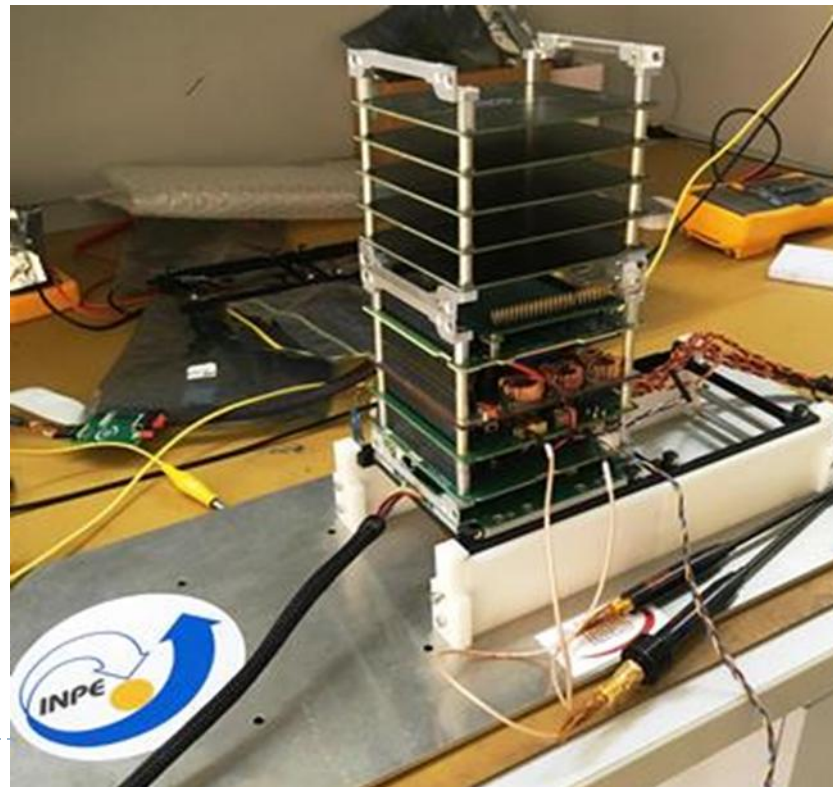
The **NCBR1 Engineering Model - EM**, in the near future, will become the **NANOSATC-BR3 - 1U CubeSat**, which is currently being studied and tested by the students of Aerospace Engineering from UFSM at the **Laboratory of Integration and Tests for Nanosatellites (LITN)**:



NCBR4 - CURRENT SITUATION



The **NCBR2 Engineering Model – EM**, will become the **NANOSATC-BR4 - 2U CubeSat**, which is currently being studied and tested by students and Software Engineers at **INPE – São José dos Campos**:



NANOSATC-BR – NCBR

Capacity Building



- ▶ The **major objective** of the INPE-UFSM's NCBR Program is to perform a **Specialized Human Resource Capacity Building Program** through the training of UFSM's undergraduate and former students.
- ▶ **Capacity a new generation of Scientists, Engineers, Researchers and Computer Scientists** through a CubeSat Program.
- ▶ **Approximate the Brazilian Space Program to Universities**, such as: UFSM, UFRGS, UFRN, UFABC, UFMG and USP.
- ▶ Therefore, **the Program provides hands-on training and learning** with **Aerospace Engineering & Technologies** and **Space Weather** issues



THE BRAZILLIAN NANOSATC-BR TEAM

x

Capacity Building



It is the NANOSATC-BR CUBESAT DEVELOPMENT PROGRAM policy not to delete any name of the 70 persons who is participating or did collaborate, directly or indirectly, with its projects and after that left the Program.

1 - NELSON JORGE SCHUCH, 2 - OTÁVIO SANTOS CUPERTINO DURÃO, 3 - ALEXANDRE ÁLVARES PIMENTA, 4 - POLINAYA MURALIKRISHNA, 5 - ADRIANO PETRY, 6 - MARLOS ROCKENBACH DA SILVA, 7 - JOSÉ VALENTIN BAGESTON, 8 - ODIM MENDES JR, 8 - NALIN BABULAU TRIVEDI, 9 - SEVERINO LUIZ GUIMARÃES DUTRA, 10 - ALISSON DAL LAGO, 11 - CLEZIO MARCOS DENARDINI, 12 - EZEQUIEL ECHER, 13 - LUIS EDUARDO ANTUNES VIERA, 14 - GEILSON LOUREIRO, 15 - MARIA DE FÁTIMA FRANCISCO MATTIELLO, 16 - MARIO CELSO DE ALMEIDA, 17 - VALDEMIR CARRARA, 18 - JOSÉ SERGIO DE ALMEIDA, 19 - HELIO KUGA, 20 - RAFAEL LOPES COSTA, 21 - LUCAS LOPES COSTA, 22 - NATANAEL RODRIGUES GOMES, 23 - RENATO MACHADO, 24 - ANDREI PICCININI LEGG, 25 - JOÃO BAPTISTA DOS SANTOS MARTINS, 26 - RICARDO REIS, 27 - FERNANDA GUSMÃO DE LIMA KASTENSMIDT, 28 - RUBENS ZOLAR GEHLEN BOHRER, 29 - EDUARDO ESCOBAR BÜRGER, 30 - CASSIO ESPINDOLA ANTUNES, 31 - TARDELLI RONAN COELHO STEKEL, 32 - CARLOS ROBERTO BRAGA, 33 - JULIANO MORO, 34 - WILLIAM DO NASCIMENTO GUARESCHI, 35 - CLAUDIO MACHADO PAULO, 36 - FERNANDO LANDERDAHL ALVES, 37 - LUCAS LOURENCENA CALDAS FRANKE, 38 - MAURICIO RICARDO BALESTRIN, 39 - GUILHERME PAUL JAENISCH, 40 - IAGO CAMARGO DA SILVEIRA, 41 - RODRIGO PASSO MARQUES, 42 - TÁLIS PIOVESAN, 43 - JOSE PAULO MARCHEZI, 44 - TIAGO BREMM, 45 - VINICIUS DEGGERONI, 46 - LEONARDO ZAVAREZE DA COSTA, 47 - PIETRO FERNANDO MORO, 48 - THALES RAMOS MÂNICA, 49 - ANDERSON VESTENA BILIBIO, 50 - ANDREOS VESTENA BILIBIO, 51 - TIAGO TRAVI FARIAS, 52 - MARCOS ANTONIO LAURINDO DAL PIAZ, 53 - LAURO BARBOSA ALVES, 54 - PABLO ILHA VAZ, 55 - ELÓI FONSECA, 56 - LIDIA HISSAE SHIBUYA SATO, 57 - MARCELO HENRIQUE ESSADO DE MORAIS, 58 - CRISTIANO STRIEDER, 59 - FERNANDO SOBROZA PEDROSO, 60 - ALEX MÜLLER, 61 - ARTUR GUSTAVO SLOGO, 62 - LORENZZO QUEVEDO MANTOVANI, 63 - ALAN PITTHAN COUTO; 64 - PEDRO CAMARGO KEMMERICH; 65 - MAURICIO BEUX DOS SANTOS, 66 - RICARDO DUARTE, 67 - LUIZ SIQUEIRA FILHO, 68 - GABRIEL HENRIQUE DA ROSA VIZCARRA, 69 - ANDRÉ LUÍS DA SILVA. 70 - DENIEL DESCONZI MORAES.

NANOSATC-BR – NCBR

Capacity Building - Training



- ▶ **Training of students** at universities and space industries **abroad** through the former Brazilian Mobility Program Science Without Borders, in several institutions worldwide:

TU - Berlin, University of Wurzburg and DLR in Bremen in Germany;

Innovative Solutions In Space - ISIS – Delft, in The Netherlands;

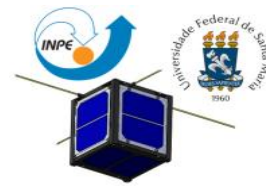
La Sapienza – Università Degli Studi di Roma, TU - Roma, in Italy,

University at Buffalo, University of Tennessee and NASA - Goddard

Space Flight Center , in USA



NANOSATC-BR – **Capacity Building** Current Engineering Research - I

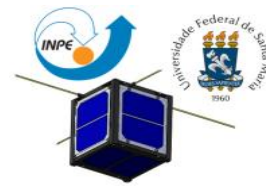


Students from **Aerospace** and other **Engineering Courses** at UFSM currently perform Research and Simulation at the CRS/COCRE/INPE-MCTIC in numerous subsystems and topics, such as:

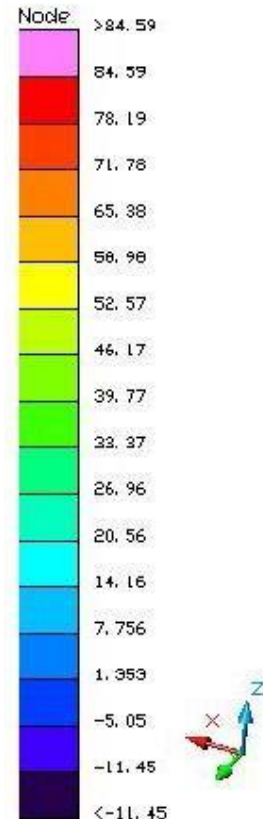
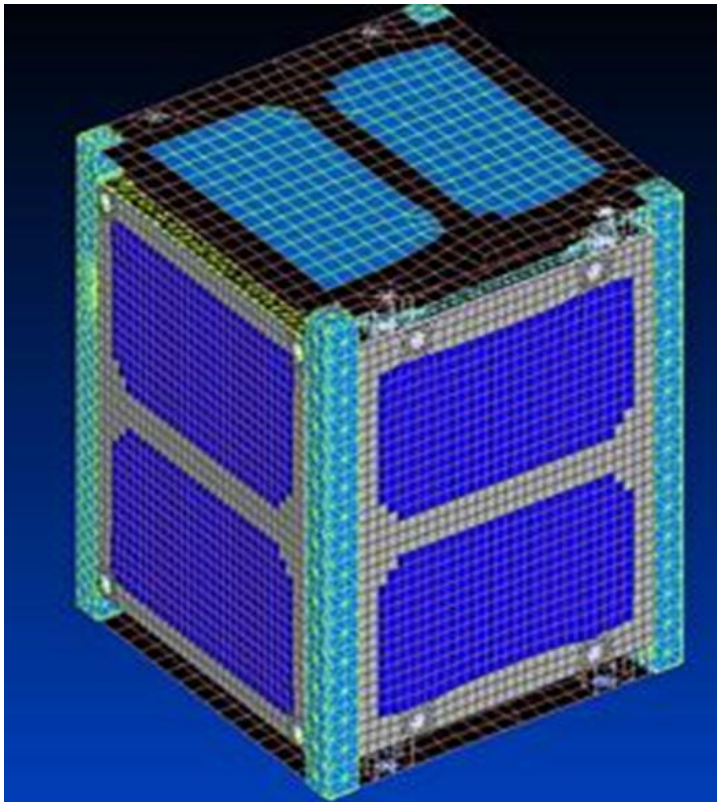
- **Thermal Subsystem** of Spacecrafts;
- **Structural and Mechanical** Analysis;
- **Orbital Analysis** and Flight Performance;
- Development of **Electronic Devices**;
- **Protection Strategies** for Solar Events caused by the Space Weather;

NANOSATC-BR – Capacity Building

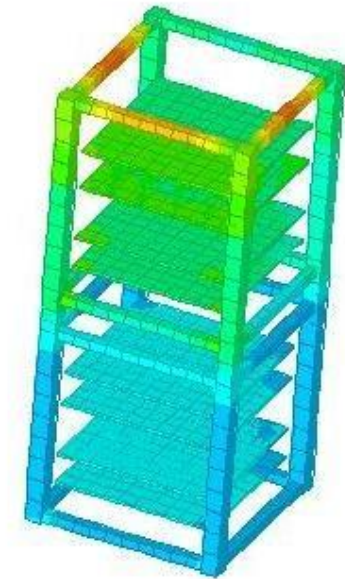
Current Engineering Research - II



Examples of Mechanical Engineering Analysis – Quasi Static and Thermal:



Temperature [C], Time = 0 sec



CONCLUSIONS



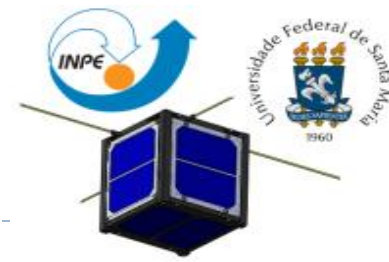
➤ Since it **provides to young Brazilian people contact with low cost and fast development on Space Technology**, the Brazilian:

INPE-UFSM NANOSATC-BR, Cubesat Development Program

proves to be an excellent tool for developing a new generation of Scientists, Engineers and Researchers, in **Aerospace Technologies** in Brazil.

➤ It is **expected an increase** in the Brazilian Government Agencies **support and more investments for the development of Space Technology** and **for new universities initiatives, in Brazil**, such as the Brazilian INPE-UFSM NANOSATC-BR Cubesat Development Program, with its CubeSats: the **NANOSATC-BR1 & NANOSATC-BR2 Projects**.

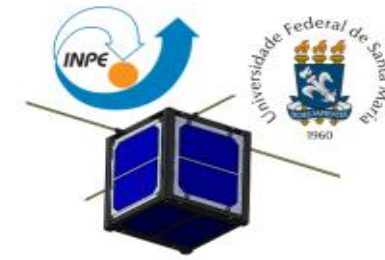




ACKNOWLEDGES

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-

The NANOSATC-BR Program site is: www.inpe.br/crs/nanosat/



Obrigado

Thanks

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