IAA-AAS-CU-17-03-02

NANOSATC-BR STATUS
A JOINT CUBESAT-BASED PROGRAM DEVELOPED BY INPE AND UFSM

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**** **The NANOSATC-BR Team** - Seventy persons from: INPE/MCTIC, UFSM, SMDH, UFRGS, UFABC, UFMG, EMSISTI, ITA/DCTA-MD

Technical Session: Mission
4th IAA Conference on University Satellites Missions & CubeSat Workshop
International Academy of Astronautics – IAA
Roma – Italy
December 4th – 7th, 2017

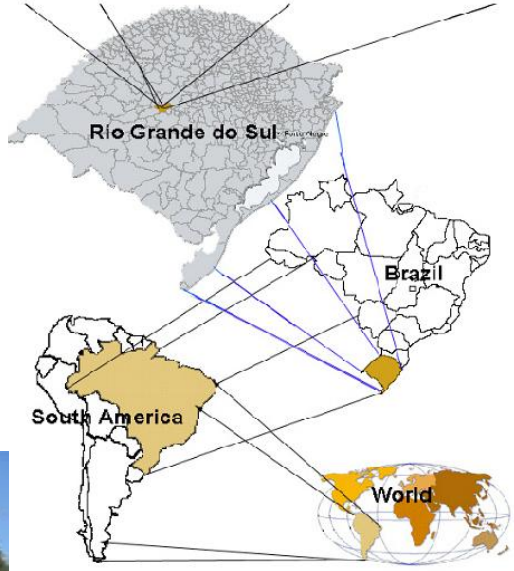
THE BRAZILLIAN NANOSATC-BR TEAM

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 SLONGO, 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.

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

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 to built the NANOSATC-BR1 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.
- To bring technology from abroad and incorporate it through the industry – joint ventures.
- To create an industry in Brazil for this class of satellite.

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 and researchers engineering and computing sciences** through a CubeSat Program.

- **Approximate the Brazilian Space Program to Universities**, such as:

  UFSM, UFRGS, UFRGN, UFABC, UFMG and USP.

- Therefore, **the Program provides hands-on training and learning** with

  Aerospace Engineering & Technologies and Space Weather issues

- **Training of the students,** at INPE and at the Brazilian space industries as well, as at universities and space industries **abroad**:

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

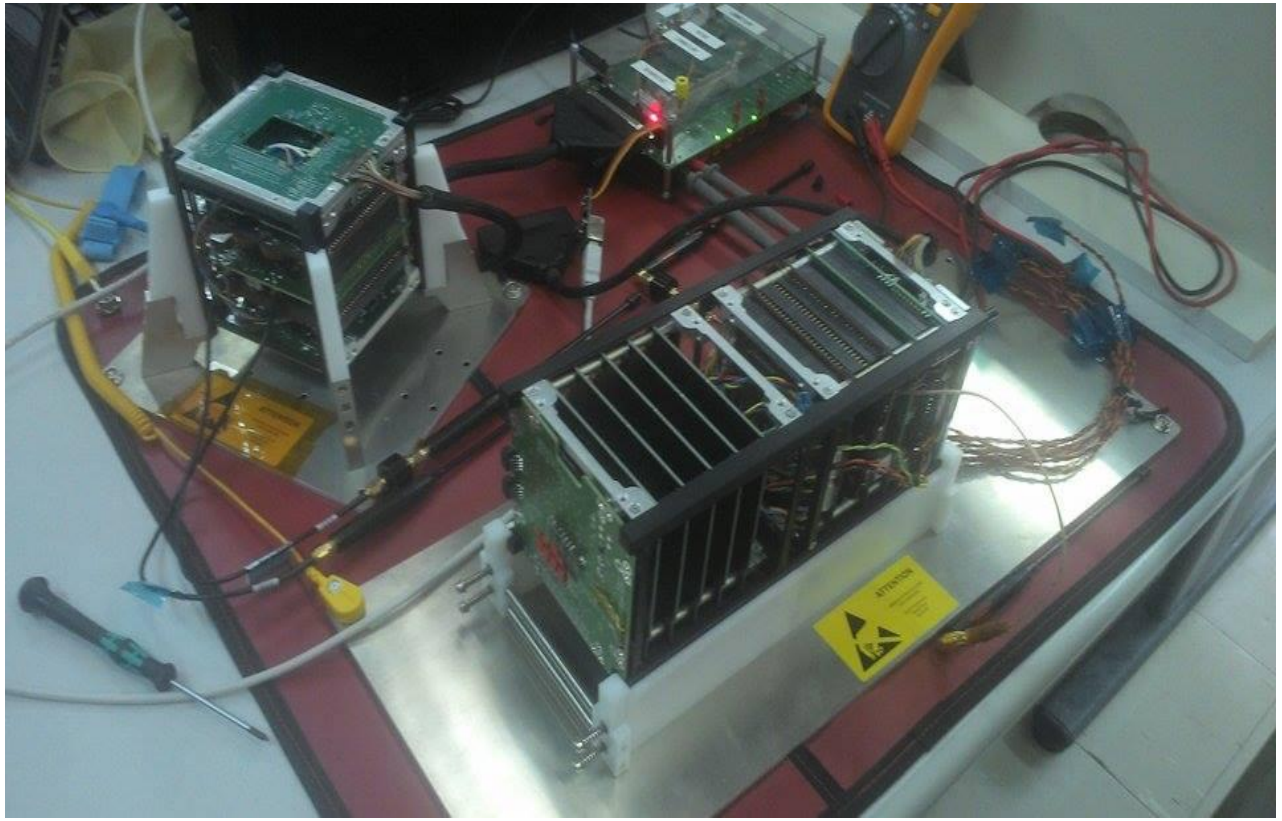
  Innovative Solutions In Space - ISIS – Delft, in The Netherlands;

  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

The NCBR1 and NCBR2
Engineering Model Platforms

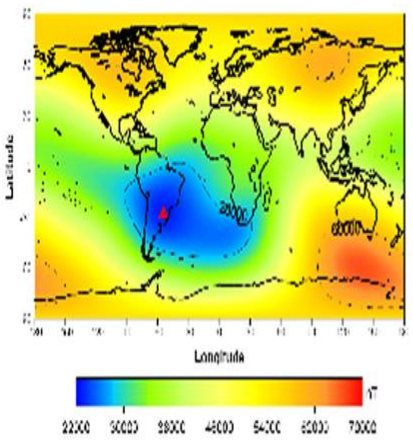


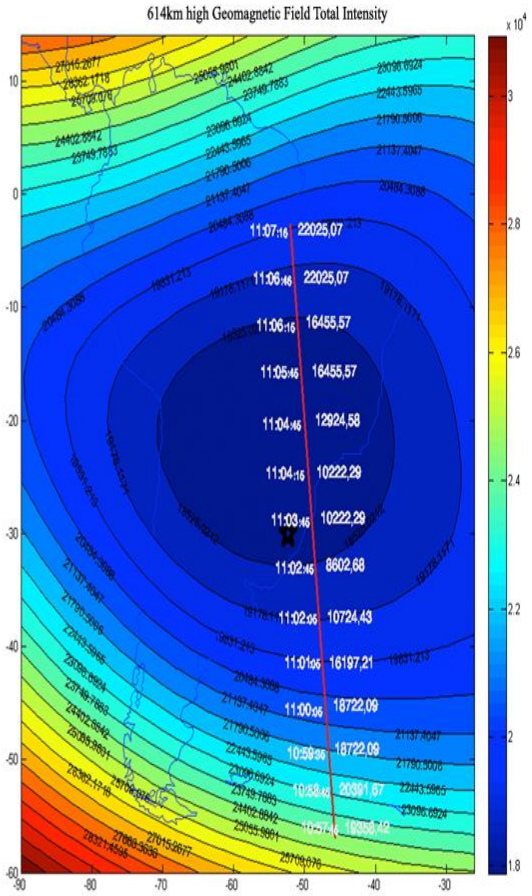
The **NCBR1, is a 10x10x11.3 cm cube, weighing 0.965 kg.**
It has name and up and down frequencies link determined by
The International Amateur Radio Union – IARU, in 2011.

NCBR1 - Science Mission

- Earth Magnetic Field intensity measurements.
- South American Magnetic Anomaly – SAMA.
- XEN-1210 is a three-axis magnetometer 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 observed data collected by **NCBR1** compared with theoretical figures for the Geomagnetic Field intensity for the same altitude from the modeling by the **IGRF-IAGA/IUGG.**

References

[*] Heirtzler, 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
Technological Mission - Payloads (1a)

- The SMDH - IC - Driver "on/off" **:**
  - The **HR-DRVTestChip-I** turn payloads **on and off** as received commands from the ground.
  - Demand presented by INPE Space Electronic Division.
  - To be used for INPE Multimission Platform – PMM (not available at CBERS).
  - **Radiation hardening** by design:
    - Design by Santa Maria Design House - SMDH, at UFSM
    - Use of own library

NCBR1
Technological Mission - Payloads (2a)

- **Radiation resistance FPGA - FIELD PROGRAMMABLE GATE ARRAY**

  Programmed algorithm for fault tolerance – Developed by UFRGS, Informatics Institute - Microelectronics Group, in Porto Alegre, RS, Brazil, [*].
  - Radiation resistance FPGA – industrial.
  - Second method for radiation hardening.

- Board final manufacturing by ISIS (Platform interfaces, BoB, etc.)

Reference:

[*] Guareschi, W. N. et al, "Analysis of Field Programmable Gate Array Alternatives for Use In Nanosatellites", 61th. IAC, Intl. Astronautical Federation, 2010.

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 a charge because it was **damage by magnetic solar storms** in September-October 2014.

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

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

NANOSATC-BR Ground Stations Network (GS)

GS(INPE – CRS) Santa Maria, RS.

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

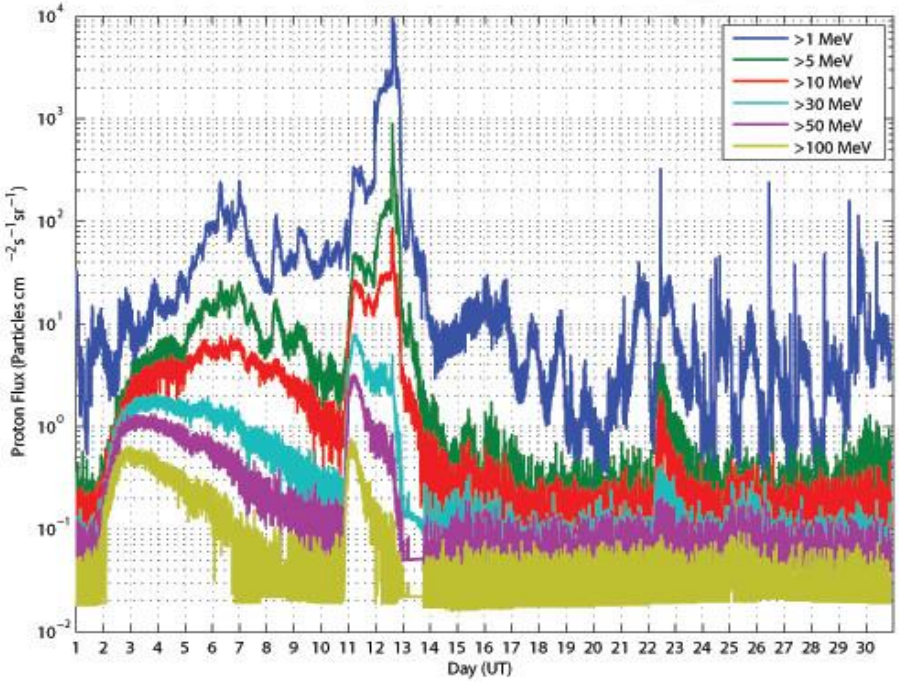
The NANOSATC-BR's Ground Station Network (GS) is already installed and in operation: on left - GS(INPE-CRS) at CRS/INPE-MCTI, in Santa Maria, RS, and *on right* - GS(INPE-ITA) at ITA/DCTA-MD, in São José dos Campos, SP, in Brazil.

NCBR1 – SMDH - Integrated Circuits (IC)

Total Ionization Dose (TID) - Single Event Effects (SEE)

➢The **Solar Energetic Protons** detected by **GOES-15** satellite during **September 2014,** [*], were used in order to analyze and quantify the energy levels measured during the R3 occurrence, [*], and thus to **estimate the tolerance of NCBR1 - Integrated Circuits (IC)** customized cells.

➢During **September 2014 first two weeks** were reported Solar Energetic Protons - **SEP**s with energies **above 100MeV,** [*].



The **Solar Energetic Protons** at different levels of energy detected by the **GOES-15** satellite during **September 2014**[1].

Reference:

[*] Noval, J. J. S. ; Medeiros, L. ; Martins, J. B. S. ; Schuch, N. J. ; Durao, O. S. C. ; Machado, R. "Design considerations for Radiation Hardened ASIC used as technological payload in NANOSATC-BR1". In: 2nd IAA Latin American CubeSat Workshop, 2016, Florianópolis. Conference Proceedings 2nd IAA, 2016.

NCBR2 - Current Situation - I

➢The **NCBR2,** is a **2U CubeSat, (10x10x22.6 cm),** has three major objectives: **Capacity Building, Scientific Mission** and **Technological Mission** development.

➢The Scientific Mission is to monitor the Earth's Ionosphere and Magnetic Field, with a Langmuir probe and a XEN-1210 magnetometer.

To finalize the NCBR2 it is necessary to do the following tasks:

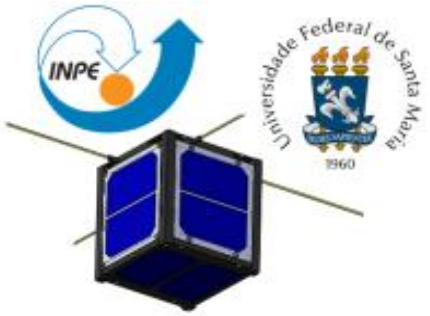
➢- **SDATF - Attitude Determination System tolerant to failure** - First Brazilian System Attitude Determination, with triple redundancy, **presently in integration and testing with the NCBR2 - EM platform**;

➢- **Langmuir Probe** - Delivered for testing and integration with the NCBR2 - EM platform and the onboard software - OBDH;

➢**Communication Experiment Packet** (store forward) - AMSAT-BR and SP-LABRE.

➢- **CubeSat board with three experiments**: FPGA-UFRGS; Magnetometer; IC - SMDH/UFSM, first unit scheduled for delivery in Dec. 2017.

NCBR2 - Current Situation - II



- 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** is now waiting the **budget** from the **Brazilian Space Agency - AEB for hiring the launch** and **future operation of NCBR2 in orbit**.

- The NCBR2 is **planned to be launched in the second semester of 2018**.

CONCLUSIONS

➢Since it is **provided to young Brazilian people contact with low cost and fast developments on Space Technology**, the Brazilian:

INPE-UFSM NANOSATC-BR, Cubesat Development Program

proved to be an excellent tool for developing a new generation of scientists, engineers and researches, 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 authors thank to **Santa Maria Design House - SMDH**, to Professors Dr. Ricardo Reis and Dr. Fernanda G. L. Kastensmidt from the **Graduate Program in Microelectronics, Informatics Institute from UFRGS**, to **UFABC** (**Dep. Engª Aeroespacial** - Dr. Luiz Siqueira Filho), **UFMG** (**Dep. Engª Eletrônica** - Dr. Ricardo Duarte), the **CITAR-FINEP** Project, and to **MCTIC-CNPq/INPE(PCI-PIBIC-PIBIT)** and **FAPERGS** Programs for fellowships.
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- Dr. Marlos Rockenbach thanks CNPq for the fellowship under the number 301495/2015-7.

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

Muito Obrigado

Thanks

Grazie

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