MINISTÉRIO DA CIÊNCIA, TECNOLOGIA, INOVAÇÕES E COMUNICAÇÕES

INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

R&D and Plans for Small Satellite Missions

Ricardo Galvão

11th September 2018

"Modern microsatellites revolutionized space in the same way that the personal computer (PC) revolutionized computing. The low cost of entry to space afforded by small satellites and their growing capabilities enabled any nation, government department, <u>small companies, and individual universities</u> to access space directly in an affordable and low risk manner."

Martin N. Sweeting, Proceedings of the IEEE <u>106</u>, 343 (2018)

"There is no doubt that nanosatellites and especially the CubeSat standard has greatly increased access to space for <u>smaller organizations and especially educational establishments;</u> however, <u>there has been a very high failure rate</u>."

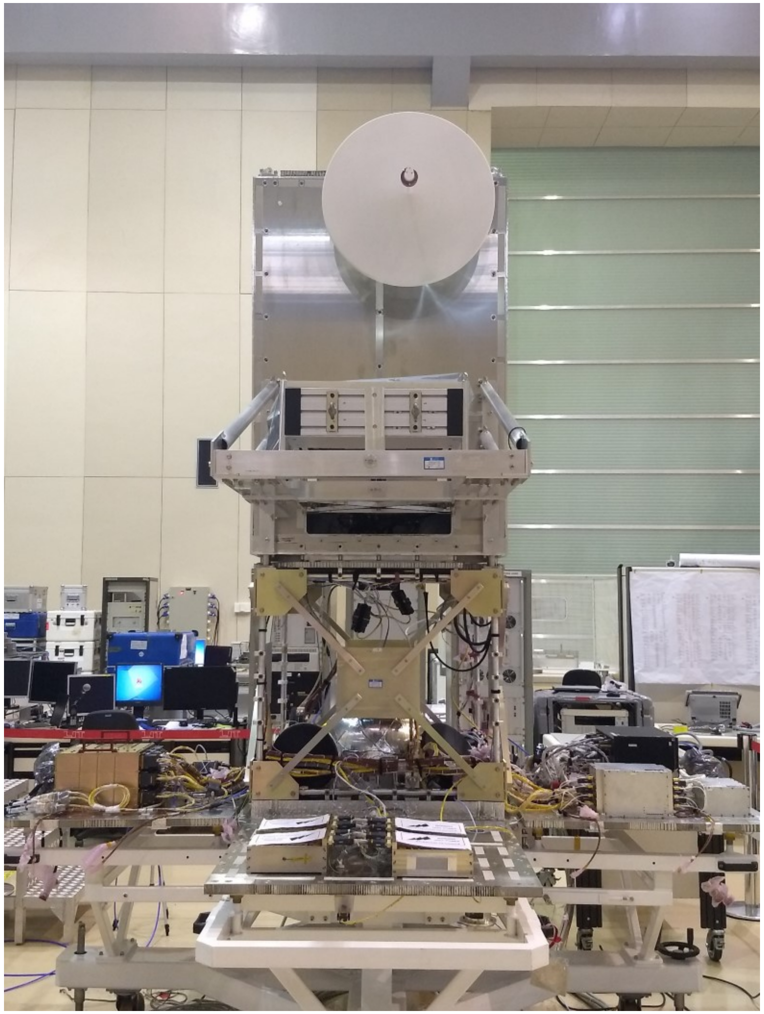
"Small satellites have become fashionable and form a major component of the so-called "NewSpace" environment that tends to imply initiatives led by business and industry with private funding, <u>rather than the more traditional model led by government agencies</u>."

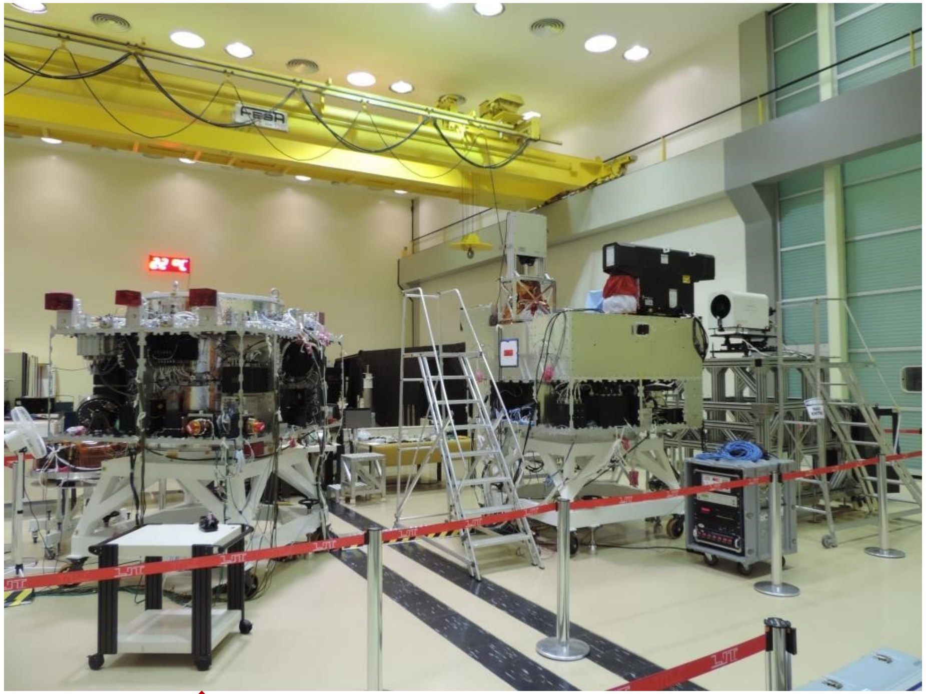
Martin N. Sweeting, Proceedings of the IEEE <u>106</u>, 343 (2018)

In this scenario, what role should be played by a large government research institute like INPE?

Routine Space Technology Activity in INPE

Medium (500 to 1000 kg) and Large Satellites (> 1000 kg)





CBERS 4A

Amazônia 1

Routine Space Technology Activity in INPE

LABORATORY OF INTEGRATION AND TESTING







Should INPE develop its own general program on small satellites ?

"Constructive" Alternatives

- Capacity building
- Play the role of open installation giving specialized support to more ambitious projects
- Develop a program concentrated on special relevant applications or advancement of small satellite technology
- Develop a program focused on scientific applications of small satellites

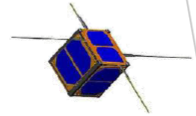
"Hindrance" Policy

- Develop a program that competes with those suitable for development in universities and startup companies.

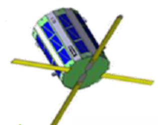
Kleber Naccarato - 2017 Symposium

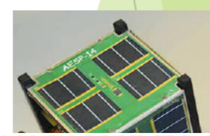
BRAZILIAN'S CUBESATS' INITIATIVES

- NANOSATC-BR1 (UFSM / INPE)
  - 2014, 1U Architecture, 600km Altitude, http://www.inpe.br/crs/nanosat/
  - **Assess data from South America Magnetic Anomaly & Brazilian's Ionospheric Electrojet**
- SERPENS-1 (AEB)
  - 2015, 3U Architecture, International Colaboration
  - UnB, Univ. Vigo, Sapienza, Cal Poly, Morehead, UFSC, UFMG, UFABC, IFF
- CONASAT
  - First CubeSat constellation (in development)
- Tancredo I (UbatubaSat Project)
  - 2017, TubeSat (~10x13cm), http://www.ubatubasat.com/
- ITASat-I (ITA)
  - 6U Architeture (in developme
- AESP-14 (ITA / LIT-INPE)
  - 2015, 1U Architecture, 400km



CONASAT





BRAZILIAN'S CUBESATS' INITIATIVES

- NANOSATC-BR2 (2U)
  - **Langmuir Probe (CEA / INPE)**
  - **Magnetometer (UFSM/UFRGS)**
  - Altitude Control System (INPE / UFMG / UFABC)
- SPORT - Scintillation Prediction Observations Research Task
  - International cooperation: NASA / AEB / CEA-INPE / ITA
  - **To study ionosphere plasm bubbles, which severe compromise / block satellite signal transmissions from / to Earth**
  - Scientific payloads: Ion Velocity Meter, GPS Occultation Receiver, Electric Field Probe, Langmuir Probe, Fluxgate Magnetometer and Swept Impedance Probe
- ITASat-2 (ITA)
- SERPENS-2 (AEB)
- FloripaSat (UFSC)
- 14BISat (IFF)
- Tancredo-2 (UbatubaSAT Project)

“Although microsatellites are physically small, they are nevertheless complex vehicles that exhibit virtually all the characteristics of a large satellite. <u>This makes them particularly suitable as a focus for the education and training of scientists and engineers</u> by providing a means of direct, hands-on experience at all stages and in all aspects (both technical and managerial) of a real satellite mission—from design, production, test, and launch through to orbital operation.”

Martin N. Sweeting, Proceedings of the IEEE <u>106</u>, 343 (2018)

1° CubeDesign

SmallSats, big ideas

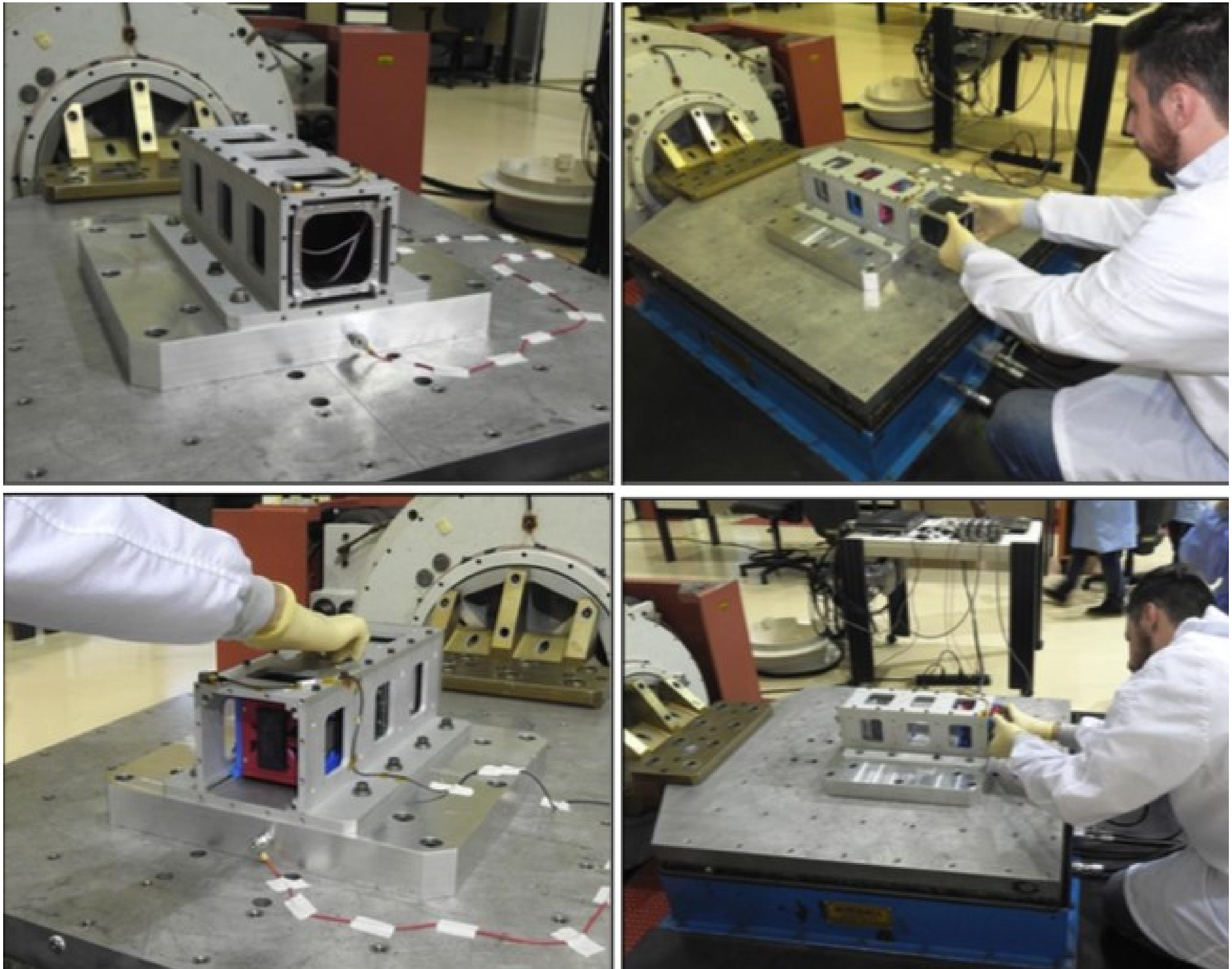
Tragam seus satélites e mostrem que são os melhores Engenheiros Espaciais!

Organização: CTEE INPE MINISTÉRIO DA CIÊNCIA, TECNOLOGIA, INOVAÇÕES E COMUNICAÇÕES BRASIL GOVERNO FEDERAL

Winter Contest on Cube Satellites

Winter Contest on Cube Satellites

Winter Contest on Cube Satellites



Outreaching Activities

2018 Meeting of the Brazilian Society for Advancement of Science

Open Support Infrastructure for Advanced Projects

Space Engineering and Technology

CPRIME

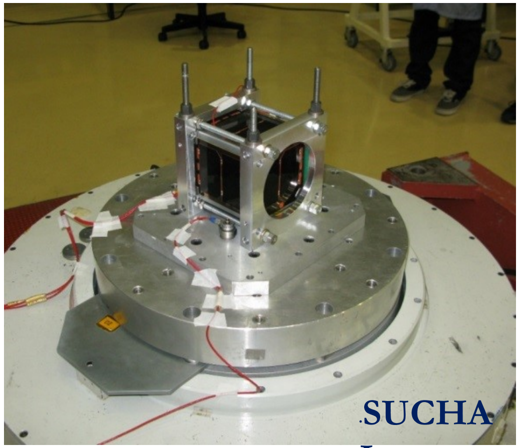
Center for Integrated Projects of Space Missions

(improved phase zero analysis ➡ decrease failure rate)

Systems	Telecommunication	Ground Systems
Operations	Power system	Simulations
Orbit analysis	Layout	Launching alternatives
Payloads	Mechanisms	Development approaches
Altitud and Orbit Control	Structures	Risk analysis
Propulsion	Thermal control	Cost analysis
Inboard supervision	COTS analysis	

CPRIME

Integration and Testing - LIT



SUCHAI

INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Ministério da Ciência, Tecnologia e Inovação

BRASIL

PAIS RICO É PAIS SEM POBREZA

PROGRAMA / PROGRAM: CUBESAT

DOCUMENTO/ DOCUMENT NO.: LIT21-AESP14-MP-001

PÁGINA / PAGE: i

VERSÃO / ISSUE: 1

TÍTULO / TITLE

PROJETO DE MGSE PARA ENSAIO DINÂMICO (VIBRAÇÃO) PARA CUBESAT 1U

LIT

CENTRO DE DOCUMENTAÇÃO

CÓPIA

CÓDIGO / CODE A.P.

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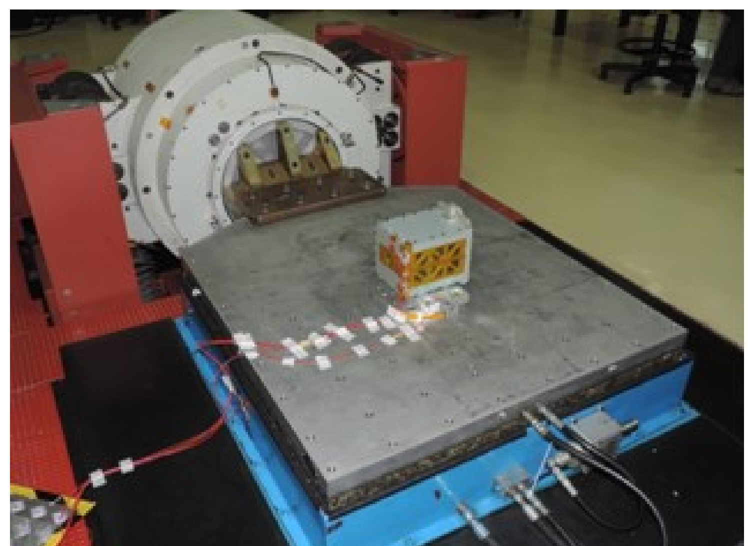
Eduardo Escobar Bürger — EDUARDO ESCOBAR BÜRGER, PESQUISA E DESENVOLVIMENTO	11,06,14	CARLOS DE OLIVEIRA LINO, GERENTE DA QUALIDADE / LIT	16,06,14
João G. Figueirôa — JOÃO GUILHERME FIGUEIRÔA, ENSAIOS DINÂMICOS	11,06,14	GEILSON LOUREIRO, CHEFE LIT	16,06,2014

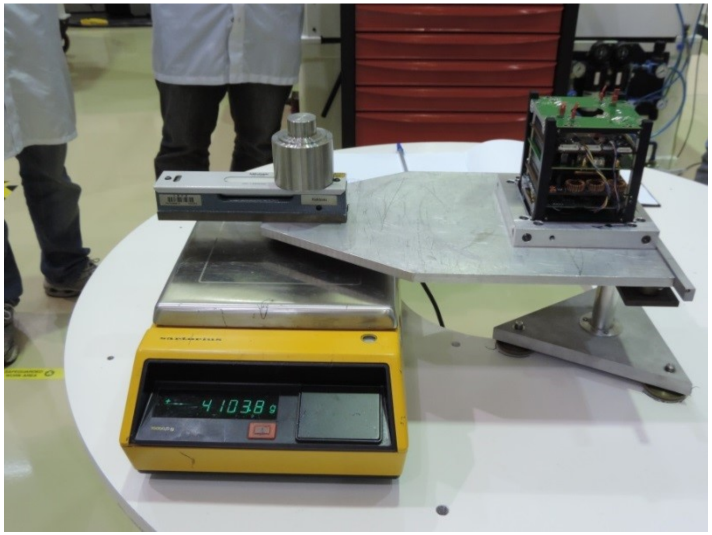
Vibration/Mass properties Interface developed by AESP-14 Team

MGSE for 1U (Developed by AESP-14)



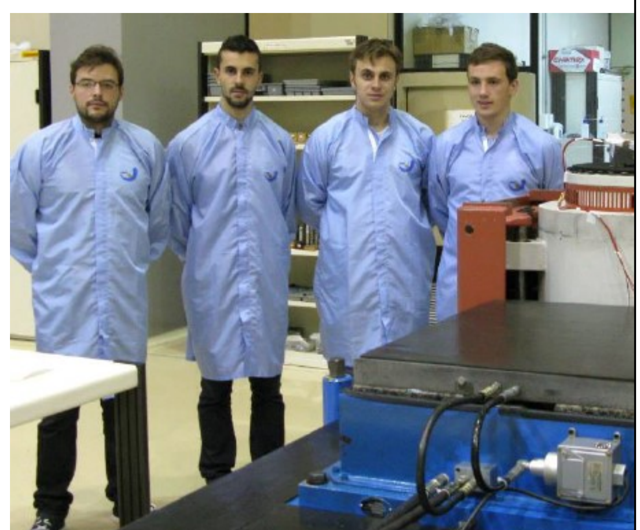
ISL/ISIS 1U Vibration Test-POD

NANOSATC-BR1 (1U)Assembly, Integration and Tests



- Vibration tests
- Thermal Vacuum Test
- Bake-out procedure
- Mass Properties (mass, MOI and CoG)

With support of LSIS/LIT staff for Flight Model integration and testing specifications.



NANOSATC-BR1
System Engineering

Ver. 2.0 Rev.1
Date: 07/01/2014
Page | 1

Author:
Eng. Eduardo Escobar Bürger

Verified by:

Dr. Otávio dos Santos Cupertino Durão

Approved by:

Dr. Nelson Jorge Schuch

SYSTEM ENGINEERING

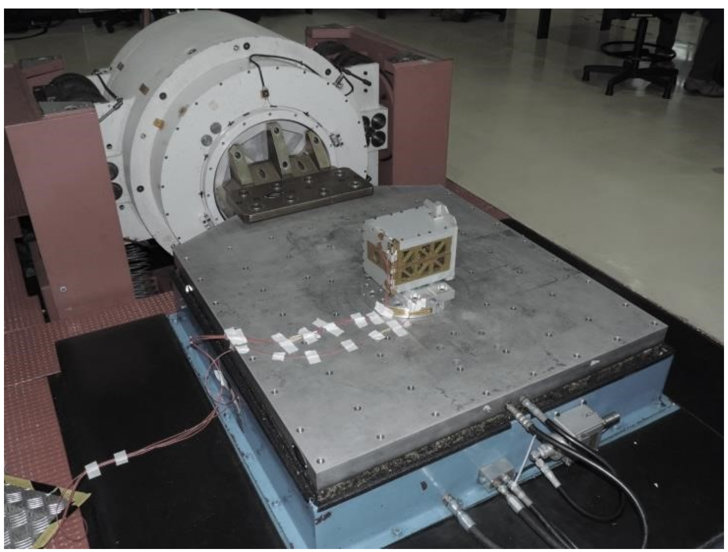
NANOSATC-BR1_SE_AI&T-Plan

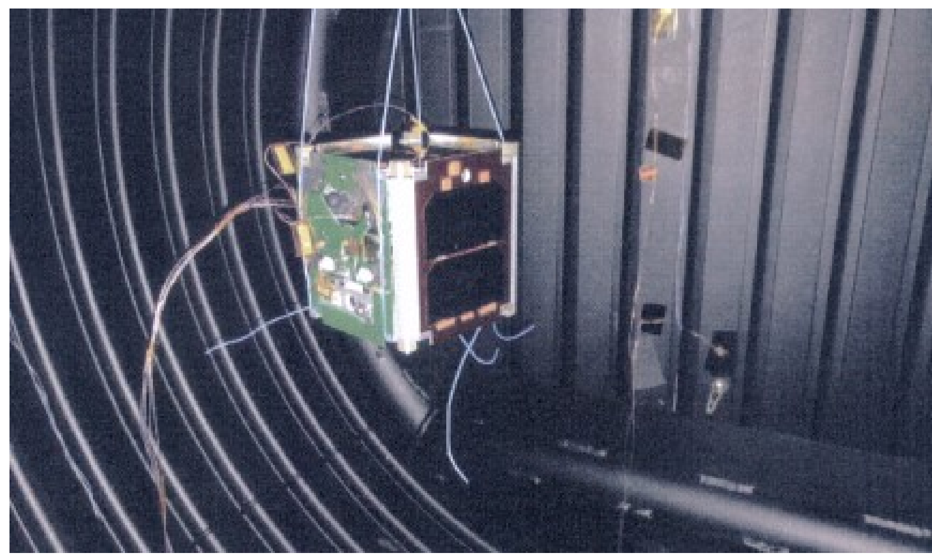
NANOSATC-BR1 TEST PLAN

CENTRO REGIONAL SUL DE PESQUISAS ESPACIAIS – CRS/CCR/INPE – MCT
UNIVERSIDADE FEDERAL DE SANTA MARIA – UFSM
Santa Maria, RS, Brasil

SUCHAI (1U - Chile) Environmental Tests

- EM and FM environmental testing
- Vibration tests
- Thermal Vacuum Test
- Mass Properties

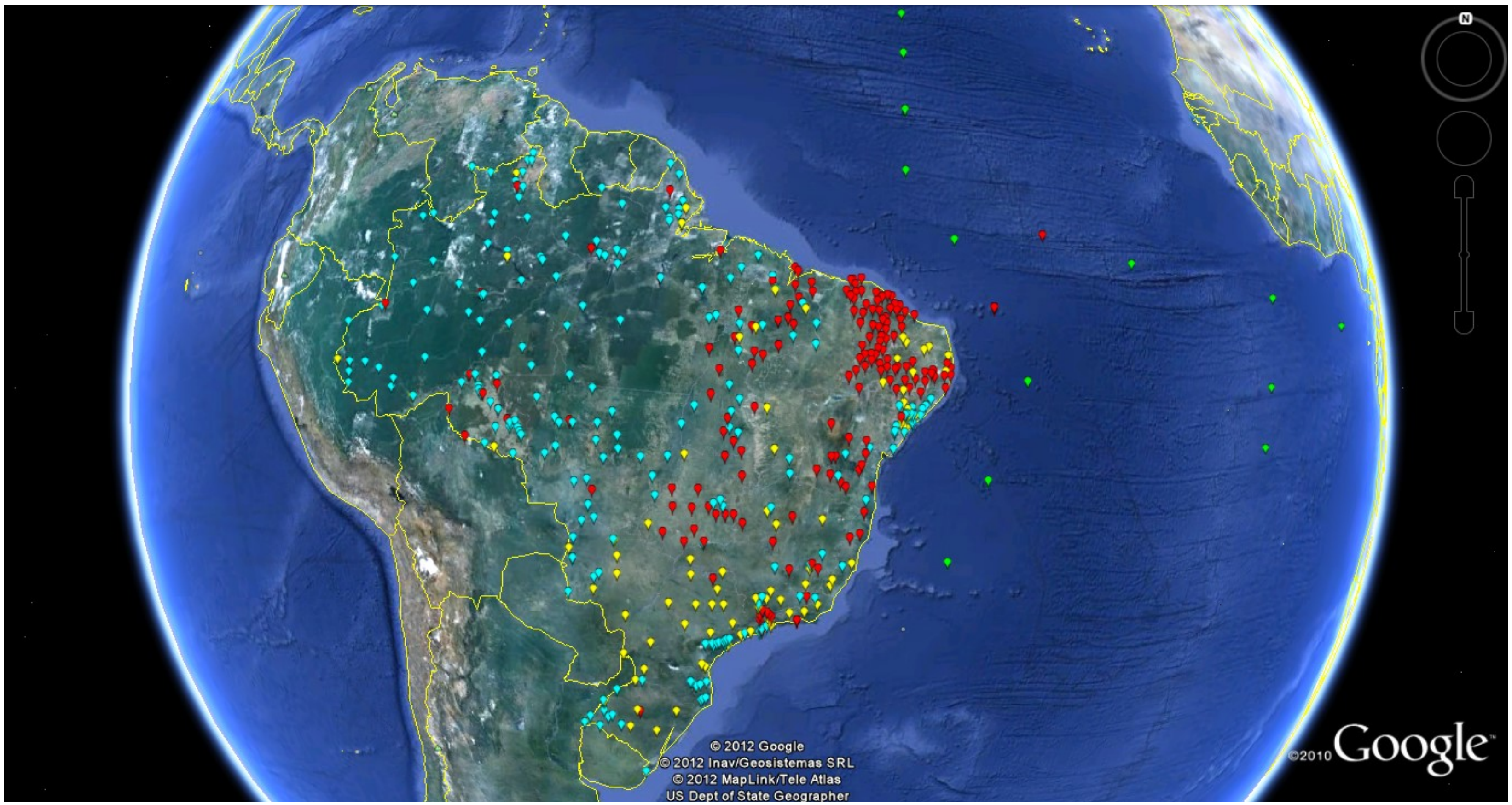




Program concentrated on special relevant applications or advancement of small satellite technology

CONASAT PROJECT - CRCRN

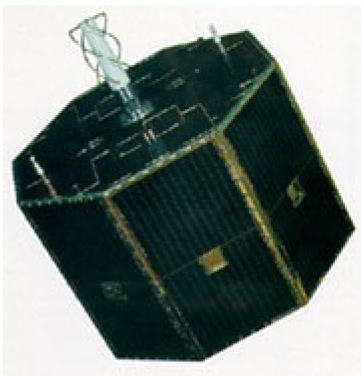
Develop a low cost solution for the Brazilian System of Environment Data Acquisition



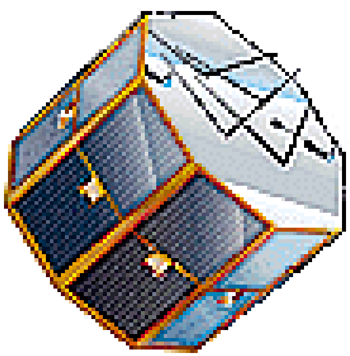
Brazilian System of Environmental Data Collecting Platforms

CONASAT PROJECT - CRCRN

SCD-1 (1993)



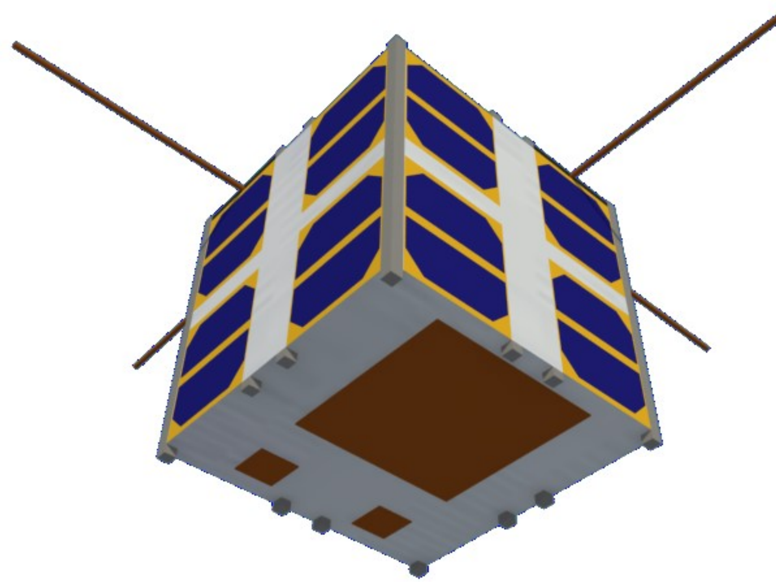
SCD-2 (1998)



1m × 1.5m; 115kg
25°, 750 Km Circular orbit
14 revolutions/day

Constelation of CubeSats

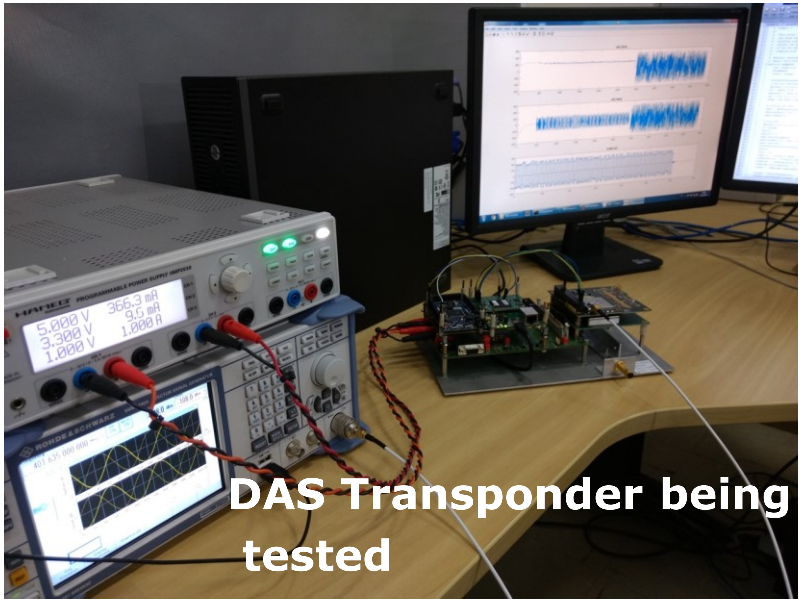
CONASAT - 1



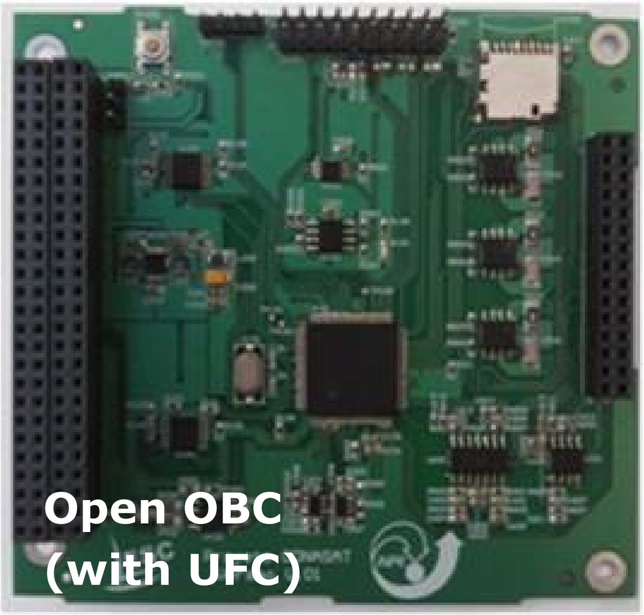
8U CubeSat

CONASAT PROJECT - CRCRN

www.crn2.inpe.br/conasat



DAS Transponder being tested



Open OBC (with UFC)

NANOSAT PROJECT - CRCRS

Get data from South America Magnetic Anomaly & Brazilian Ionospheric Electrojet

Offer hands-on training for Aerospace Engineering students of University of Santa Maria

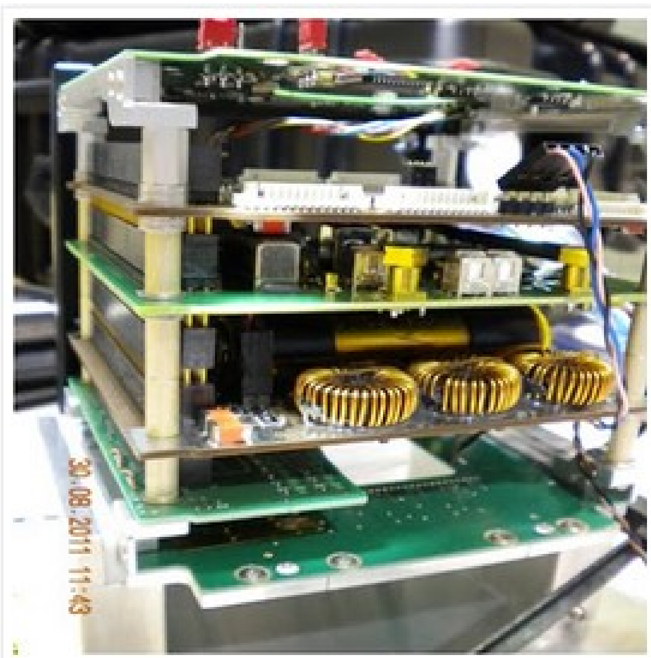
NANOSATC-BR Ground Station – GS

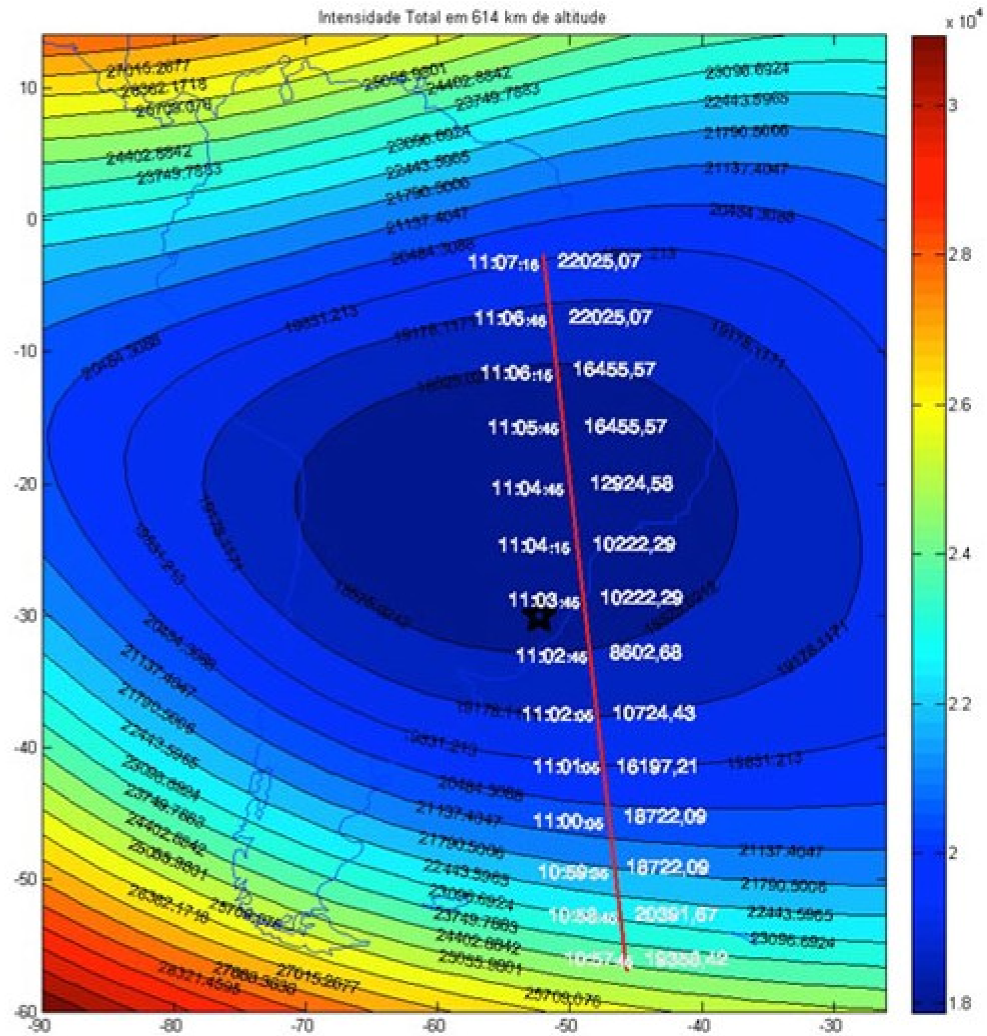
GS(CRCRS) Santa Maria, RS

GS(CRCRS) São José dos Campos

NANOSAT PROJECT - CRCRS

Get data from South America Magnetic Anomaly & Brazilian Ionospheric Electrojet





NanosatC-BR1

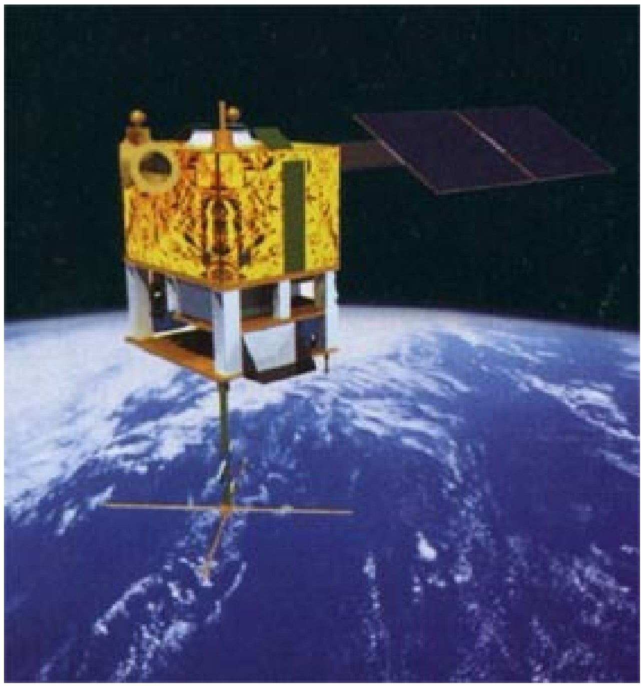
Operating for over four years

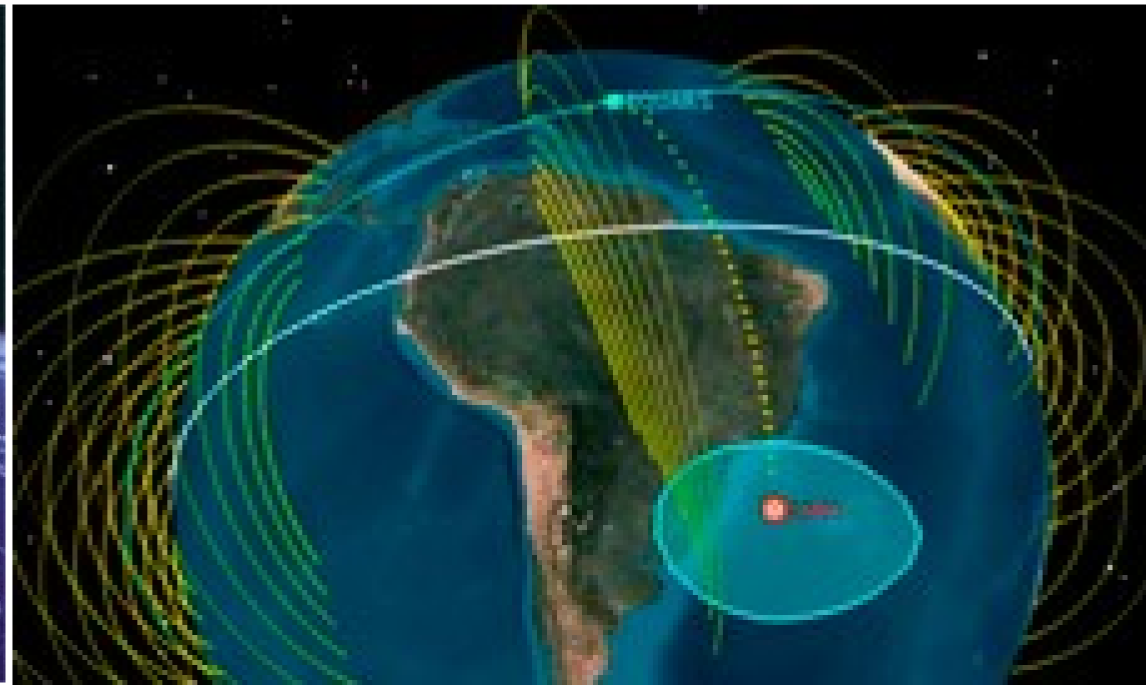
http://www.inpe.br/crs/nanosat/

EQUARS

Equatorial Atmosphere Research Satellite

(Low-High atmosphere coupling processes leading to plasma bubbles)





~120 kg;equatorial orbit; 15° inclination; 635 km

3 axis stabilized platform; NADIR poyinting

EQUARS

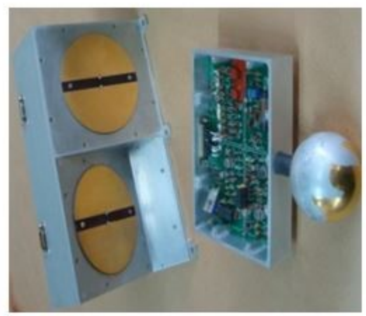
Equatorial Atmosphere Research Satellite

(Low-High atmosphere coupling processes leading to plasma bubbles)

Photometer to
register airglow

GROM

GPS receiver to employ the
radio occultation method



IONEX

HFC – high frequency
capacitive probe receiver

LP – Langmuir probe

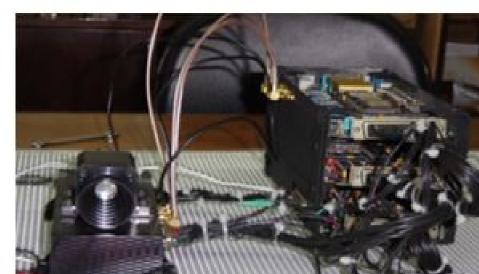
ETP – Electron
temperature probe

ELISA

Electrostatic Energy Analyzer
1 to keV

APEX

Alpha, Proton, and
ElectronfluXes



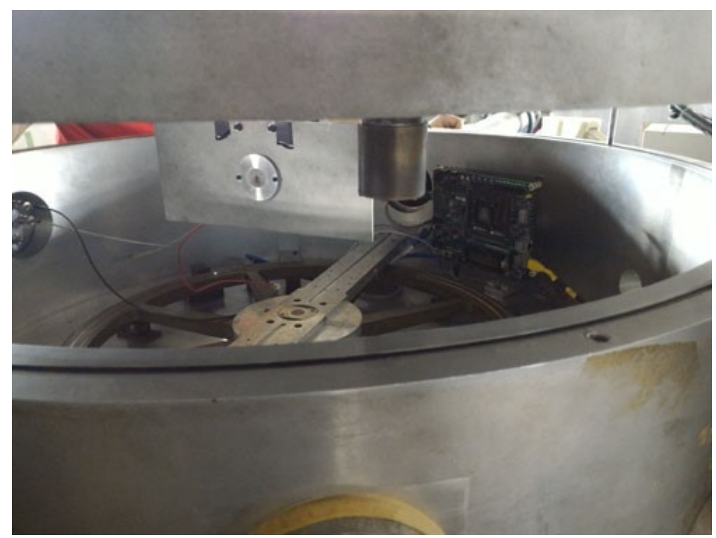
CITAR PROJECT

Radiation Resilient Integrated Circuits

Keck INSTITUTE FOR SPACE STUDIES

Small Satellites:
A Revolution in Space Science
2014

"CubeSat-derived NanoSats would hit significant challenges as they begin to work in deep space. Radiation tolerance on CubeSats has always been hit-or-miss. But as science missions require certain lifetime guarantees, radiation tolerance has become more of an issue."



Heavy-ion damage tests of FPGA-based SpaceWire component in the Pelletron Accelerator of USP

“Deep” Space Research

Home NASA Research Help Login

NSPIRES NASA Solicitation and Proposal Integrated Review and Evaluation System

NSPIRES Time: Sep 10, 2018 08:54 AM EDT

NASA Research
- Solicitations

View Solicitations
- Future
- Open
- Closed/Past Selected

NASA Research Announcement

Astrophysics Science SmallSat Studies

Solicitation: NNH18ZDA001N-AS3

Dates

Release	Fev 14, 2018
AS318 Proposals Due	Jul 13, 2018

Announcement Documents

- DUE DATES: Table 2 lists all program elements in due date order (.HTML)
- DUE DATES: Table 3 lists all program elements in appendix order (.HTML)
- ROSES 2018 Summary of Solicitation (.PDF)
- Complete ROSES 2018 NRA as amended and clarified as of August 24, 2018 (.PDF)
- D.1 Astrophysics Research Program Overview (.PDF)
- D.15 Astrophysics Science SmallSat Studies corrected April 18, 2108 (.PDF)

Other Documents

- Frequently Asked Questions as of June 12, 2018 (.PDF)

Program Element Information

- Research Opportunities in Space and Earth Sciences 2018 (ROSES-2018)

“Deep” Space Research

Keck
INSTITUTE FOR SPACE STUDIES

Small Satellites:
A Revolution in Space Science
2014

New mission concepts:

“Identify new concepts uniquely enabled by the small satellite platform”

Many relevant questions in astrophysics, heliophysics, and planetary science require

“new observation approaches such as spacecraft constellations, and/or continuous all-sky observing coverage, or sensors that are in-situ and/or in extreme environments that are simply not feasible via stand-alone large and expensive missions”

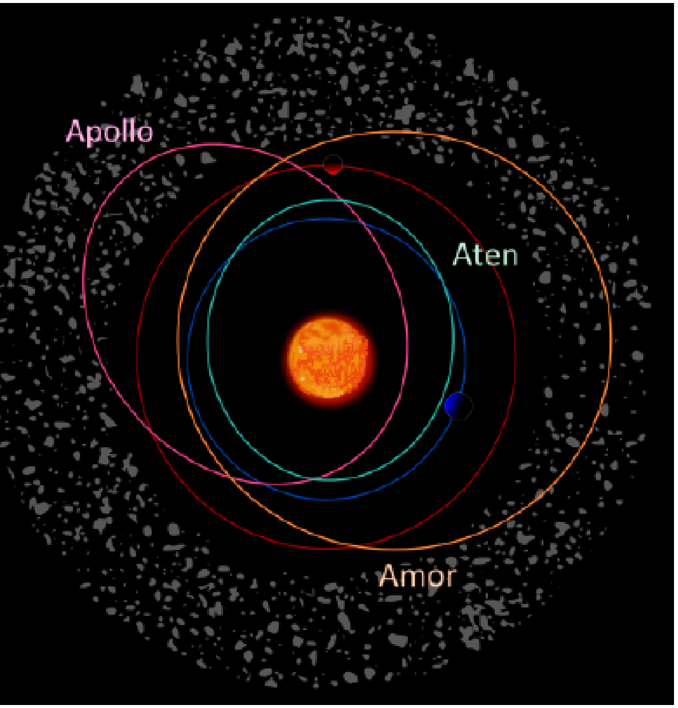
How to Boost the Brazilian Space Program?

The ASTER Mission:

Exploring for the first time a triple-system asteroid

- <u>Elbert E. N. Macau</u>
  - Instituto Nacional de Pesquisas Espaciais – INPE
- Othon C. Winter
  - Univ. Estadual Paulisat – UNESP
- Haroldo F. Campos Velhos
  - INPE
- ASTER Technological Development Team
- **Brazil**

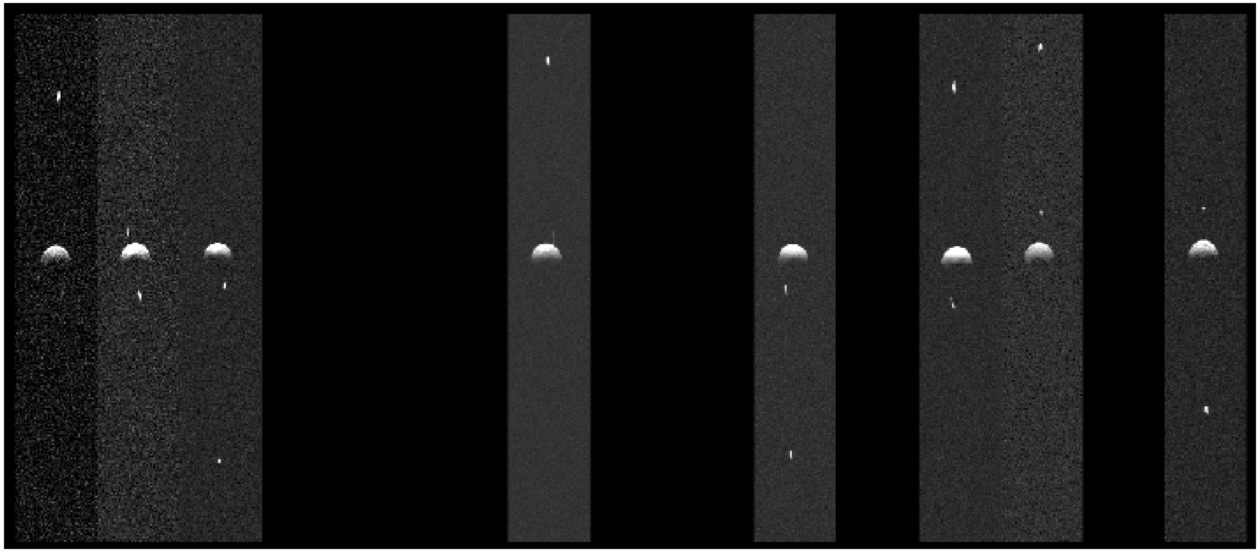
The Goal: A Near Earth Asteroid !



Is is know about 1000 of these objects > 1 km in diameter.

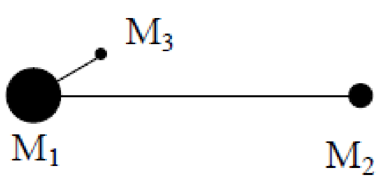
- Asteroids are believed to have formed early in our solar system's history–about 4.5 billion years ago–when a cloud of gas and dust called the solar nebula collapsed and formed our sun and the planets.
- By visiting them we can look for answers such as:
  - how did the solar system form?
  - where did the Earth's water and other organic materials such as carbon come from?
- We may learn more about past Earth impacts and possibly find ways to reduce the threat of future impacts.

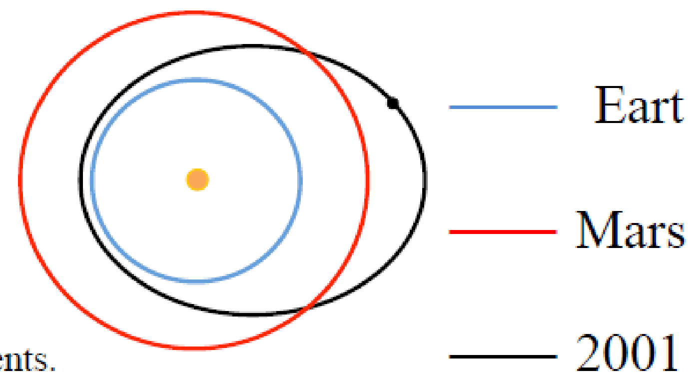
Target: triple asteroid system 2001 SN263



- It is the only C-type triple NEA known;
- C-type asteroids hold clus to the origin of the solar system, formation of planets, origins of water and life on Earth;
- C-types are dark, with low abledos, and so difficult to study from Earth.

In February 2008, radar images taken at the Arecibo Observatory revealed the first near-Earth triple asteroid system



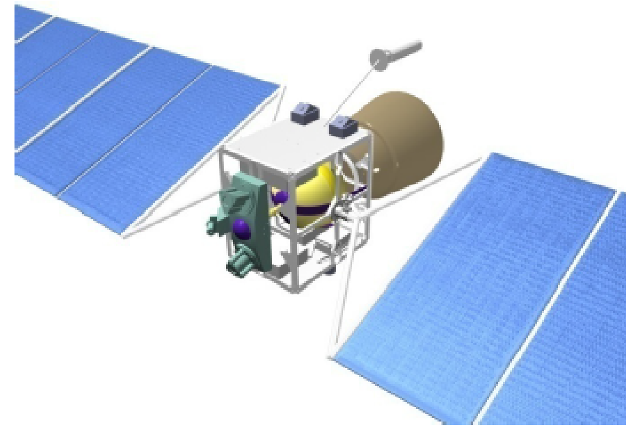


Orbital and physical elements.

Asteroid	Orbit	a	e	I	Período	Diameter	Mass
1	Sol	1,9887 UA	0,4779	6,6889º	≈2,8 anos	2.8 km	$M_1 = 1,1494x10^{13}$ kg
2	Asteróide 1	17 km	*	*	≈147 horas	1.1 km	$M_2 \approx 7,9x10^{-2} M_1$
3	Asteróide 1	4 km	*	*	≈46 horas	0.4 km	$M_3 \approx 5,7x10^{-3} M_1$

Aster spacecraft

- To be developed, integrated and test in Brazil;
- Collaboration with IKI – Space Research Institute of Russian Academy of Science;
- Other international collaborations are welcome.



Initial wet mass	152 to 157 kg
Scientific payload	30 to 35 kg
Propellant (Xe)	66 to 71 kg
Nominal power	2.1 kW
Area of solar panels (As-Ga):	5 m^2
Thrust of 1 thruster	80 to 90 mN

ASTER: subsystem development made by Brazilian companies

- Intelligent material : antenna and magnetometer;
- Star sensor
- Electric propulsion:
  - Kaufman-type ion thruster (*PION)* : station-keeping
  - Permanent Magnet Hall Thruster (PMHT) : main propulsion
- On-board computing system
- Laser Range Finder
- Infrared Spectometer
- Multi-Band Imaging Camera
- Plasma e astrobiologycal experiment

Pre-Symposium Hands-on Workshop

INPE