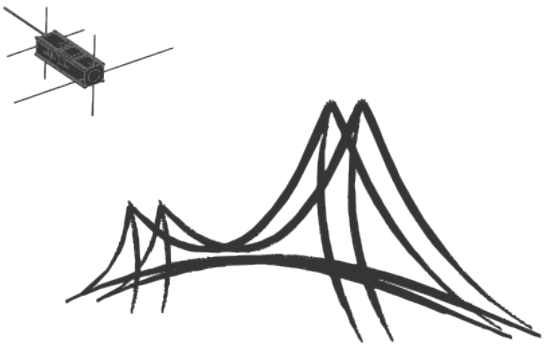
Workshop Program and Abstracts



II IAA LATIN AMERICAN CUBESAT WORKSHOP

28 February to 2 March 2016

Oceania Convention Centre

Florianópolis, Brazil

Organization

Supporting Agencies

Partners

Sponsors

Organizing Committee

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Chantal Cappelletti, PhD, UnB, IAA CM
Eduardo Augusto Bezerra, PhD, UFSC

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Scientific Committee

WORKSHOP PROGRAM AND ABSTRACTS EDITION

Chantal Cappelletti
Eduardo Augusto Bezerra
Kleber Vieira de Paiva

Welcome message

Following up its successful 2014 edition held in Brasilia, the II IAA-LACW will keep the focus on topics related to CubeSat technology, providing a forum for scientists and engineers to discuss their achievements and cutting edge findings. Considering the increasing interest in CubeSat activities, and the recent successful Cubesat missions in Latin America, IAA, Federal University of Santa Catarina (UFSC) and University of Brasilia (UnB) are organizing in 2016 a workshop where participants from industry and academia will have the opportunity to share their professional knowledge, enlarging their networks in the subject. Some of the most outstanding professionals in CubeSat missions and applications will attend the workshop giving special talks and lectures.

The abstracts of the presented works, found in this volume, are an important sample of the impressive scientific and technological advances in the Cubesat field in Latin America. The workshop organizers have made a great effort to provide a productive environment for papers presentation, knowledge exchange, and new networking opportunities.

The city of Florianopolis, a.k.a. the magic island, is located mainly on the island of Santa Catarina. Florianopolis has also a continental part and surrounding small islands. With a population of around 500,000 people, the city is known for having a very high quality of life. The island is a delicious slice of paradise with over 520 km2 (200 sq mi) of green hills, blue lagoons and 42 white sand beaches. The fishing boats, the lace makers, the folklore, the cuisine and the colonial architecture contribute to tourism. The economy of Florianopolis is heavily based on information technology, tourism and services.

Florianopolis is a home to the Federal University of Santa Catarina (UFSC), one of the largest in Brazil, with over 34,500 students. During the symposium, the temperature is expected to be in the range between 22 °C and 30 °C (71.6 °F and 86 °F).

The organizing committee would like to thank everyone for the time spent, and for the volunteering, which made possible to achieve this second edition of the workshop.

Florianopolis, 28 February 2016.

Chantal Cappelletti
Eduardo Augusto Bezerra
Kleber Vieira de Paiva

Workshop Program

Sunday, 28th February 2016

13:00- **Registration**
Hall – Oceania Convention Centre

---Tutorials---
(Chair Prof. Anderson Spengler-UFSC)

14:00-15:30 **Tutorial 1 - "*Effective Approach to Cubesat Environmental Testing*", Dario Hermida, European Space Agency**
Agata room

16:00-17:30 **Tutorial 2 - "*A Journey Into Space*", Thais Russomano, PUCRS, IAA Member**
Agata room

18:00-19:30 **Tutorial 3 - "*Amateur Radio and Space Communications*", Edson W. Pereira, PY2SDR**
Agata room

--- Meeting---
(Chair Prof. Carlos A. Gurgel Veras-AEB)

18:00-19:30 **"*Aerospace Engineering Courses Coordinators' Meeting*", Brazilian Space Agency**
Diamante room

20:00 **Welcome Cocktail Reception**
Diamante room

Monday, 29th February 2016

08:00- **Registration**
Hall – Oceania Convention Centre

08:50-09:00 **Opening cerimony**
Diamante room

---Keynotes---
(Chair Prof. Simone Battistini-UnB)

09:00-09:05 **"*Introduction to the 2nd IAA Latin American CubeSat Workshop*", Organizing Committee**
Agata room

09:05-09:45 **Keynote – "*International Academy of Astronautics and CubeSat activities*"**
Prof. Thais Russomano, IAA
Agata room

09:45-10:00 **Keynote – "*Italy and Latin American Countries: Perspectives for Cooperation in Space Activities*"**
Prof. Roberto Bruno, Italian Embassy in Brazil
Agata room

10:00-10:30 **Coffee-break**
Hall

Session 1 – Latin American Projects Overview
(Chair Prof. Simone Battistini-UnB)
Agata room 10:30-12:15

10:30-10:45
IAA-BR-01-01
LESSONS LEARNED BY THE FIRST BRAZILIAN CUBESAT PLATFORM
(Eduardo Escobar Bürger, Geilson Loureiro, Pedro Teixeira Lacava, Cleber Toss Hoffmann, Mateus de Oliveira Pereira)

10:45-11:00
IAA-BR-01-02
PUCP-SAT-3 AND THE STUDY OF TOTAL ELECTRON CONTENT
(Neils Vilchez, Jorge Heraud, Rafael Vilchez, Victor Centa, Jhonnell Fernandez, Daniel Menendez, Gonzalo Tineo and David Torres)

11:00-11:15
IAA-BR-01-03
FIRST SERPENS MISSION
(Gabriel Figuerò de Oliveira, Chantal Cappelletti)

11:15-11:30
IAA-BR-01-04
APPLICABLE SOLUTION FOR OPTIMIZING CRITICAL POINTS ON NANOSATELITE MISSIONS - NANOSATC-BR, CUBESATS DEVELOPMENT PROGRAM
(Lorenzzo Mantovani, Marcos Dal Piaz, Artur Slongo, Rodrigo Marques, Alex Muller, Leonardo Da Costa, Pietro Moro, Tális Piovesan, Thales Mânica, Tiago Farias, Viktor Dutra, Otávio Durão, Nattan Caetano, Renato Machado and Nelson Schuch.)

11:30-11:45

IAA-BR-01-05

THE FLORIPA-SAT EXPERIENCE: MISSION PROGRESS AND SATELLITE'S DEVELOPMENT

(Leonardo Slongo, Sara Martínez, Bruno Eiterer, Tulio Pereira, Marcos Klemz, Julian Salamanca, Mario Baldini, Rodrigo Pereira, Fabricio Gomes, Djones Lettnin, Leandro Becker, Anderson Spengler, Lucas Travassos, Kleber Paiva and Eduardo Bezerra)

11:45-12:00

IAA-BR-01-06

GNSS-FREE GEO-REFERENCING SYSTEM USING MULTIPLE LEO CUBESAT FORMATION

(Sergio Pamboukian, Pierre Kaufmann, Rodolpho Vilhena de Moraes and Pedro L. Kaufmann)

12:00-12:15

IAA-BR-01-07

CONASAT - NANOSATELLITE CONSTELLATION FOR ENVIRONMENTAL DATA COLLECTION

(Manoel J. M. Carvalho, Jeanne S. S. Lima, Lúcio S. Jotha, Fátima M. Francisco, Otávio C. Durão, Pedro S. Aquino, Carlos L. Gomes Batista and Daniel M. Da Silva.)

12:30-14:30 **Lunch**

Oceania Convention Centre

Session 2 – Launch Systems and Opportunities

(Chair Prof. Benjamin Kevin Malprhus-MSU)

Agata room 15:00-16:00

15:00-15:15

IAA-BR-02-01

JAMSS SMALL SATELLITE LAUNCH SERVICES OVERVIEW

(Shigeru Imai, Yoshihiko Uemura, Nobuhiko Fukuda and Shigehiro Suzuki)

15:15-15:30

IAA-BR-02-02

GAUSS NEW LAUNCH AND DEPLOYMENT STRATEGIES

(Chantal Cappelletti, Riccardo di Roberto, Filippo Graziani)

15:30-15:45

IAA-BR-02-03

PIGGYBACK PAYLOADS ON THE LAUNCH VEHICLES BY JSC SRC PROGRESS

(Oleg Lagno, Tatiana Lipatnikova and Vadim Yudintsev)

15:45-16:00

IAA-BR-02-04

CUBESAT SEPARATION DYNAMICS

(Vadim Yudintsev)

Session 3 – Modelling

(Chair Prof. Djones Vinicius Lettnin-UFSC)

Agata room 16:00-16:45

16:00-16:15

IAA-BR-03-01

VIRTUAL SATELLITE PLATFORM OF AN ON-BOARD COMPUTER FOR SPACE APPLICATIONS

(Dominic Zijlstra, Rogerio Paludo and Djones Lettnin)

16:15-16:30

IAA-BR-03-02

TOWARDS AN AUTOMATED HYBRID TEST AND SIMULATION FRAMEWORK TO FUNCTIONAL VERIFICATION OF NANOSATELLITES' ELECTRICAL POWER SUPPLY SUBSYSTEM

(Italo Pinto Rodrigues, Ana Maria and Christopher Cerqueira)

16:30-16:45

IAA-BR-03-03

OPTIMIZING 3-COMPONENT FORCE SENSOR INSTALLATION FOR SATELLITE FORCE LIMITED VIBRATION TESTING

(Bob Metz and Carmine Salzano)

16:45-17:00 **Coffee-break**

Hall

Session 4 – Educational Mission Management and Regulations

(Chair Prof. Thais Russomano-PUCRS)

Agata room 17:00-18:15

17:00-17:15

IAA-BR-04-01

T-PROST: A TRANSDISCIPLINARY PROCESS MODELLING METHODOLOGY AND ITS APPLICATION TO THE SYSTEMS ENGINEERING LIFECYCLE IN SPACE MISSIONS

(Renato Fernandez)

17:15-17:30

IAA-BR-04-02

CUBESAT MISSIONS AS LEARNING TOOLS: THE INFLUENCE ON STUDENTS

(Laio Oriel Seman and Eduardo Augusto Bezerra)

17:30-17:45

IAA-BR-04-03

A DATA CENTER FRAMEWORK FOR TECHNOLOGICAL READINESS ASSESSMENT OF INNOVATIVE TECHNOLOGY ON BOARD CUBESATS

(Andre Novais and Fátima Mattiello-Francisco)

17:45-18:00

IAA-BR-04-04

SIMPLE AND FLEXIBLE MODEL TO ASSESS DIFFERENT SCENARIOS FOR SPACECRAFT POPULATIONS AT LOW-EARTH ORBIT AND ITS SUSTAINABILITY IN THE FUTURE

(Vinicius Bigogno Costa and Hugh G. Lewis)

18:00-18:15

IAA-BR-04-05

AN ENVIRONMENT TO SUPPORT PLM IN SMALL SATELLITES PROJECT DEVELOPMENT

(Renato Fernandez)

Poster Session

(Chair Prof. Marcos Heckler-Unipampa)

Agata Room 18:30-19:30

Tuesday, 1st March 2016

08:00 **Registration**
Hall – Oceania Convention Centre

---Keynotes---
(Chair Prof. Eduardo Augusto Bezerra-UFSC)

09:00-09:30 **Keynote – "*From Education to Practical Applications of Micro/nano/pico-satellites in Japan Starting from CubeSat*"**
Prof. Shinichi Nakasuka, University of Tokyo, Japan.
Agata room

09:30-10:00 **Keynote – "*The Cosmic X-Ray Background NanoSat-2 (CXBN-2): An X-Ray Detector for CubeSats Validated through Science Data*"**
Prof. Benjamin Kevin Malprhus, Morehead State University, USA.
Agata room

10:00-10:30 **Coffee-break**
Hall

Session 5 – Assembly, Integration, Test and Verification
(Chair Prof. Eduardo Augusto Bezerra-UFSC)
Agata room 10:30-11:00

10:30-10:45
IAA-BR-05-01
BEHAVIOR MODELLING AND SIMULATION OF A FAULT TOLERANT ATTITUDE DETERMINATION SYSTEM FOR NANOSATC-BR2
(Bruno Caetano O. Miranda and Ricardo de Oliveira Duarte)

10:45-11:00
IAA-BR-05-02
ON THE USE OF NANOSATC-BR TEST SYSTEM FOR PAYLOAD OPERATIONAL REQUIREMENTS VERIFICATION
(Carlos Conceicao, Ana Ambrosio and Fatima Mattiello)

Session 6 – Mission Applications
(Chair Prof. Eduardo Augusto Bezerra-UFSC)
Agata room 11:00-12:15

11:00-11:15
IAA-BR-06-01
SEAHAWK: A CUBESAT MISSION FOR SUSTAINED OCEAN OBSERVATION
(Hazel Jeffrey, Hessel Gorter, Alasdair Gow, Craig Clark, Alan Holmes, John Morrison, Jenni Doonan and Pamela Anderson)

11:15-11:30

IAA-BR-06-02

THE RAIOSAT PROJECT: DETECTING TOTAL LIGHTNING FLASHES FROM A CUBESAT

(Kleber Naccarato, Walter Abrahao Dos Santos, Miguel Carretero, Candido Moura and Auro Tikami)

11:30-11:45

IAA-BR-06-03

RACETRACK TO ORBIT, AN ADDITIVE REVOLUTION

(Twyman Clements, Gil Moore, Mathew Dushku, Stewart Davis, Francesca Cuoghi)

11:45-12:00

IAA-BR-06-04

LAUNCH AND EARLY OPERATIONS PHASE FOR THE GOMX-3 MISSION

(Igor Alonso Portillo, David Gerhart)

12:00-12:15

IAA-BR-06-05

EXTENDING THE COVERAGE FOR THE INTERNET OF THINGS WITH LOW-COST NANOSATELLITE NETWORKS

(Vicente Almonacid and Laurent Franck)

12:30-14:30 **Lunch**

Oceania Convention Centre

---Keynotes---

(Chair Prof. Eduardo Augusto Bezerra-UFSC)

14:30-15:00 **Keynote – "*Current NanoSatellite trends and their implications for developing space programs*"**

Prof. Jordi Puig Suari, CalPoly, USA.

Agata room

Session 7 – Attitude Determination and Control Systems

(Chair Prof. Mikhail Ovchinnikov-KIAM)

Agata room 15:00-16:30

15:00-15:15

IAA-BR-07-01

ATTITUDE CONTROL MODEL FOR CUBESATS

(Juan Carlos Molina, Victor Hugo Ayerdi and Luis Zea)

15:15-15:30

IAA-BR-07-02

STABILIZATION OF A NANOSATELLITE BASED ON FUZZY CONTROL

(Gustavo Mendoza-Torres and Gustavo Rodriguez-Gomez)

15:30-15:45

IAA-BR-07-03

A TEST-BED FOR ATTITUDE AND DETERMINATION CONTROL OF SPACECRAFTS.

(Pedro Beghelli, Simone Battistini, Renato Borges, Chantal Cappelletti, Rodrigo Cardoso da Silva, Ulisses Rodrigues, Sarah Costa, Brenno Popov and Mariana Sampaio)

15:45-16:00

IAA-BR-07-04

THE DESIGNING AND TESTING OF A PASSIVE MAGNETIC ATTITUDE CONTROL SYSTEM FOR FLORIPASAT

(Stefany Dutra, Bruno Lugnani, Lucas Casaril and Alexandro Brito)

16:00-16:15

IAA-BR-07-05

A STAR IDENTIFICATION ALGORITHM USING A NEW METHOD BASED ON A QUASI-EQUILATERAL GEOMETRY

(Berenice Rodríguez Pedroza, Rogerio Enriquez Caldera and Eduardo Mendoza Torres)

16:15-16:30

IAA-BR-07-06

OPTIMIZED CONTROLLER DESIGN FOR CUBESAT ATTITUDE TRACKING CONTROL USING MAGNETIC ACTUATORS

(Felipe Coelho, Andre Da Silva and José R. Pinheiro)

16:30-17:00 **Coffee-break**

Hall

Session 8 – Structure and Thermal Design

(Chair Prof. Kleber Vieira de Paiva-UFSC)

Agata room 17:00-17:45

17:00-17:15

IAA-BR-08-01

NUMERICAL INVESTIGATION OF THE INFLUENCE OF THE ORBIT INCLINATION ON THERMAL CONTROL OF A NANOSATELLITE IN LEO

(Edemar Morsch Filho, Êmili Bohrer, Kleber Vieira De Paiva, Talita Sauter Possamai and Xisto Lucas Travassos Junior)

17:15-17:30

IAA-BR-08-02

DESIGN OF THE STRUCTURE AND REENTRY SYSTEM FOR THE LAICANSAT-3 PLATFORM

(Matheus F. S. Alves, Arthur P. Wernke, Felipe C. Pereira, Diego H. Gomes, Guilherme S. Lionço, Caio H. Franco L. Domingos, Daniel B. da Trindade, Chantal Cappelletti, Manuel N. D. Barcelos Junior, Simone Battistini and Renato Alves Borges)

17:30-17:45

IAA-BR-08-03

STUDY OF RIGID STRUCTURE VIBRATIONS AND MECHANICAL MODELING FOR THE NANOSATC-BR2: MODAL ANALYSIS AND 3D PRINTING CONSIDERATIONS

(Rodrigo Passos Marques, Viktor Bizarro Dutra, Artur Gustavo Slongo, Lorenzzo Quevedo Mantovani, Thaffarel Santos, Tiago Farias, Tális Piovesan, Leonardo Zavareze Da Costa, Pietro Fernando Moro, Thales Ramos Mânica, Alex Müller, Otavio Durão, Nattan Roberto Caetano, Renato Machado and Nelson Schuch)

Industry Session

(Chair Prof. Kleber Vieira de Paiva-UFSC)

Agata 18:00-19:00

20:00- **Social Event – Gala Dinner**

Wednesday, 2nd March 2016

08:00 **Registration**
Hall – Oceania Convention Centre

---Keynotes---
(Chair Prof. Simone Battistini-UnB)

09:00-09:30 **Keynote – "*Coastwise Sailing: Prospects of Using Solar Sails in Near-Earth Orbits*"**
Prof. Mikhail Ovchinnikov, Keldysh Inst. of Applied Mathematics.
Agata room

09:30-10:00 **Keynote – "*Programmable Devices in Nano Satellites: Radiation Effects, Fault Tolerance and Integration Perspectives*"**
Prof. Fernanda Lima Kastensmidt, UFRGS.
Agata room

10:00-10:30 **Coffee-break**
Hall

Session 9 – On Board Systems (OBC, EPS, P/L)
(Chair Prof. Prof. Fernanda Lima Kastensmidt-UFRGS)
Agata room 10:30-12:30

10:30-10:50
IAA-BR-09-01
SOFT ERRORS ANALYSIS ON FPGAS FOR CUBESAT MISSIONS
(Victor Martins, Leonardo Slongo, Paulo R. C. Villa and Eduardo Bezerra)

10:50-11:10
IAA-BR-09-02
TETHERED 2U CUBESAT DEVELOPMENT IN SPACE TETHERED AUTONOMOUS ROBOTIC SATELLITE PROJECT
(Nohmi Masahiro and Yoshiki Yamagiwa)

11:10-11:30
IAA-BR-09-03
OPENOBC: AN OPEN-SOURCE, LOW-COST AND HIGH-RELIABILITY ARCHITECTURE FOR A CUBESAT ON-BOARD COMPUTER.
(David Mota, Júlio César Soares Américo Filho, Davyd Melo, Jarbas Silveira, João Cesar Mota and César Augusto Marcon)

11:30-11:50
IAA-BR-09-04
NANOSATELLITE ENERGY HARVESTING MAXIMIZATION THROUGH AN ENERGY AWARE SCHEDULING ALGORITHM.
(Leonardo Slongo, Eduardo Bezerra, Sara Martínez, Bruno Eiterer and Tulio Gomes Pereira)

11:50-12:10
IAA-BR-09-05
DESIGN CONSIDERATIONS FOR RADIATION HARDENED ASIC USED AS TECHNOLOGICAL PAYLOAD IN NANOSATC-BR1.
(Jorge Johanny Sáenz Noval, Leonardo Medeiros, João Baptista Dos Santos Martins, Nelson Jorge Schuch, Otávio Dos Santos Cupertino Durão and Renato Machado)

12:10-12:30

IAA-BR-09-06

Electrical Power System (EPS).

(Arnaldo Alves Viana Junior, Otávio Moreira Petito, Tiago Augusto Orcajo, Demay Cordeiro, Alessandro de Oliveira Santos, Saulo Finco, Silvio Manea)

12:30-14:30 Lunch

Oceania Convention Centre

Session 10 – Telecommunications, Tracking and Command

(Chair Prof. Lucas Travassos, UFSC)

Agata room 14:30-16:15

14:30-14:45

IAA-BR-10-01

INTEGRATION OF THE INPE GROUND STATION INTO THE SATNET NETWORK FOR SUPPORTING SMALL SATELLITES PROGRAMS IN BRAZIL

(Ricardo Tubío-Pardavila, Jorge Enrique Espindola Diaz, Adair José Rohling, Fernando Aguado-Agelet, Mauricio Gonçalves Vieira Ferreira, Walter Abrahao Dos Santos and Jordi Puig-Suari)

14:45-15:00

IAA-BR-10-02

BEACON RECEIVERS FOR CUBESAT MISSIONS AND IONOSPHERIC STUDIES

(Edgardo Pacheco and Jose Chavez)

15:00-15:15

IAA-BR-10-03

LAICAnSat-3: A MISSION FOR TESTING A NEW ELECTRONIC AND TELEMETRY AND TRACKING SYSTEM

(Simone Battistini, Rafael Resende Dias, Alex Kraus, Renato Alves Borges and Chantal Cappelletti)

15:15-15:30

IAA-BR-10-04

GROUND STATION LINK CHARACTERIZATION UTILIZING BIT ERROR RATE.

(Nathaniel Richard and Kevin Brown)

15:30-15:45

IAA-BR-10-05

ELETROMAGNETIC ANALYSIS OF INSTALLED PERFORMANCE OF ANTENNAS INTEGRATED ONTO NANO-SATELLITES

(Juner Vieira and Marcos Heckler)

15:45-16:00

IAA-BR-10-06

PICO AND NANOSATELLITE GROUND STATION ARCHITECTURE DEVELOPMENT REFERENCE PROCESS

(Jaime Enrique Orduy Rodriguez, Geilson Loureiro, Walter Abrahão Dos Santos and Douglas Soares Dos Santos.)

16:30-17:00 Coffee-break

Hall

17:00-17:15 Closing remarks - Diamante room

POSTER SESSION
POSTER LIST

(Exhibition in the Hall during the whole workshop)

IAA-BR-16-1P-01
Mission analysis for a remote sensing CubeSat mission over the Amazon rainforest
(Gabriel Coronel, Eduardo Escobar Bürger, Geilson Loureiro and Otávio Luiz Bogossian)

IAA-BR-16-1P-02
SpaceWire Application
(D. T. dos Santos , R. C. Ferrãoa, V. C. Parroa)

IAA-BR-16-1P-03
Developing and Operating an Automated Ground Station
(Lucas Amaduro, Rogerio Atem De Carvalho, Lucas Hissa, Willian Vianna, Cedric Cordeiro, Sara Souza, William Oliveira, Luiz Gustavo Lourenço Moura)

IAA-BR-16-1P-04
Recycling of Packaging for Obtain Paraffin and Nanoparticles of Aluminum Oxide for Doping of Fuel Used in Hybrid Motors
(Narielly Campos, Luan Henrique Dos Santos Oliveira, Renan Henrique Alves de Araújo, Pilar Falla, Marcelo Bento Silva and Leandro Xavier Cardoso)

IAA-BR-16-1P-05
Developing the Software for Cubesats in a Concurrent Engineering Environment: a toolset and case study
(Rogerio Atem De Carvalho, Galba Arueira, Milena Silveira de Azevedo, Rafael Toledo and Cedric Cordeiro)

IAA-BR-16-1P-06
CubeSat Frame Design - Petal Model
(Felipe Lima Mahlmeister, Rodrigo Alvite Romano, Vanderlei Cunha Parro, Rafael Corsi Ferrão, Sergio Ribeiro Augusto, Saulo Finco and Silvio Manea)

IAA-BR-16-1P-07
A SysML reference model to satellite/launcher interface and its instantiation to a Cubesat Project
(Ricardo Franco and Walter Abrahao Dos Santos)

IAA-BR-16-1P-08
Serpens: assembly, integration and test activities
(Ishioka, I. S. K.; Figueiró de Oliveira, G.; Cappelletti, C.; Amui, B. G. R.; Lôpo Júnior, N. P.; Kaled da Cás, P. L.; Nodar, D.; González, A.; Aguado Agelet, F.; Vázquez, A)

IAA-BR-16-1P-09
Low Outgassing Accelerometers and Cables for Thermal Vacuum and Vibration Test Environments
(Bob Metz and Carmine Salzano)

IAA-BR-16-1P-10
Experimental Analysis of Thermoelectric Energy Generation for Nanosatellites
(Diego Audiffred, Anderson Spengler, Kleber Paiva, Gabriel Fraporti and Gabriella Hagedorn)

IAA-BR-16-1P-11
Remote Sensing based on Cubesat: is there any added value?
(Giovanni LaNeve, Giancarlo Santilli)

IAA-BR-16-1P-12
Orchestration and Controlling of a Automated Ground Station Network
(Lucas Hissa, Luiz Gustavo Lourenço Moura, Rogério Atem, Lucas Amaduro, William Silva Vianna, Cedric Salotto Cordeiro and Sara Souza)
IAA-BR-16-1P-13
Ablative Pulsed Plasma Thrusters for high Delta-V Nanosatellite/Microsatellite Missions
(Paolo Gessini, Lui T. C. Habl, Gabriela Possa, Stephen B. Gabriel)
IAA-BR-16-1P-14
Development of a small Thermal-Vacuum chamber using systems engineering philosophy
(Roy Stevenson Soler Chisabas, Eduardo Escobar Bürger and Geilson Loureiro)
IAA-BR-16-1P-15
Microstrip planar antenna for cubesats
(Marcio Mathias, Gabriel Vilella Matos, Saulo Finco, Silvio Manea)
IAA-BR-16-1P-16
Functional verification of a hardware satellite communication module
(Fabrízio Maziero and Djones Lettnin)
IAA-BR-16-1P-17
Design and optimization of ground station antennas for the floripa sat project
(Thais Baena Moura, Raíza Benedecti and Lucas Travassos)

Table of Contents

(Chair Prof. Anderson Spengler-UFSC)

14:00-15:30 - Agata Room - Tutorial 1

"Effective Approach to Cubesat Environmental Testing"

Dario Hermida
European Space Agency (ESA)

1. **Introduction to environmental testing**
    - 1.1. Fundamentals and effective approach
    - 1.2. Mechanical testing
        - 1.2.1. Mechanicaltestingsetup
        - 1.2.2. Resonancesearch
        - 1.2.3. Randomvibration
        - 1.2.4. Sinevibration
        - 1.2.5. Shocks
        - 1.2.6. Example: ETS facilities
    - 1.3. Thermal testing
        - 1.3.1. Thermal testing setup
        - 1.3.2. Bake-out and Thermal vacuum cycling
        - 1.3.3. Ambient pressure thermal
        - 1.3.4. Example: ETS facilities
    - 1.4. Ok, but should I do this with my Cubesat?
2. **Test preparation**
    - 2.1. Pre-test activities
    - 2.2. Documentation
    - 2.3. Test material
3. **Test execution**
    - 3.1. Social skills
    - 3.2. Mechanical test examples
4. **Test analysis**
    - 4.1. Dataduringtesting
    - 4.2. Data after testing
5. **Learning by experience**

(Chair Prof. Anderson Spengler-UFSC)

16:00-17:30 - Agata Room - Tutorial 2

"A Journey Into Space"

Thais Russomano
PUCRS / Imperial College

Content: All living organisms are subject to the influence of the gravitational force of the Earth, which has dictated the anatomy and physiology of terrestrial organisms for millions of years, including human beings. As soon as this force is increased (hypergravity), reduced (hypogravity) or becomes absent (microgravity), all body systems are affected and try to find new ways to restructure themselves and function. This tutorial is designed to cover historical aspects of manned space flight, including the evolution of spacecraft and spacesuit environments, and to present an overview of human physiological changes during acute and chronic exposure to microgravity. The impact on human physiology of hypogravity environments, such as those found on the Moon and Mars, will be presented. The use of analogues will also be discussed, why the study of human adaptation to space is required and how they are used to simulate extra-terrestrial environments on Earth, also covering advantages and disadvantages of different simulation devices. In addition, a summary is given of how telemedicine and eHealth systems are applied to evaluate astronauts, providing health support for medical diagnosis and treatment during space missions. The establishment and evolution of the Microgravity Centre/PUCRS (MicroG), an internationally recognized reference center in the study of Space Physiology, Biomechanics, Pharmacy, Physiotherapy, Biomedical Engineering, and TeleHealth will be discussed and some of the main research of its laboratories presented. The tutorial will finish by outlining future plans for human space exploration, including interplanetary trips to Mars and space tourism.

Key words: Space physiology; Space flight; extra-terrestrial environments; space analogues; space tourism; MicroG Centre

Bio: Thais Russomano has more than twenty years of experience in the field of Space Life Sciences and founded and continues to coordinate the Microgravity Centre (MicroG-PUCRS) Brazil, a unique and internationally recognized reference center in the study of Human Space Physiology and Space Biomedical Engineering. A medical doctor specializing in internal and emergency medicine, she further completed a Master's degree in Aerospace Medicine at Wright State University, Ohio, USA, and subsequently a PhD in Space Physiology at King's College London, UK. Thais is a full professor at PUCRS, Brazil, a visiting senior lecturer at King's College London where she contributes to space related courses and also a guest scientist at the German Space Agency (DLR). In addition, she is Chief Medical Officer of the USA based International Space Medicine Consortium (ISMC) whose mission includes the enhancement of medical knowledge and development of new technologies to enable long-duration, deep space human exploration. Thais is actively involved in the space-related international scientific community, contributing to numerous working groups and committees in the field of manned space flight, has numerous publications in the area and regularly presents her work in international scientific meetings.

(Chair Prof. Anderson Spengler-UFSC)

18:00-19:30 - Agata Room - Tutorial 3

"Amateur Radio and Space Communications"

Edson W. Pereira
PY2SDR

Area:

Ground Segment and Stations Network

Abstract:

An expressive number of cubesat projects utilize the amateur radio frequencies for communications. Radio amateurs have been working with space communication since the early sixties, have designed and launched an expressive number of satellites, and have accumulated a large amount of experience in designing, implementing and operating satellites and ground stations. The tutorial will present a brief history of amateur radio space communications, normative and regulatory aspects of amateur radio activities, satellite radio frequency coordination with the International Amateur Radio Union (IARU), space and ground segment licensing process for Brazilian cubesats, digital communications, and technical topics in designing and operating satellite ground stations.

Keywords:

Amateur radio, satellite communications, radio regulations, IARU, LABRE, AMSAT- BR

Learning Objectives:

Familiarization with the Amateur Radio Satellite Service, Amateur Radio regulations, and technical aspects of designing and operating an amateur radio satellite ground station.

Target Audience:

Project managers, teachers, and students involved in satellite missions operating in the amateur radio spectrum.

9:05-9:45 - Agata Room - Keynote

"International Academy of Astronautics and CubeSat activities"

Prof. Thais Russomano, IAA

9:45-10:00 - Agata Room - Keynote

"Italy and Latin American Countries: Perspectives for Cooperation in Space Activities"

Prof. Roberto Bruno, Italian Embassy in Brazil

Session 1 - Latin American Projects Overview

IAA-BR-01-01

LESSONS LEARNED BY THE FIRST BRAZILIAN CUBESAT PLATFORM

Eduardo Escobar Bürger; Geilson Loureiro; Pedro Teixeira Lacava; Cleber Toss Hoffmann; Mateus de Oliveira Pereira

This paper presents the lessons learned from the first Brazilian CubeSat Platform, ITA's AESP14 Project. This work is a summary of notes and recommendations of what to do (and what not to do) when developing an educational nanosatellite. The system was used as hands-on activity to ITA Aerospace course Systems Engineering discipline. The undergraduate students were focused on systems engineering activities and documentation to give inputs needed for INPE and ITA graduate students to build and test a low cost national CubeSat platform. Results showed that a CubeSat project is feasible to teach systems engineering concepts, but no signal was received since its ejection. The CubeSat was launched in early January 2015 through Falcon-9 launcher, and ejected from ISS on February 5th. Design and test pitfalls as well as probable causes of failure are discussed.

IAA-BR-01-02

PUCP-SAT-3 AND THE STUDY OF TOTAL ELECTRON CONTENT (TEC)

Neils Vilchez; Jorge Heraud; Rafael Vilchez; Victor Centa; Jhonnell Fernandez; Daniel Menendez; Gonzalo Tineo; David Torres

The Institute for Radio Astronomy (INRAS), after its first experience in the development, construction and launching into orbit of a nanosatellite 1U CubeSat type called PUCP-Sat-1 and a femtosatellite called Pocket-PUCP (PUCP-Sat-2) [1], the first two Peruvian satellites, is developing a new project with LEO satellites, in collaboration with the Instituto Geofísico del Perú (IGP). With the increased infrastructure in testing facilities and equipment, we are starting the new development of a 2U CubeSat named PUCP-Sat-3 that will have as its main payload a transmitter at harmonically related frequencies, developed by IGP, for the measurement of Total Electron Content (TEC) through a bi-static radar. The transmitter will be operating on the PUCP-Sat-3 and the receiver on the ground. This experiment will contribute to the study of the ionosphere at the E and F layers regions. The above information will be received by the 8m dish antenna at INRAS and will be compared with measurements made at the Jicamarca Radio Observatory.

IAA-BR-01-03

FIRST SERPENS MISSION

Gabriel Figuerò de Oliveira; Chantal Cappelletti

Small satellite missions and applications figure today as one of the most recent revolutions space. In special, nanosatellites in the form of CubeSats have earned a prominent place in the aerospace field with exponential increase in the number of launches in the past decades. While some still argue about the validity and limitation of these small platforms, their impact and relevance for education and the formation of human resources are beyond any doubt.
With focus on the development of specialized personal to collaborate with the Brazilian Space Program, the Brazilian Space Agency (AEB) has given special attention to the educational programs and to the consolidation of Aerospace Engineering Courses in Brazil. In this scenario, AEB announced the SERPENS program (Space System for Conducting Research and Experiments with Nanosatellites) in December of 2013. The program is rooted in the guidelines of the Brazilian Space Activities Program, which emphasizes the capacity building of students, young researchers and engineers.
This first nanosatellite inherited the name of the program, and its development was taken under the supervision of several Universities in Brazil with young (less than five years old) Aerospace Engineering Courses.
The first mission has been launched in August 2015. In this paper, the main aspects and results achieved by the first SERPENS Nanosatellite are presented and discussed.

Session 1 - Latin American Projects Overview

IAA-BR-01-04

APPLICABLE SOLUTION FOR OPTIMIZING CRITICAL POINTS ON NANOSATELITE MISSIONS - NANOSATC-BR, CUBESATS DEVELOPMENT PROGRAM

Lorenzzo Quevedo Mantovani; Marcos Antonio Laurindo Dal Piaz; Artur Gustavo Slongo; Rodrigo Passos Marques; Alex Muller; Leonardo Zavareze Da Costa; Pietro Fernando Moro; Tális Piovesan; Thales Ramos Mânica; Tiago Travi Farias; Viktor Leon Bizarro Dutra; Otávio; Santos Cupertino Durão; Nattan Roberto Caetano; Renato Machado; Nelson Jorge Schuch

The main goal of this paper is to show possible applicable im-provements in the milestone of nanosatellites, based on critical points that were identified in both NANOSATC-BR1 and NANOSATC-BR2 missions, reducing and optimizing them in order to enhance mission performance by lowering risks levels. To support this analysis, the PDCA Methodology is used. The V Model – from System Engineering – will be used in this case as well because of its architecture, which has the capability of verifying what is being built with what was defined, to guarantee that the mission stakeholders will be fulfilled. Analyzing the obtained risk analysis data, solutions are presented with the objective to reduce risks, in specified parts of nanosatellites milestone in order to get a better result with less changes. The nanosatellites analyzed are the NANOSATC-BR1 – which has already completed one and a half year in operation on space - and the NANOSATC-BR2, both of them from the NANOSATC-BR - CubeSats Development Program. This Program aims to improve and capacitate building of human resource by designing, de-veloping payloads and platforms, test, launch and operate national sci-entific satellite in CubeSat standards. The Program has been designed and executed in a partnership between the Southern Regional Space Re-search Center (CRS) from the National Institute of Space for Space Re-search (INPE – MCTI) and Santa Maria Space Science Laboratory (LACESM), from the Federal University of Santa Maria (UFSM).The program has aid and support from the Brazilian Space Agency (AEB).

IAA-BR-01-05

THE FLORIPA-SAT EXPERIENCE: MISSION PROGRESS AND SATELLITE'S DEVELOPMENT

Leonardo Slongo; Sara Martínez; Bruno Eiterer; Tulio Pereira; Marcos Antunes Klemz; Julian Salamanca; Mario Baldini; Rodrigo Pereira; Fabricio Gomes; Djones Lettnin; Leandro Becke; Anderson Spengler; Lucas Travassos; Kleber Paiva; Eduardo Augusto Bezerra

CubeSat projects have become a good option for universities that intend to engage their students in space activities. The Floripa-Sat project is an initiative of researchers and students from the Federal University of Santa Catarina (UFSC) together with the Federal Institute of Santa Catarina (IFSC) to develop an 1U Cubesat. The main objective of this project is to expose students to the space applications field. The students have been divided in groups, in order to work in the following areas: Payload, Power, Ground Segment, Onboard Computer and Communications. Initially, the groups worked aiming to obtain a basic knowledge of designs targeting space applications. Afterwards, the groups worked in the developed of the modules, conceiving the mission as a whole. This paper shows the design decisions and preliminary results of the current phase of all the mentioned modules.

IAA-BR-01-06

GNSS-FREE GEO-REFERENCING SYSTEM USING MULTIPLE LEO CUBESAT FORMATION

Sergio Pamboukian; Pierre Kaufmann; Rodolpho Vilhena de Moraes; Pedro L. Kaufmann

CubeSats are ideal transponder carriers to integrate a new GNSS-free geo-referencing system. The system concept might be viewed as an "in-verted GPS" configuration, utilizing four ground-based reference sta-tions and a number of repeaters in space. A time signal transmitted by one of the reference bases is retransmitted by transponders in space, re-ceived back at the bases,

producing four ranging measurements for each satellite. The measurements are corrected for time delays in every time coded retransmission caused by three main sources: the transit time at the transponders, the path delays, and delays at the ground-based trans-mitter and receivers antennas, cables and electronics. An algorithm compares the repeaters' positions for at least two groups of three refer-ence bases, minimizing unknown signal delays, providing the accurate position for each repeater. Once the repeaters' coordinates are known, the other determinations and applications become straightforward. It is demonstrated by simulations, based on the system performance algo-rithms, that with a formation of at least four repeaters, the position of a remote target is determined for a single coded time signal transmission. A formation of multiple CubeSats in low earth orbits (LEO) is particular-ly suitable to accomplish the new geo-referencing system. Simulations are presented, exhibiting accuracies which may become comparable to other space-based systems. This system has various strategic and eco-nomic applications in remote clock synchronism, navigation and target geo-positioning. It may be used as a backup to GNSS location systems in critical applications, or when such systems are not available

IAA-BR-01-07

CONASAT - NANOSATELLITE CONSTELLATION FOR ENVIRONMENTAL DATA COLLECTION

Manoel J. M. Carvalho; Jeanne S. S. Lima; Lúcio S. Jotha; Fátima M. Francisco; Otávio C. Durão; Pedro S. Aquino; Carlos Leandro Gomes Batista; Daniel M. Da Silva.

There is currently a pressing necessity of developing new satellites, both to assure the operation continuity of the Brazilian Environmental Data Collection (SBCDA), as well as to take care of new demands for environmental monitoring, supplying new services and incorporating improvements to the system performance. The mission of CONASAT comprises designinga solution to SBCDA, based on the use of a constellation of nanosatellites with mass between 1 kg to 10 kg, using emerging technologies in the fields of electronics and telecommunications and the definition of a space mission in accordance with international standards applied in thespace. The primary mission of the CONASAT satellite will receive the signals sent by the Platforms Environmental Data Collection, which are installed in the Brazilian territory and oceanic surface, treat them and retransmit back to ground stations. This paper presents the CONASAT conception and development phases

Session 2 - Launch Systems and Opportunities

IAA-BR-02-01

JAMSS SMALL SATELLITE LAUNCH SERVICES OVERVIEW

Shigeru Imai; Yoshihiko Uemura; Nobuhiko Fukuda; Shigehiro Suzuki

Japan Manned Space Systems Corporation (JAMSS) started the small satellites launch services in 2014. Now our launch services provide more launch opportunities to foreign entities because JAXA (Japan Aerospace Exploration Agency) opened launch opportunities not only for Japanese entities but also foreign entities on condition that Japanese organization applies and makes contract with JAXA on behalf of them. JAMSS can provide launch and deployment service using J-SSOD (JEMSmall Satellite Orbital Deployer) and other deployers from Japanese Experimental Module (JEM) of International Space Station (ISS). In 2015, JAMSS successfully completed deployment services of two Brazilian CubeSats, AESP-14 and SERPENS, from the ISS. JAMSS is now preparing for deployment of a Brazillian TubeSat from ISS. This paper introduces overview of JAMSS small satellites launch services with some key notes from technical and procedural standpoints.

IAA-BR-02-02

GAUSS NEW LAUNCH AND DEPLOYMENT STRATEGIES

Chantal Cappelletti; Riccardo di Roberto; Filippo Graziani

Since early nineties GAUSS team is involved on the design and manufacturing of small satellite platforms. In 2013 the company launched the first system able to release CubeSat from an orbiting satellite proving a new concept for small satellite launch services. After the UniSat-5 mission performed in 2015 that allowed the launch in orbit of 8 satellites from the UniSat Platform (including the first PocketQubeSat ever launched), the company performed another successful mission relaeasing other 4 satellites. The paper deals with the history of UniSat platform, new perspectives and new technologies developed by GAUSS in order to allow low cost solutions for small satellite launches. In addition the paper will discuss about the new materials and new technologies carried on by GAUSS to design is new deployment mechanism taking into account that GAUSS is the only company in the world able to offer launch services and deployment mechanism for CubeSat, PocketQubeSat and TubeSat.

IAA-BR-02-03

PIGGYBACK PAYLOADS ON THE LAUNCH VEHICLES BY JSC SRC PROGRESS

Oleg Lagno; Tatiana Lipatnikova; Vadim Yudintsev

The opportunities to launch small satellites using launch vehicles by JSC Space Rocket Centre Progress are presented. JSC Space Rocket Centre Progress is the world leader in the number of launches of carrier rockets. This launch capability can be used effectively to launch piggy-back payloads. JSC SRC Progress has developed a new CubeSat de-ployer that adapted to the launch vehicles, spacecraft and upper stage manufactured by the Space Rocket Centre. Advanced modular design of the CubeSat deployer allows building a deployer for any type of Cu-beSat: from 1U to 3U+. Tried-and-true elements of high reliability level are used in the deployer that ensure the reliability of the deployer and the safety of the primary payload. Special attention paid to reducing the tip-off rate of the separated CubeSats. The simplest and most cost-effective way to undertake short-term scientific experiments utilizing Soyuz family rockets is using the free volume in the payload adapter. In the payload adapter can be placed up to 20 kg of the additional payload. It would be CubeSat deployers or non-separable scientific pods. Orbital parameters of the separated satellites correspond to the working or-bit of the upper stage of the launcher: near circular orbit with an altitude of about 200 km. Micro and nanosatellites can be carried into orbit as a piggyback onboard the Volga Upper Stage. The Volga Upper Stage of the Soyuz-2 1a, 1b,1v space vehicles can inject various satellites into circular orbits of up to 1,500 kilometers and sun-synchronous orbits of up to 850 kilometers. On the payload adapter of the Volga Upper Stage can be installed CubeSat deployers by the Space

Session 2 - Launch Systems and Opportunities

Rocket Centre Progress or by other manufacturers. The Volga Upper Stage is a most suitable platform for launching small satellites. The CubeSat deployers can be placed on the satellites developed by JSC RSC Progress. Opera-tional orbit of the Bion-M/Foton-M type spacecraft is a near circular or-bit with an altitude of about 450-580 km. In 2013 five CubeSats were successfully separated from the Bion M1 satellite.

IAA-BR-02-04

CUBESAT SEPARATION DYNAMICS

Vadim Yudintsev

A CubeSat should be released from the deployer with minimum tip-off rate due to the physical constraints and limitation of onboard power budget. The energy that would have been spent on detumbling the satellite can be spend on main mission-specific objectives. This is especially important for CubeSats released far from the Earth's magnetic field. This paper addresses the dynamics of separation of CubeSats from the CubeSat deployer. The equations of the motion of a CubeSat in the deployer is derived. The influence of the parameters of a CubeSat and the parameters of the deployer to the tip-off rate of a CubeSat is investigated. It is shown that the stroke of the spring pusher, the gap between the guide rails of a CubeSat and the guide rails of the deployer, the position of the center of mass of a CubeSat impact most on the tip-off rate. The dependence of the tip-off rate on these parameters is obtained for 1U and 3U CubeSats. The comparison between the calculated and measured tip-off rate during the ground experiment gave good agreement. The recommendations are made to reduce the separation tip-off rate of a CubeSat. The analysis of the motion of a CubeSat in the deployer allows to develop technical solutions that significantly reduce the tip-off rate and plan the onboard power budget more accurately. The proposed mathematical model and the results are used during the development of the CubeSat deployer by JSC SRC Progress.

Session 3 – Modelling

IAA-BR-03-01

VIRTUAL SATELLITE PLATFORM OF AN ON-BOARD COMPUTER FOR SPACE APPLICATIONS

Dominic Zijlstra; Rogerio Paludo; Djones Lettnin

This work presents the design of a virtual satellite platform to vali-date the system architecture and to support the embedded software de-velopment for the Floripa-Sat project. The platform is dedicated to a nanosatellite of type Cubesat, which makes use of the TI MSP430 mi-crocontroller for its subsystems. It is realized in the SystemC language, with the communication described by transaction-level modeling and the instruction set simulator generated by the architecture description lan-guage ArchC, with added support for interrupt handling and system call emulation. The instruction set simulator is capable of running the exact same binaries as the physical board. The communication between the subsystems (on-board data handling, electrical power system, and te-lemetry, tracking and command), each containing a processor, memory, communication modules and further peripherals, is demonstrated using the I²C protocol, which reaches speeds up to 203 kB/s. The basicmath part of the MiBench benchmark was run on the instruction set simulator, showing simulation speeds of 56 MIPS in a system setup without exter-nal memory and 49 MIPS in a setup consisting of an instruction set sim-ulator connected to a TLM memory. A software control system was de-veloped to show that the I²C protocol is capable of transferring com-mands between the satellite subsystems, controlling their states. Finally, the real-time operating system FreeRTOS was run on the platform, with a timer module providing the system tick, and used to schedule and exe-cute various example tasks of the on-board data handling satellite sub-system as well as the communication with the other subsystems. The re-sults show that the proposed approach is effective and that the virtual platform is capable of performing the nanosatellite's tasks. The perfor-mance proves to be on par with previous works on transaction level modeling. Additionally, the virtual platform enables the validation of the system architecture and supports the embedded software development early on the Floripa-Sat project.

IAA-BR-03-02

TOWARDS AN AUTOMATED HYBRID TEST AND SIMULATION FRAMEWORK TO FUNCTIONAL VERIFICATION OF NANOSATELLITES' ELECTRICAL POWER SUPPLY SUBSYSTEM

Italo Pinto Rodrigues; Ana Maria; Christopher Cerqueira

Tests in the space systems development life cycles are necessary to early verify requirements fulfillment, ensuring that the systems developed are correct. Nowadays, the efforts to develop miniaturized satellites and their test suite is increasing. Additionally, it is growing the initiatives is adopting MBSE (Model Based System Engineering) to automate the processes of: model design, simulation and model transformation. In MBSE development approach, models are the focus of the activities. The models describe requirements, functionalities and interfaces of a system, and their subsystems, considered here as "input models". In the context of an Electrical Power Subsystem (EPS), the design engineers have to (i) generate models representing solar array, battery, voltage regulators, loads, etc., for implementation solutions, and (ii) provide a verification plan, derived from requirements, to ensure the correctness of the developed functionality. In this scenario, the following question raises: "how to interconnect the "input models" with verification plans, developed solutions and test executions?" This paper aims to describe the structure of an automated verification framework to nanosatellite's EPS, using COTS (commercial-of-the-shelf) tools, such as MATLAB/Simulink, MS. Excel, and Arduino. We propose the models are as granular as in the verification plans (it is not possible to test internal behaviors from a black box artifact), so, each model represent an element in a unique file and a sequencer will integrate them, as a DSM (Design Structure Matrix) in Excel. In the context of the proposed framework, the subsystem verification enables three test configurations: fully simulated, fully simulated considering physical interface model, and hardware-in-the-loop (HIL). One advantage of the proposed framework is to reuse models from the start of the mission

development, providing the reuse of these models throughout the life cycle, minimizing costs. The paper shows also results of development of the framework using an EPS behavioral model.

IAA-BR-03-03

ON THE USE OF NANOSATC-BR TEST SYSTEM FOR PAYLOAD OPERATIONAL REQUIREMENTS VERIFICATION

Carlos Conceicao; Ana Ambrosio; Fatima Mattiello

The need for a global quick and efficient communication, observation and understanding of events on Earth and conquest of space, motivates spacetechnology development. The CubeSat standard, also known as U-Classnanosatellite platform, has enabled the flight qualification of innovativespace technologies developed in academic environment and / or emergingcompanies in the sector. For over three decades leading research anddevelopment satellites in Brazil, the National Institute for Space Research(INPE) has supported over the past five years the development ofnanosatellites projects in INPE´s regional centers at Northeast and South of Brazil in cooperation with local universities. In this context, NanosatC-Brfamily has been developed. First satellite, NanosatC-Br1, is a 1U Cubesat launched in July 2014 for purposing of both collecting the Earth's magnetic field data and measuring in flight the radiation resilience of integrated circuits designed in Brazil. The qualification of embedded software systems is one of the main challenges of the second mission, a 2U Cubesat named NanosatC-Br2 that is planned to be launched in 2016. The use of existing components on the market (COTS) added to the standardization of on board subsystems in nanosatellites platforms have allowed to reduce significantly the space mission development cycle enabling new space technologies being qualified on flight at low-cost. However, the verification and validation activities (V&V) at different stages of the space project lifecycle are still required and onerous in terms of resources and time. At least functional and dependability aspects of the payload integration with the satellite platform need to be systemically tested. Aiming to avoid the development of new test environment every new mission of a nanosatellite family, which spends time, hardware and software resources, this article presents a reusable Test System for NanosSatC-BR family. The reusability issues of Test System are addressed in two perspectives: (i) reuse the Test System at different stages of the same mission; (ii) reuse the Test System in different satellites of the same family. The proposed Test System architecture supports the V&V process focusing on interoperability features between the NanosatC-Br onboard computer and its payloads, aided by fault injection mechanisms.

Session 4 – Educational Mission Management and Regulations

IAA-BR-04-01

T-PROST: A TRANSDISCIPLINARY PROCESS MODELLING METHODOLOGY AND ITS APPLICATION TO THE SYSTEMS ENGINEERING LIFECYCLE IN SPACE MISSIONS

Renato Fernandez; Elaino Kelson Teixeira Silva; Germano de Souza Kienbaum; Álvaro Augusto Neto

This work describes a transdisciplinary process modelling methodol-ogy, denominated T-ProST, for creating a conceptual reference model of the Systems Engineering lifecycle processes, which can then be trans-formed into specialized models, making use of the traditional autono-mous methodologies and techniques originated from disciplines that deal with complex discrete event process problems, namely: (Model Based)Systems (Concurrent) Engineering, Project Management, Business Process Management, and Simulation Modelling. The transformation of the Systems Engineering lifecycle processes (an aggregate of the sys-tem´s engineering and the organization´s management processes) into specialized models and their implementation, making use of the appro-priate inherent methodology and tools originated from the referred study areas, result in integrated applications that can be used as tools to sup-port basic.Product Lifecycle Management in small satellites project de-velopments. The main benefits originated from this approach derive from: The systematization of the model creation encompassing both the systems engineering and the management processes.The use of a Framework for model implementation and analysis, based on the simul-taneous use of diverse disciplines and their respective methodologies and tools; The joint assessment of the multifaceted models created to provide better solutions and to improve project development.

IAA-BR-04-02

CUBESAT MISSIONS AS LEARNING TOOLS: THE INFLUENCE ON STUDENTS

Laio Oriel Seman; Eduardo Augusto Bezerra

CubeSats' development in universities demands interdisciplinarity, team work, and a great effort regarding the interaction among students, technicians, researchers and administrative personnel. As a reward, the students have the opportunity to practice the theoretical concepts learnt in their classes, experiencing a design environment, very similar to what they are going to find in the industry. This need for interaction in such design environment, fits its development under the active learning methodology, where the student is no longer just a spectator. This technique has already been successfully tested in several universities around the world. Aiming the understanding of such technique, and how the students are affected during the process, this article proposes a qualitative analysis of issues related to those involved in a CubeSat mission, through individual interviews to raise points such as: difficulties faced; pressure to deal with deadlines; involved learning; pros and cons of working as a team; and the impact of participating in the development of something tangible. The specific analysis of an on-going CubeSat mission becomes interesting as it allows feeding the research with a universe of students at very different levels of education and with different backgrounds, making the specified active learning process eclectic and inclusive. Considering the collected data at an individual analysis level, it is possible to cast a critical review on the pedagogical contribution of the CubeSat mission, tracing a profile of the interviewed students. Afterwards, the free software IRAMUTEQ is used to perform an analysis on the collected data. The software is based on the R language and allows different forms of textual corpus statistics and analysis on charts of individuals in words. Thus, we intend to understand how students are affected by the development of a CubeSat mission and how it is or it is not beneficial to their academic and professional growth.

Session 4 – Educational Mission Management and Regulations

IAA-BR-04-03

A DATA CENTER FRAMEWORK FOR TECHNOLOGICAL READINESS ASSESSMENT OF INNOVATIVE TECHNOLOGY ON BOARD CUBESATS

Andre Novais; Fátima Mattiello-Francisco

The CubeSat platform, due to the reduced development cycle, launch standardization and operation cost, has been widely used to demonstrate innovative technologies in space environment with acceptable levels of risk. The INPE has a CubeSat development program with Brazilian uni-versities called NanoSatC-BR. The first CubeSat, successfully launched in June 2014, carried on board four technological experiments for demonstration in space environment. Although the mission has a web-site to store and make the raw data accessible to the scientific communi-ty, they lack tools to provide an evolutionary history of the experiments operation in flight and means to assess the maturity achieved by tech-nology. This paper conceptualizes a data center framework as solution to store, process and distribute data of the experiments on board NanoSatC-BR1, and supports technology maturity assessment mission using satellite operational data acquired in orbit. The framework uses as reference the Technology Readiness Level (TRL) indicator, proposed by NASA, which has nine descriptive levels of technological maturity. The aim is to provide an extensible environment to support several maturity assessment methods. The multi-mission data center architecture will also enables stakeholders to monitor the operating behavior of several exper-iments during their flight qualifications and record related results of TRL evaluations. This historical data base will allow INPE managing the pro-cess of new technologies qualification on board CubeSat tracking the incremental evolution of nano satellite experiments developed in the country.

IAA-BR-04-04

SIMPLE AND FLEXIBLE MODEL TO ASSESS DIFFERENT SCENARIOS FOR SPACECRAFT POPULATIONS AT LOW-EARTH ORBIT AND ITS SUSTAINABILITY IN THE FUTURE

Vinicius Bigogno Costa; Hugh G. Lewis

The rise of Cubesats as a new solution for spacecraft architectures for low Earth orbits (LEO) has brought up the discussion of the space population sustainability and its future. Although Cubesats are a more feasible solution for lower budgets, they also are smaller objects, with-out orbit control and manoeuvring capabilities. That means this is an is-sue for space debris regulators: the increasing popularity of Cubesats may lead to an overpopulation of low Earth orbit and threaten its stabil-ity. The models developed by the Inter-Agency Space Debris Coordina-tion Committee for assessing the stability of LEO environment, although very accurate, are complex and changing their parameters is not simple, they lack flexibility when needed to evaluate different scenarios other than those previously programmed. The model proposed here, the Dy-namic Assessor of LEO Population Stability (DALPS) was developed between February and June 2015 and its point is to allow the prediction of many different scenarios by changing the simulations parameters, such as yearly launch rate, the average number of objects inserted in or-bit per launch or the percentage of objects that comply with the space debris mitigation guidelines. Based on the principles of a predator-and-prey population, this model had its complexity increased over iterations and the parameters of the differential equations were defined so as the trend and the values would be coherent with the ones found using the UK Space Agency model “DAMAGE” (Debris Analysis and Monitoring Architecture to the Geosynchronous Environment). Although this pro-posed model is far from the precision that the ones developed by the IADC member agencies have, it gives not only Cubesat developers, but any LEO spacecraft developer an insight onto many different scenarios, allowing them to understand the consequences of policies taken or to be taken, and raises questions and debates on the course of the future use of Cubesats.

Session 4 – Educational Mission Management and Regulations

IAA-BR-04-05

AN ENVIRONMENT TO SUPPORT PLM IN SMALL SATELLITES PROJECT DEVELOPMENT

Elaino Kelson Teixeira Silva; Renato Fernandez; Marcelo Coicev; Eduardo Gartenkrau; Rodrigo Britto Maria; Márcio Rodrigues; Germano de Souza Kienbaum; Álvaro Augusto Neto

The objective of this work is to present and to apply a multifaceted process modelling methodology and a set of integrated applications, which can be used as a basic PLM environment to support the product lifecycle management processes in the context of small satellites project development, aiming at improving its planning, execution and management. The methodology has been named Transdisciplinary Process Science and Technology and it consists in building and analyzing specialized transdisciplinary models of the systems engineering and management processes, based on the techniques originated from the disciplines of (Model Based) Systems Engineering, Project Management, Business Process Management, and Simulation Modelling. The methodology can be used to model and analyze complex discrete event processes in general, but it is demonstrated in this work specifically applied to the modelling and analysis of the space systems engineering design phase processes and their management. Organizations and academic institutions involved in the development of cubesat space missions, as well as those related with small satellites in general (pico, nano and micro satellites), can benefit the most from the use of this methodology. This work documents a case study conducted by the students of the postgraduate Course on Systems Engineering and Management (CSE-331/ETE/INPE), demonstrating the application of the methodology and the potential of the basic PLM environment created to produce a great jump start in the quantity and quality of the knowledge and management abilities acquired by the participants in the execution of projects involving small satellites space missions.

9:00-9:30 - Agata Room - Keynote

"From Education to Practical Applications of Micro/nano/pico-satellites in Japan Starting from CubeSat"

Prof. Shinichi Nakasuka, University of Tokyo, Japan.

In June 2003, Japanese two universities, University of Tokyo and Tokyo Institute of Technology completed the development of and launched the world first CubeSats "XI-IV" and "CUTE-1" using Russian rocket "ROCKOT" together with 4 other universities' CubeSat. That was the icebreaking event of micro/nano/pico-satellite development activities in Japan. Triggered by the success of XI-IV and CUTE-1, many universities in Japan started their own satellite projects, mostly for educational objectives, and 34 Japanese university satellites have been launched till now. University professors and students community named "UNISEC", University Space Engineering Consortium, has been contributing very much in spreading these activities in Japan, and the space agency JAXA has supported us in launching piggy-back satellites on its rockets.

University of Tokyo already developed 8 satellites, and 7 of them were launched and operated successfully in orbit. Two CubeSat "XI-IV" and "XI-V (2005)" were primarily for space engineering education, but from the third satellite "PRISM," we have been challenging towards more practical applications. PRISM aims to obtain about 30 m resolution Earth remote sensing images, which was actually achieved in 2009. Our fourth satellite "Nano-JASMINE," which is now waiting for launch, has "Astrometry" mission to obtain very precise 3D map of more than 500,000 stars in space. Last year, three Earth remote sensing satellites "Hodoyoshi-1,3,4" were launched by Dnepr, which showed excellent performance of taking Earth pictures of 6m, 40m and 240m ground resolutions, with which now we are collaborating with several remote sensing companies in processing and selling these pictures for business use. In December 2014, we launched world first micro deep space probe "PROCYON," which escaped from Earth gravitational field and various observation and experiment were conducted in deep space. All of the seven launched satellites are still operational in space.

In this way, University of Tokyo have been stepping up from education to practical applications of micro/nano/pico-satellites, but the initial experiences of first two CubeSats have contributed a lot to our follow-on projects. We are now developing 3U size CubeSat again for remote sensing and communication missions. In my talk, I will show this history and future vision of micro/nano/pico-satellites in Japan, and UNISEC activities as well.

9:30-10:00 - Agata Room - Keynote

"The Cosmic X-Ray Background NanoSat-2 (CXBN-2): An X-Ray Detector for CubeSats Validated through Science Data"

Prof. Benjamin Kevin Malprhus, Morehead State University, USA

CXBN-2 is a follow-on mission to CXBN, a 2-U cubesat that was launched on September 13, 2012 as a secondary payload on the NASA ELaNa VI OUTSat mission. While CXBN successfully operated on orbit, a number of improvements are incorporated into CXBN-2 that will improve the precision of the scientific measurement and improve the reliability of the spacecraft bus. The goal of the CXBN-2 mission is to, in ~1 year of operation, collect 1million seconds of data and increase the precision of measurements of the Extragalactic Diffuse X-Ray Background (DXB) in the 20-50 keV range to a precision of <5%, thereby constraining models that attempt to explain the relative contribution of proposed sources lending insight into the underlying physics of the early universe. Existing measurements disagree by about 20%. The DXB is a powerful tool for understanding the early universe and the mission addresses a fundamental science question that is central to our understanding of the structure, origin, and evolution of the universe by potentially lending insight into both the high energy background radiation and into the evolution of primordial galaxies. CXBN-2 will measure the DXB with a quasi-COTS Cadmium Zinc Telluride (CZT) detector that is adapted from the medical imaging community. With the novel CZT detector aboard CXBN-2 and an improved array configuration that includes unique feature - a 3-D printed Tungsten pixelated collimator, a high precision measurement is possible. Use of the 3-D printed Tungsten components have implications for radiation shielding for other critical components of small spacecraft. The science mission requirements allow for the design of a relatively simple spacecraft, making this mission ideal for the CubeSat form factor. The conops is characterized by a free-flying, minimally spinning spacecraft, which provides the most effective celestial sphere coverage of the areas of interest. Both the science program and the engineering of the spacecraft will conducted by graduate and undergraduate students in concert with university faculty mentors. CXBN-2 is scheduled for delivery in summer 2016 and launched in 2017. CXBN-2 is collaboration between Morehead State University (Morehead, KY, USA), Kentucky Space LLC (Lexington, KY USA) and Space Tango (Lexington, KY USA), and the Keldysh Institute of Applied Mathematics (Moscow, Russia). This presentation will focus on characterization of the X-Ray detector and validation of its performance by comparing measurements with simulations of the expected diffuse X-Ray background.

Session 5 – Assembly, Integration, Test and Verification

IAA-BR-05-01

OPTIMIZING 3-COMPONENT FORCE SENSOR INSTALLATION FOR SATELLITE FORCE LIMITED VIBRATION TESTING

Bob Metz; Carmine Salzano

Due to the high cost, long development times, and uniqueness of satellites, it has become imperative to implement techniques that ensure their safety during vibration qualification testing. Force Limited Vibration is used to limit the reaction force between the shaker and unit under test. The use of piezoelectric, 3-component force sensors facilitates easy and accurate measurement of the input force. This force relates directly, using Newton's Second Law, F=ma, to the "quasi-static" acceleration of the structure's center-of-gravity. Payloads are often fitted with piezoelectric force sensors using flight hardware or adaptor rings that present the problem of proper installation and preload required for a successful test. Preloading selection criteria is reviewed in detail along with its effects on gage sensitivity caused by bolt material effects. Case studies are presented showing 3-component piezoelectric force gages at each mounting point using flight hardware and factory supplied preload studs.

IAA-BR-05-02

BEHAVIOR MODELLING AND SIMULATION OF A FAULT TOLERANT ATTITUDE DETERMINATION SYSTEM FOR NANOSATC-BR2

Bruno Caetano O. Miranda; Ricardo de Oliveira Duarte

In this paper we present a procedure to model and simulate the operation of the Fault Tolerant Attitude Determination System (SDATF) that will be embedded as payload of the brazilian cubesat NanosatC-Br2. This system has been designed to provide satellite's attitude information in the presence of Single Event Upsets (SEU) over integrated circuits. In this work, a behavioral model for the fault tolerant solution was formulated using Statechart formalism, and simulation was performed in Mathwork's Simulink environment. At first, the fault tolerant solution principles and the requirements in the context of NanosatC-Br2 are described. A brief discussion is presented about aspects related to this system's operation under the occurrence of Single Event Upsets (SEU) and how to emulate the payload behavior in response to these non-deterministic events. The basic features of Statechart formalism are stated and we discuss the reason why it is an effective approach to model complex systems like the fault tolerant solution. Once the basic theoretical aspects are covered, simulation model is presented based in the mentioned formalism and also the practical aspects of implementation in Simulink environment. Some scenarios were simulated in order to trace embedded processors states over time. Finally, the experimental results are analyzed and conclusions are presented. Future work is discussed as well.

Session 6 – Mission Applications

IAA-BR-06-01

SEAHAWK: A CUBESAT MISSION FOR SUSTAINED OCEAN OBSERVATION

Hazel Jeffrey; Hessel Gorter; Alasdair Gow; Craig Clark; Alan Holmes; John Morrison; Jenni Doonan; Pamela Anderson

Developments in CubeSat sub-systems at Clyde Space, such as state-of-the-art deployable solar panels, electrical power systems and lightweight structures are transforming the use of CubeSats. In developing more ca-pable CubeSat systems which can produce more power, give improved pointing accuracy and reduce mass the next generation of CubeSat mis-sions can be enabled. Clyde Space, in collaboration with the University of North Carolina Wilmington, Cloudland Instruments and Goddard Spaceflight Center funded by the Gordon and Betty Moore Foundation, are developing SeaHawk a CubeSat mission for sustained ocean colour observation. The goal of the project is to enhance the ability to observe ocean colour in high temporal and spatial resolution modes through the use of a low-cost, next-generation ocean colour sensor flown aboard a CubeSat. The development times of traditional sensors can be prohibi-tively long. For example, SeaWiFS took more than 10 years to develop. By contrast, two 3U SeaHawk CubeSats with HawkEye Ocean Colour Sensors will be produced in 2 years. The final product will be 530 times smaller (0.0034 vs 1.81 m3) and 115 time less massive (3.4 vs 390.0 kg) but with a ground resolution 10 times better (95 vs 1000 m2 per pixel) whilst maintaining a signal/noise ratio approximately 50% that of Sea-WiFs. This paper will describe the technical and science objectives of the mission and outline the spacecraft platform to support it. Clearly this is an ambitious mission with challenges in the development of an ad-vanced payload of this type, capable of fitting within the constraints of a 3U CubeSat, and also in the platform in terms of pointing accuracy, on-board data processing, the downlink of very significant data sets to the users every orbit, and having enough power to run all of these sys-tems. This paper therefore also highlights the latest technology devel-opments at Clyde Space which are enabling these next generation Earth Observation missions using CubeSats.

IAA-BR-06-02

THE RAIOSAT PROJECT: DETECTING TOTAL LIGHTNING FLASHES FROM A CUBESAT

Kleber Naccarato; Walter Abrahao Dos Santos; Miguel Carretero; Candido Moura; Auro Tikami

Extreme weather events are one of the major character in climate change. Predicting these complex meteorological phenomena requires high-resolution numerical weather prediction (NWP) models and the maximum amount of observational data available. Nowadays, in Brazil, several networks composed by different types of sensors provide these measurements, including electromagnetic passive sensors which are capable of detecting the lightning-producing radiation. Advanced processing units collect these data, locate the lightning discharges, integrate all the information, and store them in high-capacity and high-performance databases. These data are then assimilated into the NWP models to improve the forecast of extreme weather events. The RaioSat project intends to detect, for the first time, intra-cloud and cloud-to-ground lightning flashes simultaneously, the so-called total lightning data, using an optical sensor and a VHF antenna onboard a CubeSat platform. A dense network of surface sensors that detect and locate total lightning data in Brazil, named the BrasilDAT dataset, will be used to validate the RaioSat data as a ground-truth reference. The RaioSat mission is expected to be in a LEO orbit at 650km and it will use a 3U-CubeSat aluminum frame (10x10x30cm) to accommodate the main platform and its payload. The main platform shall be solar and battery powered, have telemetry, commanding and housekeeping capabilities via an on-board computer, 3-axis attitude control and a GPS. The payload shall have a VHF passive antenna, ranging from 50 to 200MHz, and a spectral imaging camera (SIC) with high-performance image processing capacity and large data storage memory. SIC resolution shall be 2,048 x 1,536 pixels leading to a surface imaging of 80 m/pixel at 650km altitude. Also SIC shall have a spectral range from 700 to 900nm using a band-pass optical filter. Additionally, this paper also analyses upfront the stages of the space mission over the system life-cycle which consists

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basically of: (a) mission analysis, (b) life cycle analysis, (c) functional analysis, (d) design architecture analysis and, (e) concept of operations among others.

IAA-BR-06-03
RACETRACK TO ORBIT, AN ADDITIVE REVOLUTION
Twyman Clements, Gil Moore, Mathew Dushku, Stewart Davis, Francesca Cuoghi

The recent predominance of consumer level 3D printers has brought much attention towards the additive manufacturing process. On November 19th 2013 29 small satellites were launched from NASA's Wallops Flight Facility including KySat-2, a 1U CubeSat. Some parts of the KySat-2 was built with 3D printed parts made from Windform XT 2.0, a material whose previous uses were mainly for automotive racing. Another 1U CubeSat, PrintSat, will be launched in 2015 and whose entire structure is built from the same material. This paper will discuss how each satellite used 3D printing, an overview of Windform XT 2.0, pros, cons and design considerations of 3D printing, and its future potential uses in the design and construction of spacecraft.

IAA-BR-06-04
LAUNCH AND EARLY OPERATIONS PHASE FOR THE GOMX-3 MISSION
Igor Alonso Portillo; David Gerhart

The plan for activities to be performed immediately after a satellite orbital insertion, commonly known as the Launch and Early Operations Phase (LEOP), can be sometimes disregarded or not given enough importance until later in a project, especially by new university teams developing their first CubeSat. Besides, the execution of LEOP activities brings an additional challenge after many years of project development due to its singular criticality. These activities are required regardless of the type of launcher and include: ground station set-up, reception of first beacon, satellite de-spin, downlink and uplink tuning, power budget monitoring, time synchronization, and more. Depending on the payloads the LEOP can extend from a few days to a few weeks for an average CubeSat project. In many cases, an additional challenge exists for small and/or new groups using a single ground station for communication. This means that only a few short passes per day may be available for performing all necessary LEOP tasks, depending on the type of orbit and the latitude of the ground station. Additionally, long breaks between pass sets may increase the effect of satellite anomalies as operators cannot respond to them quickly. Each of the above considerations increases the need for proper LEOP planning and execution. GOMX-3, an advanced performance 3U CubeSat financed by the European Space Agency, has been designed and built by Danish sector leader GomSpace, and was deployed from the International Space Station on October 5, 2015. The LEOP execution has been a success in terms of its planning, speed, and technical achievements. Also remarkable has been the coordination of the LEOP team members during the performance of the different tasks. This paper presents a detailed review of the GOMX-3 LEOP with the aim of sharing the positive experiences and lessons learnt with the growing Latin American CubeSat community.

IAA-BR-06-05
EXTENDING THE COVERAGE FOR THE INTERNET OF THINGS WITH LOW-COST NANOSATELLITE NETWORKS
Vicente Almonacid; Laurent Franck

Recent technology advances have made CubeSats not only an affordable means of access to space, but also promising platforms to develop a new variety of space applications. In this paper, we explore the idea of using nanosatellites as access points to provide extended coverage to the Internet of Things (IoT) and Machine-toMachine (M2M) communications. This study is mainly motivated by two facts: on the one hand, it is already obvious that the number of machine-type devices deployed globally will experiment an exponential growth over the forthcoming years. This trend is pushed by the available terrestrial cellular infrastructure, which allows adding support for M2M connectivity at marginal costs. On the other hand, the same growth is not observed in remote areas that must rely on space-based connectivity. In such

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environments, the demand for M2M communications is potentially large, yet it is challenged by the lack of cost-effective service providers. The traffic characteristics of typical M2M applications translate into the requirement for an extremely low cost per transmitted message. Under these strong economical constraints, we expect that nanosatellites in the low Earth orbit will play a fundamental role in overcoming the IoT digital divide. The objective of this paper is therefore to provide a general analysis of a nanosatellite-based, machine-type data collection network aiming to extend coverage for the IoT. We put emphasis in the engineerng challenges faced in designing the Earth-to-Space communication link, where the adoption of an efficient multiple-access scheme is paramount for ensuring connectivity to a large number of terminal nodes. In this context, we overview the state of the art of current developments and propose a novel access approach suitable for delay-tolerant applications. Thus, by keeping a system-level standpoint, we identify key issues and discuss perspectives towards energy efficient and cost-effective solutions.

14:30-15:00 - Agata Room - Keynote

"Current NanoSatellite trends and their implications for developing space programs"

Prof. Jordi Puig Suari, California Polithecnic State University, USA

CubeSats and NanoSats have seen exponential growth in recent years. This growth is not only in the quantity of missions but also in their quality. In addition to traditional science and government missions a significant number of new commercial endeavors rely on this new class of spacecraft. The result of these advances is a "new space" industrial capability emerging in parallel to traditional space activities. This "new space" industry is based on commercial components and is evolving much faster that traditional space systems. Moreover the low-cost of these systems allows for much easier entry to new players. The result is a highly competitive environment with minimal barrios to entry for developing space programs. The presentation will discuss the emergence of the "new space" economy and the implications for developing space programs based on nanosatellties.

Session 7 – Attitude Determination and Control Systems

IAA-BR-07-01

ATTITUDE CONTROL MODEL FOR CUBESATS

Juan Carlos Molina; Victor Hugo Ayerdi; Luis Zea

An essential step in the attitude control system design process is the construction of a simulation model that is sufficiently accurate to represent system dynamics, thus allowing for algorithm validation and performance testing. There aren't many publications or models that serve as a basis for designing and understanding a satellite's attitude determination and control system (ADCS) from a CubeSat's standpoint. Faced with this challenge, an attitude control model was designed and evaluated for its use on a CubeSat's ADCS. The model is intended for CubeSats with an active control scheme based on momentum exchange devices (reaction wheels) to rotate the satellite about each of its axes. A model that combines a CubeSat's transfer function with the ADCS's control algorithm was developed in order to simulate closed-loop system response. Simulation results were used in order to validate system functionality and to test performance in response to different disturbance signals. The operational requirements and scientific drivers of Guatemala's first CubeSat mission, remote sensing for lake contamination monitoring from an orbit described by deployment from the International Space Station, were utilized as input parameters for the simulation model, including actuator's torque capacity and the systems inertia matrix. An additional simulation was performed in order to characterize the environmental disturbances that the control system must be able to reject. The simulation model for continuous attitude control was translated to an equivalent discrete model that enables the results to be implemented in a real-time embedded system. The simulation model helped validate the adequate topology for a digital control system to be used by a CubeSat's ADCS and this was used to determine adequate Proportional-Integral-Derivative (PID) controller gains.

IAA-BR-07-02

STABILIZATION OF A NANOSATELLITE BASED ON FUZZY CONTROL

Gustavo Mendoza-Torres; Gustavo Rodriguez-Gomez

In this work, we propose a control system based on a Fuzzy Control in order to counter the chaotic nanosatellite motion. The control is founded on the variation of angular acceleration from which the torque of an inertial system is modified. A disk and a DC motor compose the inertial system. We develop a fuzzy control algorithm for each axis, X, Y. For each control algorithm, we include information in both directions (X and Y), and with their combination we get the control of the third axis. This control system can be adequate for using in low-orbit satellites. Through of an accelerometer we obtain the information of the axes X, Y. To test the fuzzy control proposed, we built a scale model with the standard dimensions of a CubeSat. In this scale model was included the inertial system with the accelerometer and the tests of the fuzzy control conducted were under conditions of gravity on the Earth's surface. The control variables are specified by the value given by the accelerometer as input variable, and the pulse width of the DC current as output variable. The processed information by the fuzzy control is sent to the DC motors, which handle the disks, generating the torque required to steady the chaotic nano-satellite movement.

IAA-BR-07-03

A TEST-BED FOR ATTITUDE AND DETERMINATION CONTROL OF SPACECRAFTS

Pedro Beghelli; Simone Battistini; Renato Borges; Chantal Cappelletti; Rodrigo Cardoso Da Silva; Ulisses Rodrigues; Sarah Costa; Brenno Popov; Mariana Sampaio

The space environment peculiarities, as the presence of microgravity, the magnetic field of the Earth and the absence of atmosphere, influence the project of satellite Attitude Determination and Control System (ADCS) hardware and software. To ensure proper functioning of the

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designed ADCS, during the project phase, simulations using software or specific hardware shall be conducted. Aiming at simulating at ground the conditions of the space environment, the Laboratory of Aerospace Science and Innovation (LAICA) of the Universidade de Bras´ılia (UnB), is developing a dedicated testbed for simulating spacecraft attitude motion. The testbed is composed of an air bearing table and a Helmholtz cage. The air bearing table is an hardware platform whose purpose is to simulate the microgravity conditions of a spacecraft in orbit. The table used as the simulation platform floats by means of actuation of a pneumatic system that uses an air bearing. The table movements are controlled by the mechanical and electronic systems of mass balancing, both embedded in the simulator. The mechanical part of the platform is composed by the air bearing, fixed and movable masses, besides all the embedded in the plate hardware. The electronic system is composed by motors, batteries, microcontrollers, various sensors (e.g. accelerometers and magnetometers) and wireless communication system. The displacement of the movable masses is realized through the stepper motors, and, using a well-known balancing algorithm, aims at minimizing the distance between the center of mass and the center of rotation of the table, so as to make the gravitational torque negligible. The air bearing table top simulator is installed inside an Helmholtz cage, a device used to induce a magnetic field around the structure of the cage. In particular, inside the cage the induced magnetic field can be adjusted so as to recreate the Earth magnetic field conditions that the spacecraft encounters in orbit. The Helmholtz cage in fact consist of 6 coils in the three main axes. The coils produce an induced magnetic field with an adjustable magnitude since they are connected to controlled power sources that can be manipulated using dedicated software. This paper describes the design and realization of the whole ADCS hardware simulator taking into account the electromechanical systems and the calibration procedures.

IAA-BR-07-04

THE DESIGNING AND TESTING OF A PASSIVE MAGNETIC ATTITUDE CONTROL SYSTEM FOR FLORIPASAT

Stefany Dutra; Bruno Lugnani; Lucas Casaril; Alexandro Brito

This paper presents the main ideas for the development and testing of a PMACS (passive magnetic attitude control system) for FloripaSat – a cubesat under development by the Federal University of Santa Catarina. The control strategy is based on a set of permanent magnets and hysteresis rods that interacts with the Earth's magnetic field, providing the satellite attitude alignment. The development follows two steps: i) a numerical simulation aiming at the system specification and global performance assessment, and ii) the test of an engineering model in a magnetic set-up based on Helmholtz coils. Both steps are detailed and some preliminary results are presented.

IAA-BR-07-05

A STAR IDENTIFICATION ALGORITHM USING A NEW METHOD BASED ON A QUASI-EQUILATERAL GEOMETRY

Berenice Rodríguez Pedroza; Rogerio Enriquez Caldera; Eduardo Mendoza Torres

This paper presents a star identification algorithm employing a new method based on a quasi-equilateral geometry and statistics tools. To test the dynamical operation of the star identification algorithm, a sky picture was generated by a Star Field View Algorithm. Both algorithms have been developed on MATLAB 2013.

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IAA-BR-07-06

OPTIMIZED CONTROLLER DESIGN FOR CUBESAT ATTITUDE TRACKING CONTROL USING MAGNETIC ACTUATORS

Felipe Coelho; Andre Da Silva; José R. Pinheiro

This work presents a LQR-based PID controller design for attitude tracking control of a Cubesat-class satellite equipped with magnetic actuators only. The control strategy is structured with two closed loops: the first regards the system for attitude tracking and the second regards the stability augmentation system (SAS) for kinetic energy dumping. The PI-controller appears as a feed-forward compensator in the tracking loop, while the derivative parcel acts through the stability loop. The system-plus-compensator can be seen as an augmented system. In order to determine the controller gains, the model is linearized and a LQ cost function involving the tracking error and control is set. The technique discussed in this paper, from aeronautical literature, consists in the reformulation of the LQR with output feedback comprising the augmented system due to the PID controller. Numeric minimization of an equivalent performance index is evaluated in order to find optimal gains. The with static output feedback technique is also applied in this paper. Results have shown that the proposed methodology for controller design is clearly feasible even for the nonlinear model. However, uncertainties and nonlinearities owing to the Earth's magnetic field hamper the controller performance that requires a different design. The final controller presented positive results for attitude tracking control using magnetic actuators.

Session 8 – Structure and Thermal Design

IAA-BR-08-01

NUMERICAL INVESTIGATION OF THE INFLUENCE OF THE ORBIT INCLINATION ON THERMAL CONTROL OF A NANOSATELLITE IN LEO

Edemar Morsch Filho; Êmili Bohrer; Kleber Vieira de Paiva; Talita Sauter Possamai; Xisto Lucas Travassos Junior

Different configurations of orbit for a Cubesat result in different incident radiation on the external panels of the nanosatellite and therefore can modify its thermal bahaviour. This influence is investigated in this work in order to analyze the trends in the thermal performance of a Cubesat related to the variation of orbital inclination from 30◦ to 113.5 ◦ for the specific case where one side of the satellite is always facing earth. In order to predict the temperature for a Cubesat in orbit, a 3D thermal numerical model was developed using geometric parameters of the nanosatellite FloripaSat scheduled to be launched in 2016. The model solves he heat transfer equation for the whole CubeSat based on the Finite Volume Method. Incident radiative heat fluxes are formulated considering the transient position of the satellite on orbit. Parameters of orbit as period and eclipse are provided by commercial software STK and inserted into the numerical model. Results indicated that variation in the inclination of the orbit produces significant changes in the panels thermal behavior and temperature, drastically modifying the incident radiation and emission of each panel. For the ost affected panel a 60 K temperature variation was estimated. Notwithstanding results for temperaturerofiles on the battery of the CubeSat indicated maximum variation of temperature of approximately 20 K

IAA-BR-08-02

DESIGN OF THE STRUCTURE AND REENTRY SYSTEM FOR THE LAICANSAT-3 PLATFORM

Matheus F. S. Alves; Arthur P. Wernke; Felipe C. Pereira; Diego H. Gomes; Guilherme S. Lionço; Caio H. Franco L. Domingos; Daniel B. Da Trindade; Chantal Cappelletti; Manuel Nascimento Dias Barcelos Junior; Simone Battistini; Renato Alves Borges

The LAICAnSat is a project under development at the Laboratory of Aerospace Science and Innovation (LAICA) of the Universidade de Brasília (UnB). It consists of a platform for conducting scientific and technological experiments in atmosphere, which is lifted through a balloon. The mission is concluded with the return of the platform to the ground, after the balloon explosion, by employing a reentry system. In the framework of this project, two launches of high-altitude balloons were realized in 2014. This paper describes the latter and the new structure designed for the LAICAnSat platform. The drivers for the choice of the structure design were the structural strength and lightness, and the possibility to host different subsystems and payloads without having to change it every mission. For this, the specifications of a 3U CubeSat were adopted in the design. The whole design is based on a mountable modular platform with three working units; each one is a cube with 10 cm of side. The internal layout is composed by interconnected supports which allow for installation of electronic boards by using the PC/104 standard. In addition, the manufacturing was carried out through rapid prototyping technologies. The material poly lactic acid (PLA) was chosen in order to have a structure with satisfactory mechanical properties, but with low cost. The reentry system is responsible for safely landing the LAICAnSat platform in predetermined areas. This system consists of a paraglider and a mechanical system remotely controlled. To avoid the possibility of this system going into stall due to the strong winds during the ascent and descent phases, reinforcements were placed in the paraglider, which allows for increasing stiffness without compromising mobility. Several tests were carried out to develop and improve the design of the LAICAnSat platform.

Session 8 – Structure and Thermal Design

IAA-BR-08-03

STUDY OF RIGID STRUCTURE VIBRATIONS AND MECHANICAL MODELING FOR THE NANOSATC-BR2: MODAL ANALYSIS AND 3D PRINTING CONSIDERATIONS

Rodrigo Passos Marques; Viktor Bizarro Dutra; Artur Gustavo Slongo; Lorenzzo Quevedo Mantovani; Thaffarel Santos; Tiago Farias; Tális Piovesan; Leonardo Zavareze Da Costa; Pietro Fernando Moro; Thales Ramos Mânica; Alex Müller; Otavio Durão; Nattan Roberto Caetano; Renato Machado; Nelson Schuch

The main purposes of this paper are to introduce a Rigid Structure Vi-bration Analysis for the NANOSATC-BR2 - 2U CubeSat - combining data that was calculated and tested on the NANOSATC-BR1 - 1U Cu-beSat - (tests carried out at LIT/INPE-MCTI), and show the results of the process of mechanical modeling for the NANOSATC-BR2, made with the Computer Aided Design (CAD) software Solidworks. In order to set parameters for the calculations to the Modal Analysis, a computa-tional model of the 2U CubeSat - NANOSATC-BR2 is designed using the software Solidworks as well, and later tooled using Finite Element Modeling and Post processing software - FEMAP. Using FEMAP, it is possible to test vibration modes, and right after it apply the Modal Cal-culation to study the phases of the mission to ensure structural stiffness and prevent malfunctions and damage to the satellite subsystems. After the calculations, the tests will be applied at the LIT to confront the theo-retical and practical data. This paper also discusses the Process of NANOSATC-BR2 3D Printing for its Mechanical Model, and the influ-ences that the 3D Printer limitations had on the Design of this nanosatellite. The INPE-UFSM's NANOSATC-BR CubeSats Develop-ment Program has been designed and executed in a partnership between the CRS/INPE-MCTI and LACESM/CT-UFSM, to improve Capacity Building in Brazil in Space Science and Technology . The Program has support from the Brazilian Space Agency (AEB).

9:00-9:30 - Agata Room - Keynote

"Coastwise Sailing: Prospects of Using Solar Sails in Near-Earth Orbits"

Prof. Mikhail Ovchinnikov, Keldysh Inst. of Applied Mathematics.

Since the time Friedrich Tsander first proposed the concept of space sailing, solar sails are traditionally treated as a tool for interplanetary flight. Being intensively studied both in the USA and in the Soviet Union in the 1970s, the technology of solar sailing had been being in the shadow for almost 20 years until the large solar mirror – Znamya 2 – was deployed onboard Progress M-15 on 4 February 1993. During the next 15 years after that Progress flight, the tremendous progress has been made which allows the first real solar sail missions of JAXA's IKAROS (2010) and NASA's NanoSail-D2 (2011) to be implemented. Surprisingly, it is the near-Earth solar sail projects that prevail nowadays. It can primarily be explained by the urgency of the space debris issue. A sail operating either in the so called drag mode or in the solar mode appears to be a perfect tool to deorbit satellites in the wide range of near-Earth orbits. Another possible application of solar sails is the orbit plane correction, the quite expensive procedure when using the conventional chemical thrust. In the paper, along with the historical review of space sailing technology, the complex orbit and attitude dynamics of a sail-equipped Earth satellite is discussed, with an emphasis on the near-future prospects of micro- and nanosailcraft. The study is supported by the Russian Science Foundation (Grant #14-11-00621).

9:30-10:00 - Agata Room - Keynote

"Programmable Devices in Nano Satellites: Radiation Effects, Fault Tolerance and Integration Perspectives"

Prof. Fernanda Lima Kastensmidt, UFRGS

Session 9 – Telecommunications, Tracking and Command

IAA-BR-09-01

SOFT ERRORS ANALYSIS ON FPGAS FOR CUBESAT MISSIONS

Victor Martins; Leonardo Slongo; Paulo R. C. Villa; Eduardo Augusto Bezerra

The reprogrammability feature of FPGA devices is achieved through the use of SRAM memory cells. The SRAM memory contents define the implemented circuit (hardware) functionality. The SRAM is also used to store software, when a processor is embedded in the FPGA. As SRAM cells are well known for their susceptibility to radiation effects in space applications, any accidental change on their contents may result in severe consequences to the whole system. The embedded electronics system of a CubeSat mission, even in a low orbit, is subject to much higher levels of radiation than the same system in operation on Earth. Considering the already traditional usage of COTS components in CubeSat missions, SRAM based FPGAs are serious candidates to be the first components in a CubeSat on-board computer system to come up with bit flips on its configuration memory. In this work, an FPGA implementation is proposed in order to perform an actual analysis of the radiation effects on this type of device. This analysis includes the occurrence of bit flips in both, the configuration memory, and in Flip-Flops, which are a lot more difficult to detect. The bit flips counting will allow statistical analysis as, for instance, internal FPGA affected resources and CubeSat mission parameters influence (satellite's orbit and inclination).

IAA-BR-09-02

TETHERED 2U CUBESAT DEVELOPMENT IN SPACE TETHERED AUTONOMOUS ROBOTIC SATELLITE PROJECT

Nohmi Masahiro; Yoshiki Yamagiwa

STARS (Space Tethered Autonomous Robotic Satellite) project purposes to evaluate and to verify a space mechanical control system by a university satellite, whose characteristics are: it consists of a mother and a daughter (and grandchildren in future) satellites; it becomes a large scale space system using tether; and also robotic mechanical system performs dynamic motion on orbit. The first satellite of the project was "STARS," which was launched by the HIIA rocket on 23, January, 2009. The second satellite was "STARS-II," which was launched by the H-IIA rocket on 28, February, 2014. Then, the third satellite "STARS-C" is now under development. It will be deployed into orbit from ISS (International Space Station) in 2016. It is a 2U Cubesat, and one is a mother and the other is a daughter satellite. They are connected by 100m long tether. Its primary purpose is to analyze basic tether dynamics motion on orbit experimentally. Mission sequence is planned as follows. First, attitude control by magnetic torquers are performed under docking condition of the mother and the daughter satellites, in order to extend the tether along gravity gradient. Initial velocities of the mother and the daughter satellites for tether extension are obtained from the spring force installed in the satellite body. The tether is stowed by the spool, and it is extended as if a wool ball comes loose. Finally, tether extension is terminated by breaking force of the tether reel. Dynamics motion of tether extension is measured by GPS which is mounted on each satellite. Also, a camera module is mounted on each satellite, which is mounted against to another satellite. Gyro sensors, magnetic sensors, and acceleration sensors mounted on each satellite also support dynamics motion analysis. Improvement of STARS-C from the past launched STARS satellites are: (I) automatic tether deployment is possible without main on-board computer; (II) CW beacon includes GPS data although they are transmitted every minutes; (III) 9600bps communication is employed for picture images downlinks.

Session 9 – Telecommunications, Tracking and Command

IAA-BR-09-03

OPENOBC: AN OPEN-SOURCE, LOW-COST AND HIGH-RELIABILITY ARCHITECTURE FOR A CUBESAT ON-BOARD COMPUTER

David Mota; Júlio César Soares Américo Filho; Davyd Melo; Jarbas Silveira; João Cesar Mota; César Augusto Marcon

This paper proposes an open-source architecture of low cost and high reliability for an On-Board Computer (OBC) compatible with the standard of CubeSat satellite. The proposed architecture encloses a TMS570LS0432 processor that has two ARM Cortex-R4 cores running in lockstep and internal memories with logic for errors detection and correcting. The processor and internal memories contain Built-In Self-Test (BIST) modules, among other safety features such as clock and supply voltage monitoring. An external flash memory is used for code and data storing. The architecture contains two independent I2C interfaces - one for transponder communication and another for communication with the other subsystems of the satellite. Moreover, the architecture has a Universal Asynchronous Receiver/Transmitter (UART) interface for debugging, three outputs of H-bridge drivers for controlling magnetic torquers and six Analog-to-Digital Converter (ADC) inputs for sunlight intensity measuring, which are placed in the satellite faces. Additionally, the architecture provides a MicroSD card for data storage and a CAN interface for real-time traffic transmission. As a project result, we developed a Printed Circuit Board (PCB) and a Hardware Abstraction Layer (HAL), which are free and available to the community through the OpenOBC project repository.

IAA-BR-09-04

NANOSATELLITE ENERGY HARVESTING MAXIMIZATION THROUGH AN ENERGY AWARE SCHEDULING ALGORITHM

Leonardo Slongo; Sara Martínez; Bruno Eiterer; Tulio Gomes Pereira; Eduardo Augusto Bezerra

The number of tasks that a satellite may execute in orbit is strongly related to the amount of energy its Electrical Power System (EPS) is able to harvest and to store. The manner the stored energy is distributed within the satellite has also a great impact on the CubeSats overall efficiency. Most CubeSat's EPS do not prioritize energy constraints in their formulation. Unlike that, this work proposes an innovative task scheduling algorithm based on energy harvesting maximization policy. The energy harvesting circuit is mathematically modeled and the solar panel I-V curves are presented for different temperature and irradiance levels. Considering the models and simulations, the scheduling algorithm is designed to keep solar panels working close to their maximum power point by triggering tasks in the appropriate form. Tasks execution affects battery voltage, which is coupled to the solar panels through a protection circuit. A software based Perturb and Observe strategy allows defining the tasks to be triggered. The scheduling algorithm is tested in the Floripa-Sat prototype, an 1U CubeSat. A test apparatus is proposed to emulate solar irradiance variation, considering the satellite movement around the Earth. Tests have been conducted to show that the scheduling algorithm improves the CubeSat energy harvesting capability in up to 8.46% in a single orbit cycle in comparison with the CubeSat operating without the scheduling algorithm.

IAA-BR-09-05

DESIGN CONSIDERATIONS FOR RADIATION HARDENED ASIC USED AS TECHNOLOGICAL PAYLOAD IN NANOSATC-BR1

Jorge Johanny Sáenz Noval; Leonardo Medeiros; João Baptista Dos Santos Martins; Nelson Jorge Schuch; Otávio Dos Santos Cupertino Durão; Renato Machado

Integrated Circuits (IC) developed for space application requires special care during design, manufacturing and qualification process as they will work on a harsh radioactive environment. There are specially three important kind of interactions which can happen between silicon and

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radiation: a cumulative long term ionization damage denominated Total Ionization Dose (TID), instantaneous radiation dose effects denominated Single Event Effects (SEE) and Displacement Damage (DD) on crystalline structure of silicon. Due technological restrictions and low production–low demand of space ICs, Radiation Hardening by Design Techniques (RHBD) using conventional Complementary Metal-Oxide-Semiconductor CMOS process are become more attractive during the last years. This solution relies on new design techniques, which mitigate the effects of radiation aforementioned. In this paper is shown design techniques and considerations using in the Application Specific Integrated Circuit (ASIC) developed in Santa Maria Design House (SMDH). This ASIC was included as technological payload in the NANOSATC-BR1. The design approaches proposed in this work will be confirmed by results collected during several months. The radiation hardened digital cells designed by SMDH proved a tolerance to solar energetic particles with energies of up to 100MeV.

IAA-BR-09-06

ELECTRICAL POWER SYSTEM (EPS)

Otávio Petito; Arnaldo Viana Júnior; Tiago Cordeiro

This article discusses the development of a power system, capable of supplying the entire energy demand of the attitude control subsystem, communication, data processing and payload of the CubeSat, Escola de Engenharia Mau´a's project. The power system developed is responsible for generating, distribution and control of the entire energy flow of the CubeSat Mau´a. The energy generated by high efficiency aerospace photocells, endowed with the triple junction technology is stored in Ion-Lithium batteries. The distribution of energy is made by three levels of stabilized voltages and regulated in 3.3V, 5V, 12V and there is a unregulated level supplied directly from the battery. In case of failure, a set of redundant power supplies are able to take any of the regulated voltages levels. All control of the power system is performed by a microcontroller, which collects and analyzes data, such as temperature, voltage and current to determine whether the system power will come from major sources or from redundant ones. Through a CAN network, the microcontroller transmits telemetry information to a Data Processing Unit (DPU), which takes more complex decisions involving all the CubeSat subsystems.

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IAA-BR-10-01

INTEGRATION OF THE INPE GROUND STATION INTO THE SATNET NETWORK FOR SUPPORTING SMALL SATELLITES PROGRAMS IN BRAZIL

Ricardo Tubío-Pardavila; Jorge Enrique Espindola Diaz; Adair José Rohling; Fernando Aguado-Agelet; Mauricio Gonçalves Vieira Ferreira; Walter Abrahao Dos Santos; Jordi Puig-Suari

The researchers of the Ground Station at the National Institute for Space Research[1] (INPE) in Brazil have started working, together with the main developers of the SATNet network, in the integration of their ground segment into that very same network. This paper presents the de-scription of that integration process together with the results obtained and with a description of the current and upcoming small satellite pro-jects in Brazil and in Latin America. The SATNet network aims at incor-porating the capabilities of all the already deployed university Ground Stations into a single, coherent and usable resource. The approach used for this network is based on heterogeneity, allowing the integration of very different ground stations into a single ground system.

IAA-BR-10-02

BEACON RECEIVERS FOR CUBESAT MISSIONS AND IONOSPHERIC STUDIES

Edgardo Pacheco; Jose Chavez

We are developing a dual-frequency ground-based receiver system and a CubeSat radio beacon in order to measure the total electron content (TEC) in the ionosphere. The measurements obtained by the ground-based receiver will be useful to investigate the ionospheric density variability and the identification of plasma irregularities that are responsible of radio waves fluctuations in the ionosphere. The TEC can be obtained by measuring the phase difference between two different radio frequency signals that propagate through the ionosphere from the low Earth orbit CubeSat to the receiver station on the ground. The receiver station that will be installed at the Jicamarca Radio Observatory in the Peruvian region is based on a software-defined radio system. After the acquisition of the radio waves, subsequent digital signal processing will be applied. In this work, we describe the configuration of our first receiver prototype system, initial tests and preliminary measurements.

IAA-BR-10-03

LAICAnSat-3: A MISSION FOR TESTING A NEW ELECTRONIC AND TELEMETRY AND TRACKING SYSTEM

Simone Battistini; Rafael Resende Dias; Alex Kraus; Renato Alves Borges; Chantal Cappelletti

This work presents the mission analysis for the third stage of the LAICAnSat project of high altitude balloon experiments developed at the University of Brasilia, the LAICAnSat-3. LAICAnSat previous stages included two launches of balloon-sats (LAICAnSat-1 and LAICAnSat-2) in 2014. These two launches allowed the test of a preliminary system, which included a broad sensor suite (a high performance camera, temperature, pressure, humidity, UV light level, altitude, position, speed, heading, and acceleration sensors) and a communication and tracking system. The latter provided with voltage, current, and internal temperature sensors, and positioning data transmitted through a GPS-integrated radio that used the Automatic Packet Reporting System (APRS), an amateur radio system useful for geolocation. Another achievement of the previous missions was the identification of the mathematical model of the parafoil used during the reentry of the payload, with the purpose of developing control system for safe landing. The main goal of the project is now to define a standard for all the subsystems. To this end, a printed circuit board (PCB) with all the computational and sensorial capacities of the system was developed. This PCB will serve as the onboard computer of the LAICAnSat

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platform and includes micro-controllers, interfaces with other modules (payload, power, communications, control, data storage), and sensors. The PCB is developed in accordance with the PC-104 format. This choice was realized in order to fulfill the newly defined dimensions for the LAICAnSat platforms, which are to be designed in accordance with the 3U Cubesat standard (30x10x10 cm). Along with the new structure, the LAICAnSat Tracking and Telemetry System (TTS) will be tested. It provides with a simple and reliable way to keep track of the platform's location, sensors and health at all times during flight. The TTS is based on an xBee system, which allows for half-duplex communication. This paper describes the concept of the LAICAnSat-3 mission, as well as the design, realization, and testing of the newly conceived subsystems.

IAA-BR-10-04

GROUND STATION LINK CHARACTERIZATION UTILIZING BIT ERROR RATE.

Nathaniel Richard; Kevin Brown

Radio communication with a satellite is vital to any missions' suc-cess, so it is important to characterize every link in the chain from the satellite to the ground to ensure mission success. The purpose of this project is to characterize one link in this chain, the ground station receiv-ing end for Morehead State's next satellite, Cosmic X-ray Background Nanosatellite-2 (CXBN-2). The amount of literature available on the performance of ground station links with Cubesats is sparse, with the expanding popularity of Cubesats a method of characterizing a ground station link would be useful for organizations that are just starting out. This project shows how one could go about characterizing a ground sta-tion link utilizing bit error rate. We will describe a series of experiments that utilizes CXBN-2's radio and observe the drop-off of the bit error rate under different link conditions. The results of this project are two-fold, it will provide risk reduction for CXBN-2's mission and demon-strate how other groups can go about characterizing their ground station link.

IAA-BR-10-05

ELETROMAGNETIC ANALYSIS OF INSTALLED PERFORMANCE OF ANTENNAS INTEGRATED ONTO NANO-SATELLITES

Juner Vieira; Marcos Heckler

In this paper, the performance of antennas installed onto meteorological nano-satellites is investigated. The size of the modeled nano-sat is 8U, with four articulated flaps, which are intended to increase the total area for installation of solar panels. The nano-sat is to serve as a data relay for the Brazilian Meteorological Data Collecting System. The antennas investigated in this contribution are related to telemetry, telecommand and data transmission (uplink and downlink). The study of the performance of the array antennas began with the electromagnetic simulation of the telemetry and telecommand structures. In order to investigate the installed performance under the influence of the nano-sat structure, two scenarios were simulated: with and without articulated flaps. The calculated gain values for the telecommand antennas were -0.44 dBi and 3.33 dBi with and without articulated flaps, respectively. The comparison of results shows that the presence of articulated flaps influences significantly the operation of the telecommand antennas. For the telemetry antennas, the gain values obtained way simulations were 2.93 dBi and 1.58 dBi with and without articulated flaps, respectively. By increasing the number of monopoles to 4, gain increases to 3.32 dBi and 1.75 dBi with and without articulated flaps, respectively. Thus, for case of the telemetry antennas, an improvement in the performance with four monopoles and with the presence of the articulated flaps has been verified.

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IAA-BR-10-06

PICO AND NANOSATELLITE GROUND STATION ARCHITECTURE DEVELOPMENT REFERENCE PROCESS

Jaime Enrique Orduy Rodriguez; Geilson Loureiro; Walter Abrahão Dos Santos; Douglas Soares Dos Santos

The CubeSat concept contributed to the consolidation of standards to small satellites that sets a role model for the construction of the space segment. However, projects and research in the ground segment of these satellites in Latin America still did not reach the same level of achievements as the space segment. This work aims to present the developments done at INPE in the development of a reference process to assist in the creation of ground stations that could be used for those interested in tracking and receiving data from small satellites in service. This refer-ence process can be used by graduate and undergraduate students in general to provide the ground segment of the next generation of small satellites. It illustrates a case study focused on Brazilian´s CubeSat pro-jects so it can become later an active and constant participation in whole Latin America. The development of small satellites projects are flourish-ing in various Latin America universities. Moreover, Brazil showed a significant improvement in the development of such satellites with re-sults as the NanoSat-Br1 and the AESP-14. Henceforth, this work pre-sents a reference process based on systems engineering (Concurrent Systems Engineering Laboratory - LSIS at LIT) as a decision-making guide for the development of a ground station architecture for small sat-ellites that meets the needs of having a ground segment itself. The re-sults are presented as a systems engineering process guide for the devel-opment of ground stations for Pico and Nano satellites.

(Chair Prof. Marcos Heckler-Unipampa)

IAA-BR-16-1P-01
MISSION ANALYSIS FOR A REMOTE SENSING CUBESAT MISSION OVER THE AMAZON RAINFOREST

Gabriel Coronel, Eduardo Escobar Bürger, Geilson Loureiro and Otávio Luiz Bogossian

This paper describes a mission analysis process used to explore and assess mission feasibility of a CubeSat satellite class which main objective was to take images of the Amazon rainforest for later deforestation analysis. The presented process shows what could be expected, its limitations and how to improve its results. Some analyses were performed through simulations using Systems Tool Kit (STK) and General Mission Analysis Tool (GMAT) software. The process consists of lifetime, payload performance and CubeSat-ground station communication link analyses. The CubeSat parameters used for calculations and simulations came from specifications found on a commercial CubeSat website, while ground segment input parameters came from the Aeronautics Institute of Technology's (ITA) Ground Station specifications. It was assumed that orbit was not designable, thus orbital position parameters were derived from the International Space Station's (ISS) orbital elements, considering the in orbit injection will take place there. Then, January 1st, 2018, was aimlessly chosen to extract ISS's orbital parameters. Results show that the payload performance fulfills the mission objectives, however, limitations on the transmission data rate limit the number of pictures that can be sent from the CubeSat to the ground station making unfeasible to fulfill objectives. One solution for this limitation could be the use higher frequencies that allow transmit at higher data rate. However, this would require using the state-of-the-art transmission equipment and would increase the size of the CubeSat. Another solution could be to adjust mission objectives in order to reduce the area of interest. Results also showed that if the altitude of a CubeSat deployment from the ISS could be chosen, then, it is better to choose the highest altitude. This would increase the CubeSat lifetime (up to 2 months) and bring advantages for radio accesses affecting very little the payload performance.

IAA-BR-16-1P-02
SPACEWIRE APPLICATION

D. T. dos Santos; R. C. Ferrão; V. C. Parro

The project aims to create a hardware using as communication the SpaceWire protocol, widely used in aerospace projects, able to read and write on analog-to-digital and digital-to-analog converters. The SpaceWire protocol is a space communication network created and coordinated by European Space Agency (ESA) in collaboration with international space agencies including NASA, JAXA and RKA. This protocol has many advantages besides being easily implemented in application-specific integrated circuit (ASIC) and transmit data with greater security and speed, it helps to reduce system integration costs. The system architecture consists of: a general controller, a registers bank and peripheral modules. The controller is responsible for system management and it is accessed directly by SpaceWire codec and serial communication. The registers bank allows the storage of data and control information for the modules. Peripheral modules access the registers bank and control external devices (LEDs, digital inputs and outputs and converters). The access to converters is via SPI serial communication protocol. This project was implemented in a development board which contains a Xilinx Virtex 5 FPGA using VHDL code. A hardware containing digital inputs and outputs, LEDs and analog-to-digital and digitalto-analog converters of two channels also was built. The converters used were the ADC MCP4922 and MCP3204 DAC, both developed by Microchip, which can be connected to devices such as temperature sensors and drive motors. The developed system can communicate to a SpaceWire network and all hardware devices have access through this communication, thus showing a key benefit of this protocol that is to promote compatibility between devices and subsystems

(Chair Prof. Marcos Heckler-Unipampa)

IAA-BR-16-1P-03
DEVELOPING AND OPERATING AN AUTOMATED GROUND STATION

Lucas Amaduro; Rogerio Atem de Carvalho; Lucas Hissa; Willian Vianna; Cedric Cordeiro; Sara Souza; William Oliveira; Luiz Gustavo Lourenço Moura

This paper aims at describing the development of the software and the initial operations of a totally automated ground station for nano satellite tracking. This work is going to described the client side of the distributed system that compose RIBRAS (Rede Integrada Brasileira de Rastreamento de Satélites), as well as it's first operational experiences. The software developed for the client side is divided into several parts, being the most relevant: Antenna Controller, Gpredict Controller, Modbus Client and the Gpredict application itself. The Antenna Controller, for the aiming and tracking calculations, it retrieves the ephemeris data, and then creates several commands to send to the movDrive, which is the driver that controls the movements of the ground station. The antenna controller allows the orchestrated operation of the station when it is part of a network, with no need of an operator in the site of the station. The Gpredict Controller does the communication between the antenna controller and Gpredict. It receives messages from a customized version of GPredict package, representing the commands which the operator wants to perform. Gpredict has been customized to attend the needs of the RIBRAS network. Some of these customizations are controls of the rotors and radio in the application, a list of next satellites that will be in range of the ground station, the configuration of transponders modes for the radio, and the appearance and color of engage and track buttons for operation of the rotor and radio controller.

IAA-BR-16-1P-04
RECYCLING OF PACKAGING FOR OBTAIN PARAFFIN AND NANOPARTICLES OF ALUMINUM OXIDE FOR DOPING OF FUEL USED IN HYBRID MOTORS

Narielly Campos; Luan Henrique dos Santos Oliveira; Renan Henrique Alves de Araújo; Pilar Falla; Marcelo Bento Silva; Leandro Xavier Cardoso

The consumption of beverages stored in disposable packaging has grown extensively, which awakens our interest to reuse these containers, which currently generate an environmental liability. In this sense, this paper describes the development of a project based on recycling of packaging materials consisted of cellulose, aluminum and plastic, as used for milk and juice. The goal is to obtain paraffin and aluminum of high purity. The experimental tests are performed on a workbench in the biofuels laboratory FGA-UnB and initially involve the crushing process of packaging and aqueous separation of cellulose; it can be also used to produce second generation ethanol, which is used at biofuel. Then, the mixture of aluminum and polymer are submitted to high temperature process to promote separation of metal and polymer, before being destined to doping the same combustive. The decomposed polymer is extracted with organic solvent to obtain paraffin. Studies of physical chemical properties of characterization using Thermo Scientific Nicolet iS10FT-IR Spectrometer and Thermogravimetric Analyzer Model SDT 2960 DSC-TGA of the products obtained are realized. Afterwards, mixtures of paraffin with different concentrations of aluminum oxide nanoparticles will be formulated with aim of improving fuel efficiency. The FTIR spectroscopy will be sufficient for quality control of product obtained in this process, enabling comparisons between the ideal paraffin from the open system. The thermogravimetric analysis will provide fuel characteristic's (undoped& doped) such as enthalpy-balance and predicts better efficient to use on hybrid rockets.

(Chair Prof. Marcos Heckler-Unipampa)

IAA-BR-16-1P-05
DEVELOPING THE SOFTWARE FOR CUBESATS IN A CONCURRENT ENGINEERING ENVIRONMENT: A TOOLSET AND CASE STUDY

Rogerio Atem de Carvalho; Galba Arueira; Milena Silveira de Azevedo; Rafael Toledo; Cedric Cordeiro

Many cubesat missions share some characteristics such as small and multi-functional teams, use of non-dedicated laboratories, use of Commercial of the Shelf (COTS) components, concurrent engineering of parts etc. Although the last one is not exclusive of cubesats, it becomes a real challenge when associated to small teams, given the complexities related with with task coordination and change management in Concurrent Engineering. This paper aims at presenting the successful application of a toolset and development process created for the cubesat 14-BISat's payloads software development in such an engineering environment. This satellite was developed by Instituto Federal Fluminense (IFF) as part of the multinational QB50 mission for the Low Termosphere characterization. The payloads are the Fipex (Flux-Φ-Probe Experiment), and GAMALink, a S-Band Software Defined Radio. The development of the payloads ran in parallel with the development of the satellite's control software, by establishing contracts in proper Interface Control Documents (ICDs) for each payload. In order to provide the needed support for developing software to the hardware that was also in development, a set of elements was developed and/or improved by the team to form an integrated and agile development toolset for the C/C++ language for micro-controllers: (i) a tool for modeling and simulating Finite State Machines, (ii) a Domain Specific Language for automated test generation, build, and deployment (iii) a mechanism for supervised FSM execution, (iv) a toolchain for compiling and debugging, (v) a version control system, and (vi) a Continuous Integration process and tool. During the case study, the proposed toolset and process were improved and could provide an efficient and low cost integrated environment for developing, testing and integrating embedded software for cubesats.

IAA-BR-16-1P-06
CUBESAT FRAME DESIGN - PETAL MODEL

Felipe Lima Mahlmeister; Rodrigo Alvite Romano; Vanderlei Cunha Parro; Rafael Corsi Ferrão; Sergio Ribeiro Augusto; Saulo Finco and Silvio Manea

This summary deals with the development of a modular structure with conceptual focus on the disposal of PCBs (printed circuit board) in a CubeSat, where instead of the traditional format in which the cards are stacked inside, the electronic boards are positioned in the hub side in order to achieve greater internal space for payloads, as well as facilitating the access of PCBs during assembly and testing. This concept was titled as "petal model." The proposed structure was created according to the needs of the various groups taking part in the project. The modeling of the structure was carried out through a graphical modeling software where we adapted our concept according to the international standard specification for CubeSats. The parameters verified were weight, dimensions and materials, amongst others. Throughout the development, several prototypes were built in order to verify the technical feasibility of the proposal, enabling improvements to be incorporated in the structure. Comparisons of design and payload volume between the model and the current model were held. From this study it becomes clear that it is an interesting model and very competitive in the conceptual aspect, but for the reliability of that there is the need for further studies such as vibration, thermal and efforts

(Chair Prof. Marcos Heckler-Unipampa)

IAA-BR-16-1P-07
A SYSML REFERENCE MODEL TO SATELLITE/LAUNCHER INTERFACE AND ITS INSTANTIATION TO A CUBESAT PROJECT

Ricardo Franco; Walter Abrahao Dos Santos

Every satellite project needs to take into account all the concerns im-posed to its interface to a real launcher vehicle, as it is the main inter-face of the satellite to the outer world during its launch lifecycle phase. This interface generates constraints that the satellite needs to comply. In this work a Model-Based Systems Engineering (MBSE) approach is tak-en to define a reference model to this interface which is later on instan-tiated to a CubeSat mission as a case study. MBSE is an emerging tech-nology that provides many advantages to the classical and document-oriented Systems Engineering (SE) process. One advantage to this ap-proach is solving the integration problem that each one of the individual systems domain disciplines have in the variety of their own well-established modelling methods and tools to support design, analysis, verification and validation. Since these disciplines are not, a priori, well connected, data exchange and sharing may become cumbersome. This is where MBSE comes into place as it primarily models the whole system from a holistic problem point-of-view. MBSE can support tools for early system verification and validation and can provide means to simulate and execute many parts or the whole system. Models are here written in SysML (Systems Modeling Language) which is a general-purpose graph-ical modeling language for specifying, analyzing, designing, and verify-ing complex systems that may include hardware, software, information, personnel, procedures, and facilities and can model systems architecture and behavior. Finally, this paper shows how the launcher-satellite inter-face reference model is effectively used during a launch lifecycle Sys-tems Engineering (SE) process, how it supports many Systems Engineer-ing (SE) processes and how it meets the constraints imposed to a Cu-beSat project taken as a satellite case study.

IAA-BR-16-1P-08
SERPENS: ASSEMBLY, INTEGRATION AND TEST ACTIVITIES

Ishioka, I. S. K.; Figueiró de Oliveira, G.; Cappelletti, C.; Amui, B. G. R.; Lôpo Júnior, N. P.; Kaled da Cás, P. L.; Nodar, D.; González, A.; Aguado Agelet, F.; Vázquez, A

SERPENS Space System for Conducting Research and Experiments with Nanosatellites is an educational project started in 2013, by AEB (Brazilian Space Agency). AEB created an academical consortium among universities engaged in the development of aerospace technology giving it the objective to design and launch a satellite mission. The main goal of the project is to involve students and young engineers in a real satellite mission in order to grant them a fundamental expertise for their future, and for the future of the PEB (Brazilian Space Program). The first SERPENS mission was coordinated by UnB (University of Brasília), leader of an international team with students and researchers from Brazil, Italy, Spain and United States. In the first mission the satellite platform, a 3U CubeSat nanosatellite, is divided in two sectors denominated Sector A and Sector B. The two sectors operate as completely separated satellites, but hosted in the same structure. Sector A communicates in VHF and sector B in UHF. This paper deals with the Assembly Integration and Test activities performed at LIT (Laboratory of Integration and Testing) by the Serpens team. Detailed analysis of the procedure and solutions adopted are given, with particular attention to the environmental and ADM (Antenna Deployment Mechanism) test results. Once AIT procedures finished, on March 2015, the satellite was transported to Japan on July 2015, to accomplish the hand over procedure that involved integration at JAXA Tsukuba Space Center to the JEM Small Satellite Orbital Deployer (J-SSOD). The satellite was launched on-board H-IIB rocket on the pressur ized cargo of HTV-5 “Kounotori 5” and released to the space on September 17th 2015.

(Chair Prof. Marcos Heckler-Unipampa)

IAA-BR-16-1P-09
LOW OUTGASSING ACCELEROMETERS AND CABLES FOR THERMAL VACUUM AND VIBRATION TEST ENVIRONMENTS

Bob Metz; Carmine Salzano

Exposure to the high vacuum level of a space environment induces material outgassing in ordinary accelerometers and cables. Any substance subjected to a vacuum has the potential to release trapped gasses. Contaminants from outgassing can condense onto nearby surfaces such as photo-optic devices and obscure them, rendering them useless during their intended application.
During random vibration, swept sine or shock testing prior to flight, spacecraft payloads are often fitted with accelerometers in hard to reach mounting locations. As the space structure is built up around them, it can become impossible to remove the accelerometers. Sensors installed for ground vibration testing may therefore remain on the structure even if they are no longer needed for testing purposes.
In any application involving a thermal vacuum environment care must be taken to select the proper accelerometers and cables prior to vibration testing. Accelerometer designs with hermetic housings and connectors can have low outgassing qualities. For all non-metallic materials outside of a hermetic package, such as cables with polymer strain relief that do not typically have low outgassing qualities, verification is required to ensure that the materials have less than or equal to 1% TML (total mass loss) and a CVCM (collected volatile condensable mass) less than or equal to 0.1%. This is verified either using NASA documentation or test results from an outside laboratory.
Given these design parameters, a series of accelerometer and cable designs for the thermal vacuum environment will be discussed in this paper. They have been specifically designed or tested for low outgassing properties."

IAA-BR-16-1P-10
EXPERIMENTAL ANALYSIS OF THERMOELECTRIC ENERGY GENERATION FOR NANOSATELLITES

Diego Audiffred; Anderson Spengler; Kleber Paiva; Gabriel Fraporti; Gabriella Hagedorn

The purpose of the present work is to study the viability of using Peltier cells as thermoelectric generators (TEG) to supply electrical power for nanosatellite subsystems. There is not much work done in this specific field of study, however there are an increasing and considerable number of papers about the use of Peltier cells for energy harvesting, which has being applied to the most different areas. A mathematical model was implemented in order to evaluate the performance of such cells and predetermine their operation conditions. An experimental setup was built to evaluate the performance of a TEG. To guarantee good thermal accuracy between both sides of the TEG, two Peltier cells were used. A dedicated electronic circuit was developed to control the temperature difference and measured the generated power. Results show for 20°C of temperature gradient, the energy generated is approximately 150 mW.

(Chair Prof. Marcos Heckler-Unipampa)

IAA-BR-16-1P-11
REMOTE SENSING BASED ON CUBESAT: IS THERE ANY ADDED VALUE?

Giovanni LaNeve; Giancarlo Santilli

The CubeSats have become very popular, mostly as a low cost means to train students and young researchers in the space engineering and science. However, since the cost of accessing the space is still quite relevant the educational motivation could be sometime not enough for planning and execute a Cubesat mission. From this the need to understand if satellite based remote sensing could take advantage of the potential availability of tens of micro satellites.
Of course, according to Planet Labs, a private start-up company of San Francisco owner of the Floke-1 constellation, cubesats could enhance the Earth Observation capability of the present available systems. This enhancement is mainly based on the possibility to construct constellation of hundred of satellites which will allow a daily coverage of the Earth at very high spatial resolution (2 - 3 m). However, there are some constraints that remote sensing pose to fully exploit the data acquired, namely: constant solar illumination conditions, accurate repetition of the ground track, global coverage, multi-spectral observation.
Now, at the present time, no one of these conditions is respected by the constellation presently settled-up by Planet Labs. However, some of those constraints could be made more flexible to be obtainable by using Cubesat based images.The present paper will explore some applications which could really benefit of remote sensing systems based on Cubesat. In other words, CubeSats are cheap and light, so their launching is cheap as well. This enables the structuring to constellations, which provide better coverage and revisit time than any other solution. However, larger satellite still present advantages for which Cubesat should be seen as a system which could provide the opportunity to build constellation of satellite at low cost devoted to special applications.

IAA-BR-16-1P-12
ORCHESTRATION AND CONTROLLING OF A AUTOMATED GROUND STATION NETWORK

Lucas Hissa; Luiz Gustavo Lourenço Moura; Rogério Atem; Lucas Amaduro; William Silva Vianna; Cedric Salotto Cordeiro; Sara Souza

Currently there is a tendency to develop constellations of small satellites rather than a single large satellite. To attend the data gathering demand from a constellation of satellites, the CRSEA (Centro de Referência em Sistemas Embarcados e Aeroespaciais - Reference Center for Embedded and Aerospace Systems) of Instituto Federal Fluminense (IFF, Brazil) is developing the RIBRAS (Rede Integrada Brasileira de estações de Rastreamento de Satélites - Brazilian Integrated Satellite Tracking Network) with funding of Agência Espacial Brasileira (AEB) and the support of Ministério da Educação (MEC). The RIBRAS consists of ground stations for satellite tracking distributed around Brazil and the RIBRAS system is a collection of softwares with the objective of controlling the network of ground station. The Ground Stations will work in a synchronized fashion following a previous generated working plan. In order to achieve these goals, each ground station is equipped with two independent towers, one for S-Band and another for UHF and VHF communications. Considering this information, this paper aims at describing the RIBRAS' software for orchestration and controlling. This work is going to describe the server side of the distributed system that compose the RIBRAS system, as well as its concepts of distributed computing with centralized decision.

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ABLATIVE PULSED PLASMA THRUSTERS FOR HIGH DELTA-V NANOSATELLITE/MICROSATELLITE MISSIONS

Paolo Gessini, Lui T. C. Habl, Gabriela Possa, Stephen B. Gabriel

Ablative Pulsed Plasma Thrusters have great applicability in the context of small and nanosatellite missions, for their compactness and robustness, mainly due to the fact that they use solid propellant. In this paper the possibility of sending a nanosatellite mission to a Low Lunar Orbit (LLO) using a high-energy APPT is explored. In the first part of the paper the working principles of APPTs are described, with a brief review of recent research and semi-empirical models. In the second part the main relations between the basic parameters of the APPT and the mass budget of the satellite are shown. In the last part a case study is shown, exploring the possibility of using such propulsion system in a 20 kg spacecraft to perform the aforementioned mission and the necessary assumptions.

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DEVELOPMENT OF A SMALL THERMAL-VACUUM CHAMBER USING SYSTEMS ENGINEERING PHILOSOPHY

Roy Stevenson Soler Chisabas, Eduardo Escobar Bürger and Geilson Loureiro

Pico and nanosatellites environmental testing are usually outsourced, and they can be very expensive for some academic institutions. Thermal-vacuum tests usually comprehend an important amount of such costs. An in-house development of a thermal-vacuum chamber has great potential to lower these costs, and also diversify the educational project research scope. The objective of this paper is to describe the Systems engineering methodology used to develop a thermal-vacuum chamber to be used for environmental testing pico and nanosatellites. The conventional operational requirements of various state-of-the-art commercial chambers (found in different laboratories and research institutions) are described considering their morphology, type of manufacturing, structure materials, supplies necessary for its operation, internal and external interfaces, data acquisition systems, pumping systems (low, medium, high and ultra vacuum), ways and means of heat transfer, temperature ranges, operating pressure and general operation and monitoring requirements. The study allowed the definition and classification of operation, states, modes, passive and active operations and control and monitoring philosophy of the analyzed chambers. The work also considered the general pico and nanosatellite thermal-vacuum testing requirements to develop the chamber specification. The study showed that the design of a small thermal-vacuum chamber is feasible and very promising. Using an in-house chamber tends to reduce overall testing costs, and opens more research and development opportunities for students involved in space area.

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MICROSTRIP PLANAR ANTENNA FOR CUBESATS

Marcio Mathias, Gabriel Vilella Matos, Saulo Finco, Silvio Manea

This proposed solution intended to be a low cost radio transmitter system for sending the collected data CubeSat missions. A compact rectangular patch antenna was chosen to provide a low profile, lightweight and robust design, without requiring any moving parts after the satellite deployment in the space. Because its directional characteristics, the expected antenna gain is about 9,0 dBi.

(Chair Prof. Marcos Heckler-Unipampa)

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FUNCTIONAL VERIFICATION OF A HARDWARE SATELLITE COMMUNICATION MODULE

Fabrízio Maziero and Djones Lettnin

The usage of Commercial-Off-The-Shelf SRAM based FPGAs in aerospace applications has increased in recent years. Comparing to the traditional ASIC development process, FPGA technology offers lower development costs, and it is a more interesting solution for small production volumes and specialized systems which cannot be released without an assurance of being free of faults and bugs. This hardware verification process requires an extensive amount of effort, especially on testbench writing, and testcase design that can cover all the possible, and even some impossible conditions of operation. Besides that, a testbench is designed for a given model, requiring changes each time the model is updated, making this effort even greater. Our work inspectes the verification of an industrial system, the Telemetry and Telecommand Unit (UTMC) of the artificial satellite Amazônia I, devel-oped in partnership with the Brazilian Institute of Space Research (INPE), and also aims to develop a verification environment able to verify multiple implementations of the CCSDS protocol in hardware-only (e.g. FPGAs), re-ducing the time spent of verification on the following missions using this protocol, and assuring a general verification process, maintaining each de-sign consistent to the same characteristics of the protocol. The UTMC is the subsystem responsible for the earth-satellite communications, receiving the On-Board Computer (OBC) commands from the mission control, and send-ing data from the satellite back to earth using the CCSDS protocol.
In order to maximize verification productivity, both on writing testbench-es and running simulations, a customized implementation of the Universal Verification Methodology (UVM) was implemented. This methodology de-fines guidelines on testbench architecture, allowing reusability of testbench-es and testcases between multiple designs that share similar data interfaces (e.g. communication protocols). The proposed approach was able to find de-sign bugs and implementation inconsistencies, mainly on differences be-tween the original documentation and the actual implementation, which shows the importance of a unified design process in which the project is cor-rectly described, reducing the time spent on design errors.

IAA-BR-16-1P-17
DESIGN AND OPTIMIZATION OF GROUND STATION ANTENNAS FOR FLORIPA-SAT PROJECT

Thais Baena Moura; Raíza Benedecti; Lucas Travassos

This work describes the antenna development of the Floripa-Sat ground segment. The Floripa-Sat project is an initiative of researchers and students from the Federal University of Santa Catarina (UFSC) together with the Federal Institute of Santa Catarina (IFSC) to the develop an 1U Cubesat. Once the design and optimization of ground station antennas were conducted by undergraduate students, this work will describe the procedures adopted to achieve an improved solution. The design and optimization of antenna to the earth station was done to achieve a better link budget. Therefore, the antenna should have the directivity maximized, with a low reflection coefficient for the input impedance of 50 Ohms. In order to determine the better antenna model it was studied and simulated two types of antennas: yagi-uda and a helical. Both antennas were built to operate at the central frequency of 437MHz and with 120MHz bandwidth. It was performed a parametric study in the antennas, based on articles and models in the literature, focused on the influence of essential parameters and considering the specifications requested to established a communication link with the nanosatellite. Fur-thermore, the tradeoff between performance and cost was considered in the process. The simulation was performed using commercial tools as FEKO, Antenna Magus. In order to achieve a better design antenna optimization methodology was studied. An antenna optimization aims at creating advanced and complex electromagnetic devices that must be competitive in terms of performance, serviceability, and cost effectiveness. This process involves selection of appropriate objective functions (usually conflicting), design variables, parameters, and constraints. A genetic algorithm created in Matlab, was used to determine the best values of yagi-uda antenna's ele-ments, the distance between them, the length and radius of these, so that the antenna reaches its highest gain, directivity and has an appropriate reflection.

Notes