SAR Satellite Mission Analysis and Implementation with Along-Track Formation Flying - IAA-LA2-01-01

Leonardo Cappuccio*; J. Lugo; P. Weder / INVAP
*lcappuccio@invap.com.ar

Over the last few years, there has been a definite trend in the satellite industry that shows distributed mission concepts being increasingly considered in satisfying a vast diversity of needs. Some of the distributed missions are designed to fulfill specific goals which would not be possible to accomplish with monolithic satellite missions. Others take advantage of the new distributed scenarios to further optimize previously existing systems. A particular case is the utilization of the distributed concept to enhance some capabilities of satellite Synthetic Aperture Radar (SAR) missions.

In this context, an along-track flying formation composed of two polarimetric satellites is introduced, as a feasible alternative to single satellite SAR. This new approach is driven by a reduction of size and mass per satellite, making them suitable payloads for less expensive launch services. As an additional advantage, a supposed critical failure in one of the satellites would not imply the end of the whole mission, but only a degradation of the achieved performance. Replacement of a damaged satellite may also be considered, since it would represent a reduced fraction of the overall mission cost. Another interesting fact is that multiple mission phases, each with different formation geometries, could be possible as well, so that the same system could also be used, for example, in across-track configuration.

The segmented architecture SAR presented in this work is possible because it relies on the reception of the echo information from two independent phase centers, one per satellite. If the locations of the satellites during transmission and reception are suitable arranged, a closer distance between samples of the synthetic aperture can be achieved. This, in turn, relaxes the restrictions imposed by ambiguity suppression requirements, enabling a significant shortening of antenna length without losing of performance. This reduction in antenna total area could not be conceived without a Signal-to-Noise Ratio (SNR) degradation, but this drawback is compensated in terms of radiometric resolution, thanks to the finer azimuth spatial resolution obtainable with shorter antennas.

This work pretends to be not only a theoretical approach, but also a feasibility analysis aimed to verify if the proposed system is practicable with current technologies. A detailed analysis is made to obtain position, velocity and temporal tolerances in accordance to the mission objectives, along with some proposed techniques to reach those tolerances. Simulation results are presented to support these analytic results.

A preliminary physical model proposal for the satellites payloads and platforms was also designed, as well as a feasible deployment mechanism that allows for a reduced launch configuration size. This is in convenience with one of the pursued goals of this work mentioned before, which is less demanding launch vehicle requirements than the expected for monolithic satellite SAR missions.

On the Connectivity Optimization of a Potential CONAE's Network of LEO Satellites - IAA-LA2-01-02

Santiago M. Henn*, Denis F. Martinez / UFS, CONAE - Universidad Tecnológica Nacional
Juan A. Fraire / CONICET - Universidad Nacional de Córdoba
*shenn@conae.gov.ar

Mission design plays a crucial role in projects based on networked satellite constellations. Among the several aspects to optimize, the interaction and access of each mission segment requires of non-trivial numerical approaches involving a careful inspection of control parameters such as orbital elements, ground station locations and communication constraints. Moreover, the consideration of auxiliary relay satellites whether of the bent-pipe or store-carry-and-forward type, further complicates the efficient calculation of optimal mission parameters.

Argentina's space agency, CONAE (Comisión Nacional de Actividades Espaciales), in line with the national space plan, focuses on Earth observation satellites in low-Earth orbits, that in most cases use or have used sun-synchronous orbits. These orbits provide scarce opportunities to contact ground stations that are situated far from earth poles -due to the satellite's height and cuasi-polar inclination-, characteristic that a mission needs to take into account when designing communication systems and operational procedures that maximize efficiency during the pass of a satellite, not to mention the added complexity for an agency that manages more than one mission at the same time.

Additionally, Earth observation satellites produce a large amount of data and could take advantage of rapid access for uploading commands and/or rapidly receiving products derived from on board processing and/or telemetry, especially those that are part of an early emergency response and management networks, such as the SIASGE system (Sistema Italo Argentino de Satélites para la Gestión de Emergencias).

In this work, we apply state-of-the-art informatics techniques based upon heuristic algorithms, to analyze a potential network comprising Inter-Satellite Links (ISL) among current and planned CONAE's Low-Earth Orbit (LEO) Earth observation satellites and available ground stations. Specifically, we evaluate the case where an extra nanosatellite is deployed to increase the rate at which commands and telemetry are delivered to and from each of the agency's satellites. The Maximum Asset Accessibility Algorithm (M3A) is applied to determine appealing orbital parameters for such relay, to then introduce possible mission configurations that would increase the overall constellation accessibility.

CONAE to Address Autonomous Formation Flying and Rendezvous Preliminary Analysis - IAA-LA2-01-03

Leonardo Comes, Felipe Pasquevich, Pablo Marino*, Maximiliano Fischer, Leonel Mazal / GGT – CONAE
*pmarino@conae.gov.ar

In the last decades, several missions of distributed space systems aimed at performing Formation Flying (FF) and/or Rendezvous and Docking (RVD) have been realized. The ETS-VII (Engineering Test Satellite VII), developed by JAXA, constituted the first mission that accomplished flight in proximity with FF requirements and RVD. Other successful missions include: Prisma, GRACE, AeroCube-4, among others. There are even more in stage of development. Most of these missions constituted technological demonstrations, with the exception of GRACE (Gravity Recovery and Climate Experiment) that had a specific scientific purpose.

Through its Department of Research, Development and Innovation, and motivated by the new context of the space industry and the rise of the microsatellite component industry, the “Comisión Nacional de Actividades Espaciales” (CONAE) is envisioning the engineering, launch, and operation of space missions composed by multiple space segments working cooperatively with certain levels of autonomy. This proposal could allow CONAE to step into and put hands-on among these new technologies.

Autonomous FF and RVD missions should address various technological challenges. In order to develop a solid experience in the field, CONAE is currently considering several fields for research and development. Among others, Autonomous Guidance, Navigation and Control of multiple cooperative satellites, inter-satellite communication, and embedded software for autonomous coordination of the system. These fields are perceived crucial for Synthetic Aperture Radar (SAR) missions (envisioned as the next phase of the aforementioned Department IDI) or other missions also oriented to collaborative sensing. The success of these type of missions would contribute to expand CONAE’s strategic partnerships with some of the world's leading space agencies and industries.

In this context this mission would allow to test in flight all the necessary technologies for FF and RVD. As a secondary objective, it would serve as a test-cell to evaluate the performance in orbit of certain “commercial-off-the-shelf” components (COTS) and possibly flight software. The purpose of this presentation is to exhibit the proposed mission, encouraging the involvement of Argentinean academic institutions and private sector companies in this endeavor, as associates, users, or suppliers.

Although the mission is not completely defined yet, various alternatives are being analyzed, regarding the number of satellites, formation configuration, orbits and types of autonomous maneuvers to be performed. These satellites would be launched in the same launch, as secondary payloads ("piggyback"). After the commissioning stage, the vehicles would perform a first cooperative and autonomous maneuver that would place them in relative orbits with a high degree of stability for formation flying. The system would then be reconfigured to test various types of formations that may be of interest to envisioned CONAE missions, such as a distributed SAR (Synthetic Aperture Radar). In a subsequent stage, another experiment would be conducted, in which the satellites would be induced to drift apart one from each other up to certain maximum distance, and an approach maneuver would follow to predefined distances ("rendezvous" maneuvers), using computational vision-based navigation. CONAE is considering the option of allowing other research groups to use the formation flying satellite system to perform tests once the mission is accomplished.

The presentation and paper will elaborate on the various proposed ideas, analyses and corresponding simulations.

Commercial Satellite Constellations in China - IAA-LA2-01-04

James Zheng*, Chengyin Xie, Weijia Ren / Spacety
*james@spacety.cn

With the successful launch of Dongfanghong 1, the first Chinese satellite, into the earth orbit on April 24, 1970, China started its space journey and became a key member of the international space community. Over the past 49 years, China has made remarkable achievements in its space programs, ranging from advanced satellites, human space flight, permanent space station, to the world first soft landing on the far side of the Moon with its Chang'e 4 lunar mission. All these achievements and successful missions were led and implemented by the Chinese state-owned enterprises or institutes such as the China Aerospace Science and Technology Corporation (CASC).

In 2015, the Chinese government introduced a new space policy, which opens launch vehicles, satellites, and satellite applications to private investment and enterprises. Since then, private commercial companies started to get into the space business and enjoyed a significant growth in terms of number of companies and also their sizes in developing launchers, satellites and applications. Spacety is one of these companies. Founded in 2016 as one of the commercial space pioneers in China, it has launched 14 satellites for science, technology demonstration, earth observation as well as space education, and is planning to build constellations for earth observation and IoT applications.

Even though a big space country, China is relatively new to commercial applications of satellite data, and there is a huge potential for commercial satellite applications based on constellations. Advancement and rapid growth of small satellite industry, especially cubesats, have shifted the paradigm for satellite constellations. Huge numbers of satellites, low cost production, and short live cycle have made many applications possible. With its innovative way to develop satellite constellations, Spacety is positioned to lead the satellite constellations for commercial applications in China.

Enabling Distributed Small Satellite system through Modular Open System Architectures - IAA-LA2-01-05

Stanley O. Kennedy, Jr., **Alexander Dunn*** / Oakman Aerospace
Juan Martin-Semegone, **Luciano Rizzuto** / ArsUltra, S.A.
*alex.dunn@oak-aero.com

Today's aerospace industry is engineering the next generation of constellations to provide innovative services such as "Space Dial Tone," Internet of Things (IoT), M2M Communications, reliable global access to internet, on-demand Earth observation, and advanced remote sensing. These sophisticated technology concepts will require robust, effective architecture designs in order to ensure interoperability throughout the systems. Recent technology advancements, driven by the implementation of Modular Open System Architectures (MOSA) standards, has made small satellites cost-effective and more reliable; the ideal platform for these constellations. This paper will discuss the evolution of MOSA standards, the technology advancement they have enabled, and their projected implications on the next generation of advanced technologies and distributed systems.

Standardized designs that ensure interoperability within complex systems have been successfully implemented in a number of other technical industries: automobiles, automation, mobile phones/app markets, Linux, USB, etc. The benefits these technical industries have been able to capitalize on are well known and documented. Their success inspired sectors within the aerospace community to implement MOSA, a design approach that ensures interoperability among physical (mechanical and electrical) and software (protocols, etc.) interfaces for highly complex systems. The establishment of MOSA standards in small satellite design was necessary to facilitate new technologies, innovation, and market growth.

MOSA has quietly evolved over the last decade, acutely synchronized with the SmallSat utilization trend from technology demonstration missions to operational systems and constellations. The United States Government was an initial force advocating for MOSA and standardized spacecraft design. Having recognized the need to modernize and control costs of space systems, a number of government initiatives were established to foster MOSA. On a global scale, public organizations such as the International Standards Organization (ISO) and the Consultative Committee for Space Data Systems (CCSDS) emerged as the common standard providers and compliance baseline for MOSA constructs in the international aerospace market. Industry acceptance of MOSA standards ensured that future innovations, fueled by new technologies within the SmallSat industry, continue to support interoperability while promoting commercial viability. Open systems and emerging open-source hardware and software solutions are providing the infrastructure, products, and services necessary for interoperability and integrated mission capabilities.

Fully functional Space Dial Tone and IoT will require constellations of small satellites with disparate payloads and functionalities. In the coming years, MOSA will continue evolving to facilitate these innovative applications and emerging technologies in the Space industry. A comprehensive evaluation of MOSA constructs and its integration is imperative to realizing the technological potential residing in these distributed systems of advanced technologies. Progressing from the original, monolithic approach to satellite development toward MOSA constructs, the industry is poised for a new era of disruption in the NewSpace market.

Session 2 – GROUND SEGMENT

Application of machine learning techniques for telemetry analysis

– IAA – LA2 – 02 – 01

Denis Fernando Martinez*, Santiago Martin Henn, and **Ariel Sosa Visconti** / CONAE - UFS UTN
*denisfmartinez@gmail.com

In space systems, faults are detected mostly autonomously when any monitored variable (for example: voltage, electrical current, temperature) adopts a value outside the expected range of operation. The values that define this range are established before implementation and with a margin that ensures transient behaviors are not interpreted as failure states.

Telemetry provides the only source of information about the satellite's state of health, once te mission reaches the launch phases. When telemetry data only have the set of monitored variables or health status information, it is often called housekeeping data. When each telemetry flow is monitored individually, the health status of a component or a subsystem is obtained.

Nowadays, satellites monitor certain parameters generated by its components. If the monitored parameter adopts a value outside the expected range of operation, an alarm is sent in the telemetry. This tracking mode only allows actions when the anomaly has already happened, which means that in the case of a failure or imminent failure, no action further from isolation and recovery is likely possible.

Based on previously acquired knowledge about the operation states of the components, fault detection is achieved through fixed limits. At this level, simple limit checking methods are used, often called "thresholding" or "out of limits". These numerical limits are set at the upper and lower acceptable values for each particular component.

Machine learning is a subject of artificial intelligence, whose objective is to develop techniques that allow computers to learn. This learning is achieved through the development of programs capable of generalizing behaviors from information provided in the form of examples. It is a process of knowledge induction that considers the study of the computational complexity of the problems.

The aim of this paper is to provide a useful methodology for the mission operations group using the machine learning techniques. The identification, analysis, and experimentation of different models and algorithms will allow their application in future projects of the National Space Activities Commission of Argentina (CONAE). This work is part of the development of a master’s degree thesis that is carried out at the Higher Education Unit.

To conclude this work, supervised and unsupervised algorithms will be used to analyze real and simulated telemetry anomalies. Telemetry obtained from the SAC-D mission will be analyzed and data of critical components of a satellite mission will be simulated, such as those that belong to the attitude and orbit control subsystem.

Experiences and lessons learned developing a next-generation ground segment prototype – IAA – LA2 – 02 – 02

Pablo Soligo, Jorge Salvador Ierache, UNLaM (Universidad Nacional de La Matanza)
*psoligo@unlam.edu.ar

In this paper we discuss how using general purpose software tools and advanced programming techniques it is possible to create a multi-mission ground segment software application that can be applied in almost (virtually in) any mission. We developed a functional prototype and worked with real satellite telemetry and commands. Different alternatives were explored, and several analyses have shown the advantages of this approach in terms of productivity, maintainability and cost. One of the main goals was to use modern general-purpose tools instead of old or spatial industry classical ones, providing a cost-effective and multiplatform solution. We used general purpose databases, a well-known Object Relational Mapper (ORM), popular programming languages, libraries, frameworks and advanced programming techniques. We avoid any tool, protocol or strategy not used in software industry. Telemetry data from several sources, is processed, stored and finally showed through Open Source Mission Control Software (OPENMCT) application by National Aeronautics and Space Administration (NASA). External software units can interact with the system using Representational State Transfer (REST)/JavaScript Object Notation (JSON) and web sockets interfaces. The interfaces are available to receive telemetry from different external systems or to publish telemetry to different external clients. In this work the publish telemetry interface is used by OPENMCT.
An initial prototype was developed to support the flight segment of a cubesat engineering model provided by Innovative Solutions In Space (ISIS) in the context of the academic mission Formador Satelital 2017 (FS2017), as part of Master in software development for space application (MDIAE). Currently we test compatibility (without commands) not just for cubesat but also for medium or large missions. The system evolved from a traditional client- server architecture to a distributed system in order to improve the horizontal scalability and, in its most recent version, data mining and machine learning techniques were incorporated. Using well known libraries this telemetry processor can predict future telemetry values and compare them with the real ones in order to detect anomalies or unknown patterns.

TU Berlin satellite programmatics and multi-ground station concept

– IAA – LA2 – 02 – 03

Martin von der Ohe*, **Sascha Weiß**, **Sascha Kapitola** Technische Universität Berlin, Department of Aeronautics & Astronautics
Livio Gratton** / Instituto Colomb - Conae
*martin.vonderohe@tu-berlin.de
**lgratton@conae.gov.ar

With the launch of BEESAT-9…-13 Technische Universität Berlin (TU Berlin) has successfully launched and operated 21 satellites. Mission objectives include technology demonstration, communications experiments and education. In 2019, 12 of these satellites are still operated on a daily basis and seven more satellites are to be launched before 2022. The main communication link for TT&C is in the amateur-satellite UHF band, which comes with both advantages and disadvantages. The main advantage is that the UHF amateur equipment is comparatively cheap, easy to install and handle and can be deployed even under harsh environmental conditions. The disadvantage is that data rates are low and amateur-satellite bands require compliance with amateur rules. For payload data, S band transmissions in the space-research bands are used. While these bands provide higher data rates, the ground station setup is more complex and more difficult to set up in a remote area. Besides the technical parameters of the ground stations, operational requirements have to be taken into account.

Most TU Berlin satellites are developed by different project teams, having concurrent operation needs and not always a common operations system. This necessitates thorough planning of ground station availability and mission operations. When capacity limits of single ground station solutions are reached, a ground station network for satellite operations becomes necessary. TU Berlin has pursued an approach of successively building up a distributed network of ground stations with international partners throughout the world.

This paper provides an overview of TU Berlin's satellite missions and their ground station network. Besides the "home base" on the rooftop of the institute of aeronautics and astronautics at TU Berlin, stations in Backnang (Germany), Longyearbyen (Svalbard, Norway), Buenos Aires (Argentina) and San Martin Base (Antarctica) exist. These stations are either built and operated independently or in close collaboration with partners, e.g. Instituto Colomb of UNSAM in Buenos Aires. Additionally, transmissions that are downlinked in amateur-satellite bands are collected via the SatNOGS network. The paper will conclude with an outlook of how TU Berlin plans to further optimize the ground station network.

A Data Science approach for Telemetry Analysis on Smallsats Systems

– IAA – LA2 – 02 – 04

Marcio W. Silva Jr*, Denise Rotondi, Walter A. Dos Santos / National Space Research Institute – INPE
*marciowaldir.sjr@outlook.com

Generally, telemetry data tends to be an important 'communication channel' between an embedded system and it´s developer, or operators, regarding the system status as a whole. But, in space systems, telemetry data is the only information available about the system status, it provides to the stakeholders a full visualization of the system, and the lack of telemetry can even compromise the space system mission since, without it, it's impossible to conclude anything about the system status, and therefore, the lack of it turns the system operation unfeasible. But, even with well functional telemetry, there is an inherent characteristic of space system imposes some difficulties regarding the analysis of the telemetry data mass, e.g. the telemetry data mass that incomes every time a satellite enters in the field of view. Some satellites have hundred, sometimes thousands, of different telemetry signals, and analyzing all that data mass, in order to infer something, takes time which it's not always available. This works describes an approach using data science tools and techniques to turn the telemetry data mass analysis and data visualization more clear and easier to handle. To accomplish this task will be use a telemetry data mass from a satellite, that will be called in this paper as SATAN(Satellite Anonymous), which the telemetry acquisitions were made in years 2000 and 2003. The first time-window to be analyzed will be of January of both years, and the second window will be a period between March 1 to 16, 2000 and 2003. There is also a time window for the month of June 2003 that can be evaluated. In this work, only analog telemetries will be used that indicated measures of interest to the power supply subsystem, especially those associated with batteries, solar panels, SHUNT and BDR equipment. These telemetries were chosen because they are the most representative of the power subsystem behavior and thus have the greatest potential to identify problems and anomalies. All the process will be developed through a Jupyter Notebook, in Python language, making use of Pandas library to perform the data analysis and Seaborn library to perform the presentation of the resulting data. This work is under development and it's an embryo for a bigger work to be done, that will be inside the AI area, but the expected results for this EAD phase of the work it's a reliable result that we could lay on to infer about if some parts of the satellite degraded or present some kind of anomalous behavior that could leads to a subsystem failure or even a loss of mission.

Keywords: Smallsats. Telemetry analysis. Data Science. Artificial Intelligence.

Real-Time Telemetry for Low Earth Orbit Satellites based on Machine to Machine Communications and Inmarsat Constellation – IAA – LA2 – 02 – 05

Aguirre, David*; **Gomez, Emmanuel**; **Caballero, Ada Luz** / Unidad de Formación Superior - CONAE / UTN-FRM
Bava, José Alberto; **Ciafardini, Juan Pablo** / Departamento de Electrotecnia, Facultad de Ingeniería, Universidad Nacional de La Plata
Rodriguez, Guillermo / Departamento de Electrónica, Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata
*dsalcedo@conae.gov.ar

Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellites have limited radio link contact time with ground stations due to the orbital relative movement between these two elements and the geographical location of the ground station. Therefore, in order to obtain the science and/or telemetry data from the satellite, the radio link contact must be waited in order to obtain the necessary information that will allow us to obtain a diagnostic of the eventualities in orbit. On the other hand, in some cases of low passes through the ground stations, the total volume of data generated in telemetry cannot be downloaded to the ground station in a single communication, and the diagnostic of satellite health is partial and the next radio link contact must be waited to complete it.

The main drawback of this situation is the impossibility of continuously monitoring the operation of the satellite that allows to anticipate failures and/or their propagation to other components. To quantify this point with an example, a sun-synchronous orbit satellite whose altitude is between 600 and 700 km, the orbital period of 100 minutes (approximately) has 4 useful passes daily over the ground station. Two of those passes are consecutive during the morning and the other two during the night which are also consecutive. The satellite is invisible to the ground station operators for 10 hours, and taking into account that the batteries are designed to survive without charge for two orbits, an uncontrolled orientation failure, for example, can produce a catastrophic mission failure.

Space Agencies with greater resources have several reception stations distributed on the Earth surface that ensure that the period without satellite visibility is at least one orbit. This solution is non-viable for agencies with lower resources due to the operation and maintenance costs of these ground stations. Another solution implemented by NASA is to have geostationary satellites operating as reception stations in space to offer global coverage to LEO satellites, to ensure that at all times there is a receiver where to send telemetry and data. This NASA implementation is called TDRSS (Tracking and Data Relay Satellite System), it is a complete constellation that can offer at any time the possibility of sending information from a LEO satellite. Other organizations such as JAXA (Japan) have
geostationary satellites for communication, but its use is considered complementary. These satellites are dedicated exclusively to the relay information, that is, they only carry out this activity, which makes this implementation even more unattainable for space agencies with lower resources.

The visibility of LEO satellite depends on LEO satellite altitude and the orientation of the orbital plane. This determines the visibility of LEO satellites from geostationary orbit and thus the LEO-GEO contact time to fulfill downlink capacity. This investigation analyzes an approach to increase the radio link contact time of the telemetry data of a low orbit satellite, based on the relay of telemetry data from and to a low-orbit satellite using Inmarsat-F4 constellation. The link requirements for a LEO satellite with a data rate of 32kbps was analyzed.

For the study purpose, we have analyzed the SAOCOM 1A satellite TLE orbit and Inmarsat f4 constellation. The results indicate that it is possible to use a commercial BGAN M2M terminal and a conical L band antenna with hemispherical pattern radiation in elevation angle, and omnidirectional pattern radiation in azimuth angle with Right Hand Circular Polarization (RHCP). Our antenna characteristics are: HPBW: 198°, Axial Ratio (AR) lower 3dB with theta: 0° to 90°. Coefficient reflection: -35dB@1.593Ghz. Bandwidth: 173 MHz.

Session 3 – SATELLITE FLIGHT DYNAMICS, SIMULATION AND CONTROL I

State Dependent Riccati Equation Attitude Control System for Low Powered, Optimal Large Maneuvers Run on Satellogic LEO Satellites – IAA – LA2 – 03 – 01

Mariano Sternheim Misuraca* / Satellogic S.A.
*mariano@satellogic.com

Spacecraft attitude control systems are governed by eulerian dynamics and attitude kinematics, both which are highly non-linear. Common strategies include Lyapunov derived control laws, which may be difficult to tune depending on the success criteria; or linear control techniques extended to non-linear systems, such as LQ regulators or PID controllers, where stability can be hard to prove; plus a trajectory guidance loop, where fortuitous deviations from the trajectory can render the system to perform suboptimally.

To solve these issues a non-linear, optimal regulation strategy for large and arbitrary spacecraft attitude maneuvers is presented in this paper, derived from the State Dependent Riccati Equation (SDRE) technique, which is a non linear extension of the LQ regulator. The SDRE regulation strategy is currently running in the Satellogic Low Orbit Earth Observation Mission. In the paper, the formulation is derived for a four reaction wheel satellite, but the same process can be used to adapt it to another setup of actuators.

The solution is proven approximately optimal with respect to the minimization of the integral of the torque exerted by the spacecraft. The proposed strategy replaces predefined trajectories in the state space - and their related feed-forward terms - by automatically generated real time optimal guidance, which is much more robust to unmodeled disturbances, system modeling errors and potential trajectory mishaps (due to actuators momentary saturation, on board computer or networks lag, numerical errors, etc) since the optimal trajectory is recalculated at every step.

As per the implementation and tuning, automatically generated optimal trajectories (in the sense of minimizing the torque integral) are shaped by the costs that weight the state error and control effort, similar to the LQ regulator for linear systems. Tuning their relative weight as a function of the zone of the state-space is very simple and defines the spacecraft behavior over the optimal trajectory - acceleration, cruising angular speed, and convergence time to target.

Regarding the stability analysis, sufficient conditions for local and asymptotic stability are available under mild conditions for the general SDRE technique. The proof for local and asymptotic stability for the chosen strategy, applied to the spacecraft control system, is provided in the paper.

The performance and robustness of the strategy are demonstrated via on-orbit maneuvers run on the Satellogic Low Orbit Earth Observation Mission, where the trajectory in the state space is observed to approach the optimal path.

Fast and Reliable Computation of Mean Orbital Elements for Autonomous Orbit Control – IAA – LA2 – 03 – 02

Emmanuel Gomez / Instituto de Altos Estudios Espaciales Mario Gulich
Pablo Servidia*, Martín España / Comisión Nacional de Actividades Espaciales
*pservidia@conae.gov.ar

Earth Observation Satellites (EOS) entail precise orbit monitoring and control in order to achieve increasingly demanding application requirements. Classically, the orbit determination is performed by processing the last downloaded flight data to Ground stations where orbit keeping and acquisition maneuvers are also calculated before uploading the needed propulsive commands.

More recently, advanced GNSS receivers and computing resources -allowing for on board precise orbit determination- inspired the new paradigm of Autonomous Orbit Determination and Control. The orbit tracking error is determined between the observed position / velocity and the desired mission orbit. As the mission is usually defined in terms of the desired mean orbit elements, to compute the orbit control error we have to compute first the observed mean orbit elements using only the available on-board information and computational resources. Hence a fast and reliable computation of the mean orbital parameters is key to implement on board orbit control.

Earth Observation Satellites typically use Sun Synchronous Low Earth frozen orbits, which are near-circular due to the frozen condition and mission constraints. For a near-circular orbit, the argument of perigee, eccentricity and anomaly representations are close to singularity, hence the Kepler parameters are often replaced by Eckstein-Ustinov parameters that include a two-dimensional non-singular eccentricity vector and the mean argument of latitude as the sum of the argument of perigee plus the mean anomaly.

Several iterative algorithms have been proposed to calculate the associated mean Eckstein-Ustinov orbit parameters, combined with Kaula gravity disturbance model for higher order and degree compensation. A simpler, non-iterative, closed solution is here proposed consisting of two calculation steps that combine simplified versions of Eckstein-Ustinov and Brouwer-Lyddane gravity disturbance models.

Though less precise, the result is a low computing resources algorithm suitable for either injection guidance, on board first assessment of a satellite´s orbit, or even autonomous orbit control of satellite missions without too restrictive orbital requirements.

Numerical results are shown and discussed regarding applications, in the first place, to an injection trajectory into near-circular orbit (low precision simulation) and next to the orbit determination of a small Earth Observation Satellite over several orbits (high precision simulation).

As a first result based only on the J2 zonal gravity term, is the authors' intention to continue the present study including other terms of higher order and degree, but keeping a simple computational implementation.

An Energy-Based Approach to Satellite Attitude Control in presence of disturbances for a CubeSat Mission – IAA – LA2 – 03 – 03

Adolfo Chaves Jiménez* / Costa Rica Institute of Technology
Mauricio Muñoz Arias / University of Groningen
*adchaves@itcr.ac.cr

The aim of this paper is to present a novel control strategy of the satellite attitude control problem on an energy-based setting, more specifically on the port-Hamiltonian framework. Controlling the orientation with respect to an inertial frame of reference becomes challenging in presence of nonlinear external disturbances such as the gravity-gradient torque and the atmospheric drag, which are external torques coming from the iteration of the spacecraft with external entities. We make use of the advantages of representing the system under study via the port-Hamiltonian framework due to its clear control design philosophy. The structure presented on the energy setting shows the interconnection of energy storage and dissipation elements plus the input and output ports pair, i.e., efforts and flows of the mechanical system. Then, the provided approach attains an asymptotic stable orientation where the key control strategy depends on the orientation and rotation velocity measurements, together with and an integral action on the system's output. Furthermore, the advantage of our approach relies on an energy consumption optimization of the controller, together with the lack of linearization strategies due to the modeling-based framework. In addition to this, the closed-loop system shows robustness in terms of parameters uncertainty due to the nature of the port-Hamiltonian approach. Moreover, a numerical propagation of the spacecraft attitude states is provided where we have considered a satellite placed in an orbit that experiences gravity gradient and atmospheric drag external torques similarly to the orbit and external torques experienced by the International Space Station orbit. Here, the perturbations are simulated by propagating both the attitude and the orbit of the spacecraft, with atmospheric drag modeled as a coupled orbit and attitude dependent perturbation. The propagation is done modeled to replicate the conditions of the mission GWSat, a 3-unit CubeSat mission lead by the George Washington University, with the Costa Rica Institute of Technology providing the design of the attitude control system. The latter is done to demonstrate effectiveness of our controller for a realistic scenario. Finally, a classical PID approach is also included in order to compare its performance with our proposed strategy.

Framework design for high-fidelity hardware-in-the-loop LEO satellite simulations

– IAA – LA2 – 03 – 04

Ignacio S. Husain Cerruti* / School of Engineering of the University of Buenos Aires
Martín España / CONAE
*santiago.husain@gmail.com

CONAE's current interest in developing a high-fidelity hardware-in-the-loop (HIL) closed-loop testbed for testing and validation of guidance, navigation and control (GNC) hardware and software components on board future LEO distributed platform missions calls for adequate complexity management through sound software engineering design principles. We here describe the guidelines and software tools which allowed us tackling the inherent problems that arise when developing this kind of product, providing a scalable, reusable and maintainable simulator.

Being a system with various levels of interaction between its constituent modules, we adopted an incremental evolution development approach. We first used numerical software framework MatLab® to develop an interface to automate the validation of high-fidelity orbital models using AGI's commercial off-the-shelf (COTS) software STK®, comparing the results with actual orbits of the GRACE-A satellite, provided by NASA's PODAAC repository. As simulations evolved, the semantics of the interacting modules became unclear, producing extensibility and high inter-dependency coupling code problems, being the main reason the use of structured programming paradigm through MatLab's scripting language.

These problems called for the use of Object-Oriented Programming (OOP) to deal with the different layers of complexity of the simulator, as it's a paradigm which facilitates the use of abstractions through interacting objects which bind state and behaviour together, in contrast to procedural languages that treat data and functions separately.

By using software engineering principles called SOLID, providing single responsibility (S) to objects and segregating their interfaces (I), and designing the constituent objects based on contracts which specify their behaviour, we achieved a modular and extensible simulation framework. Furthermore, this component-based approach allows new changes in requirements to be made and also to add hardware and software modules transparently without affecting other parts of the architecture.

By fostering these concepts that OOP paradigm provides and using C++ as the enabling programming language, we built a multi-satellite simulator for testing various GNC algorithms in different scenarios.

We here present the design of the simulator framework together with the specification of its constituent modules and how they interact with each other. We also show the results of validating our high-fidelity orbital models against the High Precision Orbit Propagator (HPOP) of AGI's STK. Finally, we pave the way to extend the presented architecture from a single-process, single-threaded application towards real-time multi-CPU simulations.

Hardware in the Loop Test Bed for Distributed Satellite Platform Navigation and Orbit Control – IAA–LA2–03–05

Jose Relloso*, Andrés Laudari / INVAP
Andrés Laudari / INVAP
Juan Lavirgen / Instituto Balseiro
Andrés Laudar / CONAE
*Relloso@invap.com.ar

Earth observation (EO) distributed satellite platforms are able to provide qualitatively new observational data and scientific measurements with a time and space resolution that may be impossible to achieve with classical monolithic space systems.
Accompanying CONAE's growing interest in segmented architecture space systems, we here describe current CONAE and INVAP joint program to build a modular, high-fidelity test-bed with hardware-in-the-loop (HIDL) for testing and validating guidance, navigation and control (GNC) hardware and software components under realistic scenarios prior to its integration on future distributed platform space missions.
The HIDL test-bed shall enable real time validation of space-graded GNSS receivers as well as other subsystems relevant to precise autonomous orbit navigation & control (absolute and relative) subsystems of LEO EO distributed platforms. It shall also help the designer to define the requirements of the different subsystems (propulsion, power, instruments) of a prototype and to assess it at a mission level.
Besides, it shall permit to evaluate, simultaneously, the flight models of at least two LEO satellites onboard computers (OBC), each of them hosting corresponding GNC flight SW for flight formation. As such, it needs to be flexible enough to allow a user to modify his own Navigation + feed back Orbit Control modules (HW and SW-algorithms) under test.
Moreover, it is also our intention that the HIDL test bed serve for a rapid insertion of advanced students at a Master's level of the Instituto Balseiro and CONAE's Unidad de Formación Superior into the fast developing area of "Flight Formation Satellites" and itsapplications.

As described in the article, the test-bed´s architecture consists of the next interconnected subsystems:

a) CONAE´s- SPIRENT GSS8000 simulator delivering simultaneous GPS, GLONASS & GALILEO RF signal in the space to the antennae of up to 4 independent space vehicles;
b) A high fidelity real time multiple orbit propagator including the following perturbations:
Earth Geopotential, Drag, Solar Radiation Pressure, Third Bodies (Sun and Moon) and a Thrust Control Module;
c) At least 2 multi-frequency space enabled GNSS receivers;
d) The OBC running the GNC algorithms under test;
e) A simile of a Mission Control Center

Keywords: High fidelity real time LEO propagation, GNSS RF signal simulator, Satellite
GNC hardware in the loop test-bed, Distributed Space Systems.

Session 4 – SATELLITE FLIGHT DYNAMICS, SIMULATION AND CONTROL II

TPredict: A simple and effective satellite tracking and prediction software

– IAA – LA2 – 04 – 01

Tomás Burroni* / Universidad Nacional de General San Martín
Manuel Díaz Ramos / Satellogic
*tburroni@unsam.edu.ar

TPredict is an open source software developed for satellite tracking and prediction. The main function of this program is to assist in ground station planning by giving the user the time windows of the passes of certain satellites. Similar tracking and prediction programs were tested, and some problems were found: they require the user to be familiar with said software; experience has shown that these programs require the user to perform a repetitive and time consuming task in order to get results for multiple satellites; the results are not presented directly, so the user must extract the relevant data manually.

These problems arose while working as an operator at the Miguelete Ground Station at UNSAM (owned, built, and maintained by the Colomb Institute). TPredict seeks to solve these problems by presenting a user-friendly interface which requires minimal effort and returns only relevant data after being filtered by the users needs.

The main goal of this paper is to present the development of the software. In order to do this, the theory used to understand the dynamics of the problem is first explained, as well as the mathematical concepts used for the time and coordinate transformations. Subsequent to the theoretical background, an overview of the flow of the program is presented, explaining the structure and algorithms used. Finally, the user interface is shown, including examples of typical outputs.

The basic requirements that were proposed at the beginning have all been successfully accomplished. This was in part due to the systematic approach taken for the coding. The code is subdivided into different files, using functions for every step and thus creating a higher level environment for the main programming.

As well as this, it offered the possibility of an easier debugging, which simplified and shortened the time needed to verify and validate each function. On top of that, this approach gives other users the possibility of updating the program to add new functionalities and improvements.

The final validation was carried out by testing the program with real users, both familiar and unfamiliar with orbital mechanics and telecommunications. In both cases there were no problems with the interface, or with the reception of the data, unlike there was with other softwares. TPredict is therefore concluded to effectively satisfy the needs and objectives, thus solving the original problem.

Performance evaluation of a low-cost CubeSat compatible GPS receiver through in-orbit simulation – IAA – LA2 – 04 – 02

Ernesto M. López / Instituto LEICI, Fac. de Ingeniería, Universidad Nacional de la Plata (UNLP)
Javier G. García*, Santiago Rodríguez, Germán Scillone, Juan G. Díaz, Gerardo Ramón López La Valle / UIDET Sistemas Electrónicos de navegación y Telecomunicaciones (SENyT), Fac. de Ingeniería, Universidad Nacional de la Plata (UNLP)
*jgarcia@ing.unlp.edu.ar

As nanosatellites missions face increasingly complex and challenging objectives, navigation and orbit determination requirements become more restrictive and important. While these missions traditionally employ low-cost single frequency Global Positioning System (GPS) receivers, or do not even have such a system, the new objectives make it necessary to have a high performance navigation system while maintaining its low cost and consumption.

This paper presents the performance results of a GPS receiver of these characteristics obtained by simulating a low Earth orbit representative of a possible future mission with a GNSS signals generator. The receiver, designed and built entirely by the work group, is able to follow the civil GPS signals in the L1 and L2 bands, making it possible to obtain high quality pseudorange and carrier-phase measurements at two frequencies to mitigate the ionospheric effects. It is also compatible with the CubeSat format, making it particularly suitable for such missions.

In particular, the required time for the correct acquisition of the in-view signals is assessed as well as the tracking limits for such signals. In addition, the pseudorange-based real-time navigation solution obtained internally by the receiver is presented, both at single and double frequency, as well as the results of the precise orbit determination performed by postprocessing the pseudorange and carrier-phase measurements along with precise GPS satellite orbits and clocks.

The presented results demonstrate the ability of the receiver to operate under the dynamics imposed by this type of orbits, as well as its application to scientific missions, where the subsequent orbit reconstruction by postprocessing imposes accuracies of the order of centimeters.

Computational Subsystems Models For Determination Of Orbit, Attitude And Thermal Behavior Of A Leo Satellite – IAA – LA2 – 04 – 03

Juan José Saavedra Laureano* / La Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba (FCEFyN - UNC)
Marco Alvarez Reyna / Unidad de Formación Superior - CONAE
*juanjosaavedra95@alumnos.unc.edu.ar

The development of a satellite mission includes technologies and knowledge related to the design, assembly, integration and test of systems and subsystems, as well as its operation and maintenance. By carrying out this work in an academic digital-environment we expect to collaborate in the generation and development new capabilities to test and verify satellite missions, formatted and trained high-level human resources in space science and technology.

The satellite is divided in two main parts, bus and payload. The bus is a system integrated by several subsystems which interact with others for the proper operation. They usually are: Orbit Determination and Control Subsystem (ODCS), Attitude Determination and Control Subsystem (ADCS), Thermal Control Subsystem (TCS), Energy Power Subsystem (EPS), Communication Subsystem (COMS), On-Board Computer (OBC). Each subsystem has a specific task. Typically, the subsystems outputs are related with others subsystems inputs/outputs. Its functions are accomplished by using sensors and actuators on board. The subsystems provide data to be processed by the OBC, acquiring therefore the position, velocity, attitude, temperature, power, etc.

In this paper we present the primary implementation of digital-simulated bus, following the concept of ”Digital Twin”. As a tool, this work pretends to be used as a digital environment to test different configurations of the satellite along with many operational scenarios. We focused the developments in the ODS, ADS and TS subsystems. The reductionist compu-
tational models expect to simulate the main performance of these subsystems, interconnected to each other. These models are implemented to connect themselves using the co-simulation technique, forming a single coupled model. The simulation outputs are parameters of the orbit, attitude and temperature. The development is in an advanced state, ready to begin the integration phase (co-simulation) and tests.
For the development of the orbit model, numerical methods are implemented to solve the Keplerian equations, having keplerian elements as input. The attitude model is based in synthetic-measurements of different sensors, like star tracker and gyroscopes for the attitude estimation. The thermal model is implemented with the thermal network modeling. This modeling uses the nodalization method, where each node represents an element of the satellite. Therefore, we would study the variation of the temperature while the satellite travels its orbit and spin on itself.

It is important to mention that this work is carried out in the UFS Academic Laboratories of the CONAE as an undergraduate thesis to obtain the aeronautical engineering degree, where the student will develop capabilities and knowledge about space science and satellite technology.

Keywords— satellite, orbit, attitude, thermal, co-simulation

Orbital maintenance for the INFANTE maritime surveillance satellite –

IAA – LA2 – 04 - 04

A.D. Guerman* / University Beira Interior
D.S. Ivanov, D.S. Roldugin / Keldysh Institute of Applied Mathematics
*anna@ubi.pt

The INFANTE 50 kg mission is currently designed for the Portuguese home waters coverage with the synthetic aperture radar and multispectral camera. The operational orbit is a sun synchronous midnight-noon. Orbit maintenance is required due to the restrictions imposed by the bus and payload. Namely, the radar operation requires relatively narrow range of orbit altitudes. High orbit drastically increases the radar power consumption which cannot be supported by the solar panels. Low orbit, on the other hand, decreases the coverage characteristics of both the radar and the camera. Moreover, radar power consumption endangers the satellite thermal balance. As a result, the eclipse pass is required for each orbital revolution which restricts the right ascension of ascending node drift. Overall, the orbit should be maintained to be relatively close to the nominal operational one.

The altitude of about 450 km implies strong aerodynamic drag influence. However, the satellite is very elongated with low area-to-mass ratio in the nominal attitude mode. Orbital and angular motion combined simulation results are provided along with the corresponding maintenance maneuvers. Right ascension of ascending node maintenance is not required. Altitude maintenance requires about 6 m/s in half a year during high solar activity. Low and even medium activity allow the mission to operate without orbit maintenance. Attitude stabilization accuracy has a major impact on the orbit decay due to the high sensitivity of the flow facing area of the satellite on the attitude. The accuracy provided by the commercially available hardware and the Kalman filter data processing is enough to decrease the fuel consumption during maintenance maneuvers.

Preliminary analysis of a nanosat mission to integrate a lightning flashes detector with a biomass sensor in a CubeSat 3U configuration – IAA – LA2 – 05– 01

J.O. Murcia*, K. Naccarato, M. Cardoso, A. Tikami, A. C. Julio Filho, G.F. Fernandes, L. Camargo, E. S. F Paula, C.A. Dos Santos, C. Batista, W.A. Dos Santos / National Institute for Space Research, INPE
*jhonathan.pineros@inpe.br

The National Institute for Space Research in Brazil (INPE) is envisaging two individual nanosatellite missions, the RaioSat, and the BiomeSat, a joint work between its Earth Science and Space Engineering coordination. This work addresses the results of the mission analysis for a third nanosatellite option which aggregates the two payloads onboard and maps the previous two individual missions into a sole nanosatellite mission. This demands orbit definition to guarantee the two payloads coverage in the selected regions, the gaps and time intervals for the operational payloads. The RaioSat and BiomeSat missions are
designed respectively to monitor natural phenomena like lightning flashes which have a correlation to extreme events, and Biomass in the Amazon region which has been reducing recently due to deforestation, increasing the climate changes effects. The two missions were planned to be on board a 3U CubeSat configuration with an operational time lower than one year in a prospective Low Earth Orbit around 650 km of altitude, with an inclination between 70° and 99°.
The orbit configuration allows good coverage of the Amazon region and the Brazilian territory using INPE´s ground stations located in São José dos Campos, SP and Santa Maria, RS. Their payloads and bus subsystems are configured to the CubeSat Standard aiming at low cost and reduced project development time.

The individual mission analysis of the two missions shares some requirements commonalities such as orbit altitude, the region to cover, use of INPE´s ground stations, the CubeSat platform, the mission timeline, and goals to reduce cost on launch and operations. Therefore, this study is relevant by analyzing a joint mission option including both payloads which reduces the overall individual mission costs and opens the possibility to a multi-mission nanosatellite.

In this paper, it is presented the results obtained from the mission preliminary analysis. Initially, it is presented the description of the RaioSat and the BiomeSat missions. From the missions are defined the requirements and the subsystems.
The analysis includes mainly the three-axis stabilized attitude and control system, power budgets, the communications architecture, the orbit lifetime and possible use of a de-orbiting system. Finally, the results are compared with the former single missions and a constellation configuration in order to present its key advantages and/or disadvantages.

The launch of NANOSATC-BR2 and the making up of the first Brazilian INPE-UFSM CubeSats constellation – IAA – LA2 – 05 – 02

Nelson Jorge Schuch* , Rodrigo Passos Marques, Fernando Sobroza Pedroso, Thales Ramos Mânica, Leonardo Zavareze da Costa, **Jose Valentin Bageston /** Southern Regional Space Research Center – CRCRS/COCRE/INPE-MCTIC, in collaboration with the Santa Maria Space Science Laboratory - LACESM/CT-UFSM
Juliano Moro / Southern Regional Space Research Center – CRCRS/COCRE/INPE-MCTIC, in collaboration with the Santa Maria Space Science Laboratory - LACESM/CT-UFSM; State Key Laboratory of Space Weather
Otávio Santos Cupertino Durão, Marlos Rokenbach da Silva, Odim Mendes, Fátima Mattiello-Francisco / National Institute for Space Research (INPE/MCTIC)
Andrei Piccinini Legg, **André Luís da Silva**, **João Baptista dos Santos Martins** (4)**, and Eduardo Escobar Bürger** / Federal University of Santa Maria - UFSM
*njschuch@gmail.com

The work discusses both the launch of NANOSATC-BR2 and the making up of the first Brazilian INPE-UFSMCubeSats constellation. Besides that, the work also brings information regarding the NANOSATC-BR, CubeSats Development Program, its Capacity Building Program (CBP), and the Program's present and future. Currently, the NANOSATC-BR Program consists of two CubeSats: NANOSATC-BR1 or NCBR1, (1U) & NANOSATC-BR2 or NCBR2, (2U). The NANOSATC-BR1 was launched as a tertiary payload by ISIS in the event ISILAUNCH-07, by a DNEPR launcher, at the Yasny Launching Base, in the Donbarovsky Region, Russia, on June 19th, 2014. The launch of NANOSATC-BR2 is already contracted, and it will be launched in the first quarter of 2020, from a Russian launching base yet to be determined. The INPE-UFSM's CBP with activities in space science, engineering and computer sciences, has the involvement of UFSM's undergraduate students, graduate students from other institutions, and the participation of INPE/MCTIC's graduate students, which develop activities in the Onboard Data Handling (OBDH) subsystem, Development, Verification and Validation for the NANOSATC-BR2, and the development of space technologies. The two NANOSATC-BR 1 & 2 Projects Ground Stations (GS) can operate with VHF/UHF and S bands antennas, and are entirely operated by students. This paper also focuses on making up of the first Brazilian INPE-UFSM CubeSats constellation, with the development of NANOSATC-BR 3 & 4, in a partnership with the UFSM's Aerospace Engineering Course. The Program's concepts were developed to: i) monitor and determine the effects, in real time, of the Earth's Magnetic field, the Geospace, the Ionosphere and the energetic particle precipitation; ii) study the disturbances at the Earth's Magnetosphere over the South America Territory and the determination of their effects on regions such as the South American Magnetic Anomaly (SAMA). As payloads NCBR2 has: i) an attitude determination subsystem, fully developed in Brazil, from software to hardware, with triple redundancy, manufactured in CubeSat standards and with its attitude determination algorithm, using the platform solar sensors and a magnetometer, already delivered and under testing and integration with the NANOSATC-BR2 Engineering Model (EM) platform and the on-board data handling software - OBDH; ii) a Langmuir Probe also under integration and testing; iii) one board with three experiments - Field Programmable Gate Array (FPGA), Magnetometer - XEN-1210 - three-axis magnetometer with a resolution of 15nT from the Dutch company XI – Xensor Integration (www.xensor.nl) and an Integrated Circuit (IC), already manufactured and going through initial testing before integration, and iv) an amateur radio communication experiment, from the Radio Amateur Satellite Corporation - Brazil (AMSAT-Br) and the Brazilian League of Amateur Radioemission (LABRE). With the success of the NANOSATC-BR CubeSats constellation, it is expected an increase in the Brazilian Government Agencies support, with more investments for the development of Space Technology and new Universities & Institutes initiatives. The Program has received financial support from the Brazilian Space Agency (AEB) and the Ministry of Science, Technology, Innovation and Communications - MCTIC.

Glacier monitoring in Antarctica using small satellites – IAA – LA2 – 05 – 03

Sebastián Marinsek*, José Luis Seco / Instituto Antártico Argentino
*smarinsek@dna.gob.ar

Glacier monitoring has several logistics constraints all over the world. In the case of glaciers in Antarctica, the access to the glaciers is even more difficult and in the most cases, it is only possible during the austral summer. Large glacial areas and long distances from the only few permanent research stations require the use of icebreakers, airplanes and helicopters to reach the area of interest. Setting camps near the glaciers is often required, with the complexity of carrying all the survival material and instruments to accomplish the programmed tasks.

In this scenario, any possibility of doing any research and monitoring by remote sensing has a very valuable opportunity to extend the glaciers to be monitored and also the advantage of not requiring periodic visits to the site. Such experiences are usually carried out by different international satellite research missions. One of the these missions was the satellite SAC-D Aquarius, which was carrying in the on-board payload a Data Collection System (DCS) with the goal of received packets transmitted from the earth surface. Few transmitters installed with sensors (e.g. temperature and humidity) near some glaciers of interest were transmitting data twice a day to the DCS. This data were arriving to a server after being downloaded in a ground station and presented in a server to the scientists access. With this system, a near real-time glacier monitoring was set until the end of the satellite mission.

The present use of small satellites and the increasing amount of them, give the opportunity to start new glacier research and monitoring programs. The capability of the small satellite constellations to have a revisit frequency higher than large satellites is also important in Antarctica due to the usually weather conditions over the glaciers, specific the cloud cover avoid to have repeat optic images of some particular sites. New small satellite missions could be designed to carry on board cameras, different sensors and data communication devices to improve the present offer of data for monitoring glaciers.

We propose to a network of key glaciers in Antarctic Peninsula to install sensors to measure and record different kind of data, for example: air temperature; relative humidity; precipitation; snow/ice accumulation or ablation and glacier photos. We also have some other automatic weather stations (AWS) already installed in Antarctic Peninsula. The aim of this proposal is to develop electronic interfaces and transceivers to send data from the different sites to any small satellite with data transceiver capability. With the data transmitted from the field and received in the research office, an almost real-time monitoring of glacier and nearby weather could be achieved.

On the development of an International CubeSat Mission Between Italy and Argentina with Academic Purposes – IAA – LA2 – 05 – 04

B. Vega, **A. Caballero**, **S. Henn***, **D. Aguirre**, **C. Gomez**, **E. Gomez**, **D. Martínez**, **I. Pintos**, **G. Santos**, **A. Sosa**, **J. Vargas** / UFS, CONAE - Universidad Tecnológica Nacional
D. Silva Griffouliere / UFS, Instituto Gulich, CONAE
*shenn@conae.gov.ar

The Unidad de Formación Superior (UFS) of the Space Agency of Argentina (CONAE) and the School of Aerospace Engineering of La Sapienza University of Rome (Italy), in the context of an international scientific and academic effort and through the signing of a Memorandum of Understanding, have agreed to unite strengths to develop a satellite mission, consisting of a nanosatellite in Low Earth Orbit.

Given the vast experience of both countries in the aerospace field, and the need to perform an adequate training of the human resources that will take part on future endeavours of Argentinian and Italian Space Agencies and Organizations, the Mission's Joint Steering Group, composed of experts from both parties, decided to develop the Mission Satellite using the CubeSat standard, specifically, a 3U+ CubeSat.

The primary objective of the Mission is an academic one, particularly the training of Master Degree students of the UFS and the School of Aerospace Engineering in all technical and programmatic areas related to aerospace technology, such as those focused in the design, analysis, management, assembly, testing, and operation of a space mission.

CubeSats where originally designed for educational purposes and as technology demonstrators, such as training platforms for testing Commercial Of The Shelf (COTS) components usage in a space environment. Nowadays, CubeSats fit in a whole field of applications, mostly relying on missions that do not justify the development of a small satellite, like instruments developed or intended to gather data for unproven scientific theories or techniques.

The Italo-Argentinian CubeSat has been preliminary named FS2020, which stands for "Formador Satelital 2020", or Satellite Trainer 2020. This nanosatellite is composed of two modules, Payload Module and Service Module. The Argentinian team will be in charge of the Payload Module, while the Italian team will develop the Service Module.

The main scientific instrument of the Payload Module will consist of a thermal infrared camera and its associated optics, denominated MIS-CAM for "Maestría en Instrumentos Satelitales - Cámara", spanish for Master in Satellite Instruments - Camera. This instrument will be used to measure the Earth's surface temperature using a technique based on a multi-angle view of a same ground pixel, as opposed to the usual technique known as "Split Windows", that requires the use of expensive spectral filters.

This work will summarize the FS2020 project as a whole, discussing challenges, considered solutions and alternatives. Responsibles for the overall management and the satellite's subsystems performed several preliminary analysis on schedule, cost, communications, power budget, structure, electrical and mechanical interfaces, among others.

Conclusions are made on decisions and solutions intended or designed to solve the drawbacks and difficulties that arose during the early phases of the project, which is considered to be on a Phase B equivalent level of progress, according to the NASA's and ESA's Project Life Cycle Phases.

Study of displacement damage degradation using 75MeV Sulfur ions on AlInN-GaN Heterostructure Field-Effect Transistors - IAA-LA2-06-01

Nahuel A. Vega*, Seshagiri R. Challa, Romualdo A. Ferreyra, Christian Kristukat, Nahuel A. Muller, Mario E. Debray, Gordon Schmidt, Hartmut Witte, Jürgen Christen, Armin Dadgar and André Strittmatter / TANDAR accelerator, CNEA, UNSAM, Otto-von-Guericke Universität Magdeburg
*nahuelv@gmail.com

In the last two decades, GaN technology gained significant importance for the manufacturing of heterostructure field effect transistors (HFETs) due to their high breakdown field, high-temperature operation, adjustable polarization fields, and radiation hardness. Usually, for high-performance applications, GaN-based heterostructures are epitaxially grown on SiC, diamond and GaN substrates, with dramatically increasing substrate costs. That is why devices grown on silicon wafers started to rise in popularity due to their comparably lower price and steady performance increase over the last couple of years.

In this work, HFETs based on intentionally tensile strained AlInN/GaN on silicon samples were irradiated with varying fluences of sulfur ions at 75 MeV resulting in a stopping power of 11.6 MeV/(mg/cm2). Electrical and optical studies were conducted to characterize the degradation of the devices. A Monte-Carlo simulation of the stopping range of ions in matter (SRIM) was used to simulate the interaction between the heterostructure and the ion beam, and TCAD (Technology computer-aided design) modeling was used to simulate the effects on the electrical characteristics of the irradiated devices. Outstanding reliability of 75 MeV sulfur irradiated lattice-matched AlInN/GaN on silicon is evidenced.

With increasing fluence we observe a gradual increase of the threshold voltage (Vth) from initially -3.4 V to -2.9 V at a fluence of 5.5 × 1013 ions/cm2. Also, both the saturation and off-state current decrease considerably with the increasing fluence. A 25 % decrease in the maximum value is observed for the highest dose. There is also a noticeable voltage shift of the peak transconductance caused by the systematic increase in the threshold voltage. Previous results showed that carbon doped HFETs exhibit a transconductance reduction compared to undoped ones and carbon is known to form acceptor states in GaN layers.

It is generally believed that Gallium vacancies act as acceptor-type defects in the GaN crystal. The usual way to simulate the radiation effects is to introduce acceptor type dopants in the structure. We performed a TCAD simulation introducing acceptors in the structure and observed similar changes in the threshold voltage compared to the ones that were measured. However, the relationship between the introduced dopants and the number of vacancies predicted by TRIM is 3 orders of magnitude higher than in similar experiments, performed using 2 MeV protons. This seems to indicate that the number of vacancies predicted by TRIM is not the right tool to predict the displacement damage effects for GaN technology for proyectiles of different LET values.

Heavy-ion induced single event transients on a CMOS digital output buffer using TANDAR microbeam - IAA-LA2-06-02

Nahuel A. Vega*, Nahuel A. Muller, Mario E. Debray / TANDAR accelerator, CNEA
*nahuelv@gmail.com

Single event transients (SET) are current pulses induced by a single particle on a given circuit. When charged particles cross the semiconductors, they generate free charges due to the ionization mechanism. If the number of collected free charges is greater than a parameter called critical charge, the circuit can change its logic state. That is the reason why SET sensitivity is a growing concern for advanced circuits designed for satellite applications. Technology scaling has resulted in greater sensitivity to SETs due to the reduction of the critical charge.

Heavy-ion microbeams are powerful tools to study this type of effects because the ion beam produced in a particle accelerator is focused up to a micrometer size area. For this reason, SETs can be recorded for each beam position and the sensitivity of different parts of the circuit can be analyzed individually afterwards.

In this work, a custom made 500nm CMOS digital output buffer was designed and irradiated using a 75MeV sulfur beam, with a LET of 11MeV/mg cm-2. The buffer consisted of four increasing size inverters, each one made of one PMOS and one NMOS transistors. Montecarlo simulation (SRIM code) was conducted in order to calculate the ionization profile of the ion in a silicon target. During the irradiation, a 1.5GHz bandwidth and 20GS/s oscilloscope was connected to the output of the buffer in one channel and two signals proportional to the X and Y position of the beam were connected to the remaining two channels. The trigger was set slightly over the noise level in the channel connected to the buffer signal.

The map of detected events was superimposed with the layout of the circuit. Therefore, the sensitivity of each transistor was analyzed individually for two different inputs of the buffer: high and low. All detected events came from transistors in off state. When the input was low, positive pulses were detected and when the input was high only positive pulses were detected. Bigger transistors generated a larger amount of pulses but smaller transistors generated pulses of larger amplitude, as it was expected.

SPICE simulations were conducted using the double exponential model to introduce the current pulses in the circuit. It was necessary to introduce a charge of about 160fC in order to reproduce the amplitude of the output pulses. This is consistent with a charge collection depth of about 1μm which is within the order of previously reported values.

Development of a new vibro-acoustic qualification philosophy for Argentinian missions - IAA-LA2-06-03

Ariel Sosa Visconti* / CONAE, UFS – UTN
Edgardo L. Roggero / CONAE
*arielsosa.v@gmail.com

This research was carried on with the main objective of reducing the associated cost to the test phase of the national (Argentinian) scientific missions, without increasing risks and achieving the current test programs objectives.

To achieve this, the different test and models currently used were identified, so it was accurately studied how the main space agencies around the world implement the test phase of their satellite missions. These philosophies might consider the production, fabrication and assembly of different models, like prototypes, protoflights, structural models, thermal models, qualification models, engineering models, etc., depending on the desired approach of the test program.

Also, through a comprehensive research of the previously launched CONAE's missions and their test reports, it was appreciated how the national model philosophy evolved through time. Therefore, it was raised the need to continue this evolutionary process furthermore, looking forward to reduce the cost associated to the test campaigns.

After these conceptual analyses, it was decided to work in a system level test philosophy, particularly centred on the optimization of the mechanical/vibro-acoustics qualification test campaign of the system level Structural Model (SM), due to the quality of the analytical results and the strong experience obtained in CONAE's past missions.

To accomplish the objective declared above, and after a process of synthesis and analyses, the best solution found was considered to be the replacement of the SM test campaign by a flight model structure test campaign, i.e. without any mounted equipment (real or structurally simulated). These tests will still provide practically the same empirical information that can be obtained by the standard approach involving the complete SM.

This paper describes the set of tests to be done in this new approach, the information gathered from these tests, how their results will be managed, and how the requirements and objectives of the current test campaigns will be fulfilled. Finally, it is presented a costs comparison between both philosophies, where it can be appreciated the advantages of using this new approach for the different satellites categories.

Analytical approach in risk assessment applied to space mission - IAA-LA2-06-04

Ada Luz Caballero* / CONAE-UFS, UTN-FRC
Daniel Caruso, Roberto Alonso / CONAE
*acaballero@conae.gov.ar

Most space projects are characterized by the execution of innovative ideas, often without previous experience and exposed to failures in their realization. They are usually integrated by a relatively small number of highly qualified professionals, but who might not know in detail some concepts like project management, costs, and resource management that, in general, are scarce for the mission development.

In this process of innovation, where each project is a unique and first-time mission, the risks are inherent to the realization of the project. Although these might not be removed, they can be intelligently managed so that their appearance does not critically affect the space project. Therefore, it is necessary to have a risk planning that minimizes the uncertainty in the realization of the project, before its appearance on stage.

The objective of this work is to propose a methodology that assists the risk management in satellite missions, which reduces subjectivity in decision-making, and allows for a quantitative analysis of occurrence and mitigation.The methodology presented in this work accompanies the process of a satellite project from the initial conception, providing analytical support in decision-making through risk analysis. The arguments are presented for decision-making to be based on objective aspects, mathematically modeling in both the probability of failure analysis, as well as consequences and programmatic impact on the project.

The first step in the improvement proposed in this work is to use fuzzy logic tools to estimate the probability and consequences of the occurrence of each risk in analytical form, removing the subjectivity of valuation. This estimation is achieved by applying decision-making techniques and probability analysis, classifying possible causes and their consequences. This will allow the analytical construction of a risk matrix that provides a quick visualization of the risks. This work will present the conditional and independent risks and the management of each of them, which the current models do not differentiate.

Silicon Photomultiplier characterization on board a satellite in LEO - IAA-LA2-06-05

Mariano Barella / Consejo Nacional de Investigaciones Científicas y Técnicas
Tomás Ignacio Burroni*, Gabriel Sanca / Escuela de Ciencia y Tecnología - UNSAM
Irina Carsen / Escuela de Ciencia y Tecnología - FIUBA
Mónica Far, Tomás Ferreira Chase, Lucas Finazzi / Escuela de Ciencia y Tecnología - Universidad Nacional de General San Martín - Facultad de Ciencias Exactas y Naturales - UBA
Federico Golmar / Escuela de Ciencia y Tecnología - UNSAM, Consejo Nacional de Investigaciones Científicas y Técnicas
Fernando Gómez Marlasca / Comisión Nacional de Energía Atómica
Federico Izraelevitch / Escuela de Ciencia y Tecnología - UNSAM, Consejo Nacional de Investigaciones Científicas y Técnicas, Comisión Nacional de Energía Atómica,
Pablo Levy / Consejo Nacional de Investigaciones Científicas y Técnicas, Comisión Nacional de Energía Atómica
*tburroni@unsam.edu.ar

The LabOSat collaboration (acronym for "Laboratory On a Satellite") aims to increase the Technology Readiness Level (TRL) of electronic devices and components for space-borne applications. We have developed a single-board electronic platform which is able to operate under extreme conditions such as low pressure, strong vibrations, thermal stress and high doses of ionizing radiation.
This board harbors Devices Under Test (both custom and commercial devices) and performs electric experiments to test and validate them. Its reduced dimensions and light-weight design make it optimal for operating in outer space and performing experiments on board small satellites. Since 2014, seven of these platforms have been launched on board spacecrafts developed by the Argentinian company Satellogic, whose components are still fully operational in Low Earth Orbit (LEO).
Having been tested in hostile environments, the controller has been validated as an experimental platform for the study of electronic devices: LabOSat successfully passed proof-of-concept tests in Low Earth Orbit, withstood fluences of high-energy protons, and proved to operate correctly under high fluxes of thermal neutrons. This validation allowed the use of LabOSat to study three major technologies. The first one is ReRAM, an emerging non-volatile rad-hard memory technology based on the Resistive Switching phenomena. The second one is xFET technology, that is, non-CMOS thin film field-effect transistors. The third one is commercial off-the-shelf (COTS) dosimeters.
In this work we present our efforts to increase the TRL of Silicon Photomultipliers (SiPMs). In early 2019, we have integrated four 6-mm SiPMs into a 40-kg satellite in order to validate and characterize them in the space environment. Each SiPM was packaged into individual light-tight aluminum housings, which included LEDs for excitation. The SiPMs and the LEDs are operated in DC current mode. Besides the SiPMs current and voltage measurements, the experiment also collects telemetry parameters like temperature, timestamp and orbit position. The goal is to characterize and validate the use of SiPMs and its DC power supply on satellites.
In this presentation, we will describe the efforts done to integrate the SiPMs within the LabOSat platform to be launched in late 2019 and the experiments to be done in orbit. Future plans and experiments for a potential next mission are in development and will also be discussed.

General considerations on economic evaluation of satellite missions. Application in small satellites project – IAA – LA2 – 07 – 01

Guillermo A. Tricoci* / Conae - Instituto Colomb
*gtricoci@unsam.edu.ar

The economic evaluation methodologies of projects are applied in order to know ex ante if an investment project can recover the resources invested in its useful life and obtain a surplus. It is a process that requires costs associated with its development and its result, in some cases, may not be conclusive for the acceptance or not of the project. It allows, nevertheless, to have a very complete idea of the costs and benefits and to make decisions with an integral panorama between the scientific requirements, the technical complexities and their economic impact. The most used methodologies are the total cost of ownership (CPT) and the total value of ownership (VTP). The first one is of simpler use since it focuses on the identification of the costs attributable to the project throughout its life cycle, that is, from its birth to the end of its useful life, but it has important limitations of which it stands out, which only considers costs, resulting in the cheapest not necessarily the best. This methodology is most useful in the case of replacement and / or continuity of a satellite mission, a situation in which costs can be compared. The total property value method considers both the costs and the benefits of the project throughout its useful life and therefore solves one of the main problems of the CTP, but introduces the challenge of the quantification of benefits, which is an issue of great complexity. There are controllable and uncontrollable benefits and within these there may be quantifiable and non-quantifiable.
Economic evaluations of projects are almost essential when there are external funders such as banks or when looking for financial partners, in which case the evaluation is part of the business. In the event that the funder is a Government, the social impacts of the project will surely be required.
During the development of the work, the characteristics of both methodologies and the particular considerations for their application in satellite earth observation missions are explained. The complexity of the process of determining benefits, generally associated with the requirements of the missions, and the impact they cause on the decisions of the users of the satellite data, who are the main recipients thereof, are particularly analyzed. In the same way, the types of quantifiable benefits are analyzed as the non-quantifiable, which in many cases do not translate into economic figures but can decide the viability of the project. Finally, we will focus on small-satellite projects in which resources are generally limited and technical challenges are the main focus of stakeholders.
In this case there are other forms of evaluation where, for example, the generation of new knowledge or the implementation of professional practices may be more relevant, especially those for educational purposes.
Economic evaluation is not a dogma, nor the only decision rule, but a relevant aspect to consider in environments where the use of resources and the return on investment play an important role.

The ISS Japanese Demonstration Platform and International Collaboration for Small Satellites Development – IAA – LA2 – 07 – 02

Masatoshi Nagasaki*, Makoto Kanazawa / Space BD Inc
*m.nagasaki@space-bd.com

From 2018, JAXA has aggressively transferred the resources of The ISS Japanese Experimental Module “Kibo” such as satellite deployment platform and exposed experiment platform to the private sector as part of the initiative called “Kibo Utilization Strategy” for the purpose of promoting commercial use of the ISS.
Space BD Inc., one of the most evolving Japanese space startup, is the only company who has been successfully selected twice in a row by JAXA to become the commercial service provider of those two platforms. In our presentation, several representative projects related to small satellites on these ISS Kibo platforms, both satellite deployment and in-orbit demonstration on the exposed experiment area, will be introduced.
In May 2018, Space BD won the bid to the Request For Proposal by JAXA about the commercialization of small satellite deployment from the ISS Kibo (http://global.jaxa.jp/press/2018/05/20180529_microsat.html).
After this commercialization JAXA transformed technical support functions to Space BD, and Space BD has been delivering a user-friendly service from a private enterprise viewpoint. Space BD has been providing a full range of services from technical coordination, safety review support, frequency band acquisition support, flight integration, transportation, and satellite launch/deployment to reduce the customer's burdens. The aim of this service by Space BD is to create an environment where small satellite developers can focus on their payload development and their mission success. So far, Space BD got more than 15 contracts with various types of small satellite missions to launch and deploy from the ISS Kibo. While most of the satellite missions are technical demonstration, there are various types of customers such as university, research institution, space company, startup and non-professional organization.
After less than one year later from the first commercialization initiative taken by JAXA, in March 2019 SpaceBD also won the bid to the second Request For Proposal by JAXA regarding commercialization of ISS Kibo.
The second initiative was about the commercialization of exposed experiment platform of the ISS Kibo(http://global.jaxa.jp/press/2019/03/20190308a.html). Space BD is now providing the in-orbit demonstration services using this platform. It enables customers to focus only on the mission payload development without being afraid of communication failure due to the trouble with satellite bus because the customer can use electricity and telecommunication infrastructures provided from the ISS side. Space BD got the first contract from Satlantis, an evolving Spanish startup, for its demonstration of their first optical camera device for small satellites. This project is the first overseas project which utilize the exposed experiment platform on the ISS Kibo in the ISS history.

As stated above, the presentation refers how effective the ISS Kibo as very flexible and easy test bed taking quarterly regular launch available, gentle vibration environment during the launch and no debris concerns into consideration, and how Space BD promote its utilization by the power of commercialization.
In addition, this presentation explains how and why international collaboration is inevitable in order to make space sustainably growing industry.

Lessons Learned from BIRDS Program, Satellite Program for Non-Space-Faring Countries – IAA – LA2 – 07 – 03

Mengu Cho, George Maeda* / Kyushu Institute of Technology
*cho@ele.kyutech.ac.jp

Small satellites, especially CubeSats, are ideal entrance for non-space faring countries to join the space sector. There is a strong demand for human resource development programs, i.e. capacity building, through small satellite projects.

There have been various training programs offered by institutions in space-faring countries. Many programs, however, failed because they had lack of hands-on experience and did not cover the entire satellite system life cycle. The keys to success are to have trainees experience the complete cycle from mission definition to operation and to have strategy for sustainability after the training.

Kyushu Institute of Technology (Kyutech) started BIRDS program in 2015. The program is a capacity building program targeting non-space faring countries. Its mission is "By successfully building and operating the first national satellite, make the foremost step toward indigenous space program at each nation.". BIRDS program is made of a series of 1U CubeSat Constellation projects launched annually. Each project is run by students who are sent from participating countries to Kyutech as a full-time graduate student. Students experiences the whole processes of satellite system life cycle, from mission definition to operation in two years so that the project fits into two-year academic curriculum for Master course study.

The BIRDS satellites are released from International Space Station and operated by a network of ground stations located in the member countries. In July 2017, five BIRDS-1 satellites, the first generation of BIRDS program, were deployed into orbit. Following BIRDS-1, BIRDS-2 (3 satellites) and BIRDS-3 (3 satellites) were deployed in August 2018 and June 2019, respectively. Currently, BIRDS-4 (3 satellites) is under development and scheduled to be deployed into orbit in summer 2020. BIRDS-1 deorbited in May 2019. BIRDS-2 and BIRDS-3 are currently in orbit. The participating countries are Japan, Ghana, Mongolia, Nigeria, Bangladesh for BIRDS-1, Bhutan, Philippine, Malaysia for BIRDS-2, Japan, Nepal and Sri Lanka for BIRDS-3, and Japan, Philippine and Paraguay for BIRDS-4. For Ghana, Mongolia, Nigeria, Bhutan, Nepal, Sri Lanka and Paraguay, BIRDS satellite is the country's first satellite.

The BIRDS program is managed by the financial contribution from BIRDS partners for a significant part. Most of the BIRDS partners are universities. Each partner who owns a satellite covers the cost of launch, hardware, and students (at least two). Each partner builds a ground station to do the satellite operation.

Moreover, each partner is committed to initiate space education/research program where the students who worked on the BIRDS satellite play essential role after they graduate and return to the home country. The BIRDS program can be said successful once we see the second satellite built domestically by the BIRDS partners is launched into orbit.

The BIRDS program is an unprecedented international satellite project involving many aspects. It is a training program to foster the human resource in the non-space faring countries. It is a student satellite program made of students from diverse cultural backgrounds. It is the largest academic satellite constellation ever built by a single university. It experimented the lean satellite concept that utilizes non-traditional, risk-taking development and management approaches to deliver the satellite at low-cost and in short time by minimizing the waste. There are many lessons learned in the past four years. In this presentation, those lessons are shared with the audience along with the future plan.

Key-enabling factors for a successful SmallSat mission – IAA – LA2 – 07 – 04

Veronica La Regina* / Nanoracks Sapce Outpost – Europe srl
*vlaregina@nanoracks.it

In the last 10 years Small Sats are getting more and more successful and this comes from a set of key-factors, such as availability of reliable deployers and dispensers, improving of carrier safety, resilience of systems on-board, and the frequent and regular rides to Space on-board of the several space vehicles.
A key-element of the supply chain of getting Small Sats into orbit is the dispenser and/or deployer. This element is turning to be crucial to assure sustainability of the business because so fare there are different designs embark-able on board different and exclusively and not exclusively rockets. This makes the provision of this element available on-demand in a sort of handmade fashion by small manufacturers extremely dependent from market price set by launch brokers and launch service providers. The technological challenge to make more prompt the adaptation of a deployer/dispenser to the different rocket is still in development and the design is sensitive to several factors, including export regulation and military constraints, etc.
Beside this the SmallSat community is extremely diversified in terms of participation with student communities, scientific and technological communities and industrial players. The first group is aimed to deliver an outreach and engagement activity to assure inter-generation involvement into Space domains; the second one is aiming to prove their initial steps to Space and the third one is driven by business outcome and growth. The users of SmallSat mission are consequently several clusters from institutional (space agencies, public R&D centers, public universities and national and regional entities) to military, commercial companies and individuals. All these clusters of users are servable by SmallSat missions because their configuration is extremely adaptative to the changes of the needs and promptly available with a simplified manufacturing process.
This paper aims to provide a comprehensive overview about the key-enabling factors assuring a successful SmallSat mission. The overview will be conceived under PEST approach (Political-Economic-Scientific-Technological). It will conclude with a set of recommendations to support more participation to Space thanks to Small Sat missions which are more affordable for Latin American countries. The SmallSat missions are also a valuable way of augmenting the space heritage and expertise in the area through tech- and knowledge transfer from the established space faring nations.

Share Space, Shared Future Satellite Integrated Network Promote International Cooperation – IAA – LA2 – 07 – 05

Vanessa Han* / China Aerospace Academy of Systems Science and Engineering
*hanvanessa7023@gmail.com

When we are facing with the space today, we could discover that booming development of space technology has brought great benefits for human kind. On the other hand, however, it has also encountered some constraints remain unsolved. When people are utilizing different space resources, different countries are not using them properly. It could be a waste of resources. Also, there are no unified network protocols for both ground and space, making it difficult for data transmission and conversion. What's more, there is no open data sharing platform that is accessible for people on earth. Accordingly, there are three approaches that are trying to solve the problems. To establish a coordination scheme for allocating space resources, to design a universal protocol for space and ground network, and to build a data sharing platform that could be accessible to everyone.

We have come up with the concept of the Satellite Integrated Information Network (the Network). The complete project will be divided into three segments, the space segment, the ground segment, and the application segment. Electric and laser signals are collected and transmitted between the space network and the ground, creating a three-dimensional network around the Earth. The space part contains the Space Backbone Network with GEO satellites, the Space Access Network with MEO and LEO satellites constellation system, and the Ground Comprehensive Network. The ground part is consisting of ground internet and broadcasting television network. The application part includes industrial internet of things (IIoT), electric internet of things (EIoT) and household internet of things (HIoT). Accordingly, we have made great progress. The presentation we delivered during the UN/China Forum Solutions realizing the Sustainable Development Goals left deep impressions to the audience including many other people from international governments, organizations, institutions and universities. Officers of UNOOSA have agreed to participate in the study group of the project. Scientists and academicians from different fields were interested in joining the study group for pushing the project forward. We will also be delivering study proposals so that you could know the project well. To promote the progress of the project, China Aerospace Academy of Systems Science and Engineering (CAASSE) has developed relevant software and platform. Data sharing service center, including big data sharing system and cloud application service platform, has been designed for data transmission between different systems. The data sharing system could ensure the integration of information for various projects and business. By acquiring the huge amount of data resources, the platform could provide with a comprehensive database that people could get access to it. Overall, the service center is capable for data transmission and storage, data searching and inquiry, data revealing and management. The data integration system has been implemented in hydraulic and
irrigation project in Ningdong, Ningxia and Guangdong projects for data management, resources allocation, pollution navigation and automatic monitoring.In the conclusion, the global space network community could call on all the countries in the world to cooperate a unified information sharing network. We are trying to create a world where everyone on Earth could get accessibility to the platform through open sources as there are no geographical barriers for space-ground network. The Network could be standardized and benefit to the people as well as the future. We call on that people from all the fields that are interested in the project could participate in our study group for creating a better space world for human kind.

Structural Static Study with Finite Element Analysis of a Screwless CubeSat Design using a Folded Metal Sheet - IAA-LA2-08-01

Cristhian D. Coronel Arriola*, **Mayra L. Mosqueda** / The Nihon Gakko University
Javier Ferrer, **Diego H. Stalder**, **Jorge H. Kurita** / Paraguay Space Agency; Asunción National University
*cristhiancoro@gmail.com

CubeSats are one of the most popular and low cost nanosatellite platform for space science, mostly used in university projects and even for important missions such as Mars exploration projects. The structure supports external components of the nanosatellite (such as sensors, cameras, solar panels, etc.) and also internal subsystems (such as batteries, CPU, etc.). Additionally the structure must be robust enough to withstand the vibrations and mechanical stress subjected during launching. The most common solution for this is the use of rails located at the sides of the CubeSat, which are also required for the launching via the Cal Poly "Poly Picosatellite Orbital Deployer" (P-POD). Actual designs include many components such as screws that can be defective during assembly and may fail due to stress caused by mechanical loads during launch. The purpose of this study is to determine the performance comparison of a Screwless 1U CubeSat Frame Structure and a standard screw based assembly. This would be an alternative design that complies the Cal Poly CubeSat Design Specification. The innovation in this design is the use of an aluminum sheet, which will be folded in certain lines to obtain a cubic frame that holds itself. The final design of this prototype leads to a simple and easy to assemble structure that reduces the use of any screw nor similar fastening mechanisms. The main objective for this study is to gather enough evidence to compare this design with a standard design by doing a static stress simulation with the Finite Element Analysis method. Structural analysis are conducted considering the worst case scenario during launching and the conditions are set in the same values as the specifications dictates. Two loading directions are studied, vertical and horizontal loading referring to the positions that the cubesat may be set during launching. Other mechanical loadings (such as quasi static and dynamic loads) are not considered for this study. The simulations results allow us to determine the most critical parts of the structure. Then we will improve the design by iterative method guided by the simulations. Finally this design guide will be utilized as a tool to optimize future prototypes. This will be rebuild to be tested experimentally so the simulations will be validated.

UnB On-Board Computer Prototype for CubeSats - IAA-LA2-08-02

G. Silva Lionço, G. Santilli*, L. Aguayo / Faculdade Gama (FGA), University of Brasília
*santilli@aerospace.unb.br

Immersed in a global process of capacity building and knowledge improvement that aims to achieve autonomy and independence in the implementation of small satellite missions, researchers from the University of Brasilia (UnB) are studying the feasibility of a 3U CubeSat satellite mission, as a technological demonstrator. At UnB some studies have been underway for several years with the aim of independently creating and offering solutions for these small future missions.

This work aims to present the results of a research obtained so far and dedicated at the construction of an On-Board Computer (OBC) for this kind of future mission. During the OBC development the co-design methodology was used, which allowed the development of hardware and software at the same time. During the design of the theoretical model, the microcontroller and other devices were chosen to compose the OBC hardware. For the embedded software the FreeRTOS was defined as the operative system. During the tests in protoboard it was possible to verify: the microcontroller's consumption, the operational modes of the embedded software, the data acquisition and archiving, etcetera and these results are here showed.
Far from being concluded this research project, however it is worth presenting what has been achieved and realized so far. We arrived at the conclusion that the use of the TI MSP432 is a great choice for low-power and intermediate performance scenarios. The use of FreeRTOS as a real-time operative system requires only little memory to the systems, as well as the use of watchdog utilization at software level has been ratified. Some requirements established in the project have not yet been met due to the complexity of the project and the limited time available. All these points will be taken up again, developed and deepened during the project to arrive at the completion of this UnB On-board Computer prototype for CubeSats.

Key-words: CubeSat Mission, On-Board Computer (OBC), Nanosatellite.

FlexRay Networks for Critical Real-Time Intra-Spacecraft Communications - IAA-LA2-08-03

Ignacio R. Pintos Paladea*, Marcelo Bisogni, Eduardo Kunysz / Comisión Nacional de Actividades Espaciales (CONAE)
Juan A. Fraire / CONICET - Universidad Nacional de Córdoba
*pintosignacio@gmail.com

Intra-spacecraft networking is an enabling technology towards complex spacecraft platforms based on distributed systems. As demand on data-rate, latency and real-time traffic increases, the performance expectation on fault-tolerant wired protocols grows. In this context, protocols from other areas such as the automotive industry become appealing, but careful validation is required before their consideration for space applications. The reliability in spacecraft systems, as well as in other ICT systems, is a key issue in the system design process. Several system verification techniques are being applied in this process to establish that the product under consideration fills certain properties. In complex systems, like the spacecraft platforms, more time and effort are spent on verification than on construction. Techniques intends to reduce and eas the verification efforts while increasing their coverage. One of this techniques is model checking, that is a model based verification technique, and describes the possible system behavior in a mathematically precise and unambiguous manner. Essentially, is an automated technique that systematically checks whether this property holds for that model.

The methodology is focused in scheduling problems, to satisfies data rate and reliability delimited by requirements in this intra-spacecraft FlexRay networks. The selected method of solution is branch and bound, applicable by the model checking tool UPPAAL CORA, a scheduling oriented academic software for concurrent transition systems. The main advantage in this method is the graphic representation of the models with associated costs and outputs like optimal traces. In this paper, we leverage a FlexRay protocol Price-Timed Automaton (PTA) model and analyze its scalability to then study potential scheduling approaches for a FlexRay spacecraft network of the Argentinian Space Agency (CONAE), with an approach to achieve a set of particular mission requirements. There is presented a modeling application of FlexRay protocol in a launch vehicle project of CONAE. A model of a typical launch vehicle stage is under a scheduling verification, that delivers critical data between essential subsystems. For the scheduling verification, parameters like the data frame payload and temporal variables are considered. Also, the protocol parameters applied are depicted. Results show that state-of-the-art model checking techniques are valuable tools to reason about the implementation of industrial networking solutions in the space domain.

As conclusion, there will be presented a preliminary network model for an implementation that could fit into a structure that follows the CubeSat standard, allowing a technological probe in picosatellites for LEO orbit or aerostatic globe. This network must have a time sensitive critical node and a high data rate node at least.

Computational code for the determination of incident environmental fluxes and thermal analysis for CubeSats - IAA-LA2-08-04

Castello Nahuel M.* / Comisión Nacional de Actividades Espaciales (CONAE)
Tomás I. Burroni, Nicolás V. Conde, Matías I. Escobar, Enzo G. Garabito, Luis S. López, Camila Mucanna / Escuela de Ciencia y Tecnología - Universidad Nacional de San Martín
*ncastello@conae.gov.ar

On any satellite mission, an accurate thermal analysis is crucial for the design of the product, and is therefore vital to ensure mission success. The determination of the incident environmental fluxes, which includes solar radiation, albedo, and infrared radiation, is fundamental for this type of analysis.
This paper aims to describe a thermal analysis computer code developed in the free object-oriented programming language Python. This newly developed software seeks to determine the external heat fluxes that are incident on the surfaces of a CubeSat at any given orbit. In addition, the program also solves for the radiated heat and internal fluxes by means of the heat transfer differential equation. As a result, it also returns the temperatures of the nodes as a function of the orbital position. The theoretical concepts, as well as the mathematical tools and processes used in the code, are thoroughly explained in the paper.
The tool originated as an educational exercise that was brought to UNSAM Astronautical Engineering students as part of the course on Thermal Control dictated by Prof. Nahuel Castello. The main advantage of this tool is the capability to quickly and precisely determine the values of the incident environmental fluxes on a satellite. Another benefit arises with the
exclusive use of python due to its high-level language which allows users to analyze it and adapt it at will.
In order to develop the code, a CubeSat model was first proposed with some predefined characteristics such as dimensions, solar cell coverage, thermo-optical and thermophysical properties, and a circular equatorial orbit around Venus.
The task was completed by elaborating three different algorithms. These algorithms were then compared in terms of the computational performance (time and use of resources) and the precision of the results to come up with a final, far more developed code. The final version also allows for the selection of different orbits, dimensions, configuration, and materials.
The algorithm resulted in a numerical tool that provides information of the incident heat fluxes in the nodes of the thermal model, solves the heat transfer differential equations, and returns the temperature of each node throughout the orbit.
Finally, in order to validate the tool, the results were compared with a simulation done at CONAE using the same satellite and orbit conditions, with the thermal analysis commercial tool Thermal Desktop.

Low Power Communication System for a PocketQube Satellite Project - IAA-LA2-09-01

Jorge Arturo Heraud, Jhonnell Fernandez*, David Torres, Ricardo Diaz, Rafael Vilchez / INRAS-PUCP
*jcfernandez@pucp.edu.pe

After the successful launch of its first two satellites, a 1 unit (1U) CubeSat format and a smaller one based on its own format that was later ejected from within the main CubeSat, the Institute for Radio Astronomy (INRAS) of the Pontificia Universidad Catolica del Peru, has been exploring new small satellite formats to undergo equally demanding and interesting projects while keeping costs low.
The increased interest of educational, commercial and military institutions, for the CubeSat satellite standard as an opportunity to develop space technology, has caused the launch costs to increase in recent years. For this reason we have chosen a pico-satellite format with a mass no more than 250g following the PocketQube standard of 5cm x 5cm x 5cm. Since the main limitations to be taken into account in the PocketQube standard, are the low availability of energy and reduced volume, a low-power and low-cost communications system for this class of satellites has been developed. This system is based on a UHF transceiver module, which works on the 70 cm band, handles GMSK modulation and has the capability to reconfigure the carrier frequency and bandwidth. Taking advantage of the transceiver features, a packet radio communications protocol has been implemented and adjusted to our needs.
As a complementary part to the picosatellite operations, a portable platform has been developed to perform the function of a ground station. This hardware is connected to a computer from which tele-commands can be sent and telemetry downloaded in real time, under the operator's supervision. Additionally, for this complementary stage, a set of high performance antennas are required for high gain. Thus, the system has the inherent mission to serve as a training platform for ground station operators.

An attitude determination and control system for a PocketQube pico-satellite - IAA-LA2-09-02

Jorge Arturo Heraud, Neils Vilchez, Daniel Menendez, Rafael Vilchez, Carlos Busquets, Manuel Valenzuela / INRAS-PUCP
*nvilchez@pucp.edu.pe

For the last 10 years, the Institute for Radio Astronomy (INRAS) of the Pontificia Universidad Católica del Perú (PUCP) has been working on its educational satellite development program. In 2013, the first Peruvian satellites PUCP-Sat-1 and Pocket-PUCP were successfully launched and deployed into orbit. The first one, PUCP-Sat-1, began operations on November 21st. On December 6 th, Pocket-PUCP was ejected from it, being the first femto satellite, weighing 96.9g and the first to be launched into orbit from a 1U nano-satellite.
The experience obtained during the design and manufacturing of these two satellites as well as the equipment required to perform the necessary testing, has allowed the Institute to explore new satellite formats in order to lower the costs and reduce the complexity of future projects. One of these new developments is the design and implementation of a PocketQube, a standard for 5x5x5 cm3 satellites. This paper explains the work in progress of an ADCS subsystem for the PocketQube standard and it is based on the principle of conservation of angular momentum. This subsystem was built with low cost DC motors, controllers and sensors and designed using low weight reaction wheels. Its mounting mechanisms are as simple as possible for testing and mounting purposes. It was also made as small as possible and manufactured using 3D printing in order to lower costs. Its software control system is divided into 3 stages. The first one is in charge of the stabilization in 2 axes. The second one will then try to identify a reference point which will allow the third stage to aim the satellite in a specific direction.

ICEPS: Compact, all-purpose, USB 2.0 based small satellite system core - IAA-LA2-09-03

Cdr. Ronnie Nader*, Mr. Jules Nader Drouet, Mr. Gerard Nader Drouet/ Ecuadorian Civilian Space Agency (EXA)
*rnader@exa.ec

ICEPS (Irvine-Class Electric Power Supply) is the system core that EXA designed for the 1U IRVINE-03 satellite, currently in construction and in the late stages of development for the Irvine Cubesat STEM Program under a 12-year contract to provide satellite parts. It was designed based on Ecuador's first satellite NEE-01 PEGASUS's PCEPS launched in 2013, and its newer counterpart has modernized capabilities including an EPIQ Z2 Sidekick OBC (On-Board Computer) running Linux IIOS, 2 SDRs (Software Defined Radio) with a frequency range from 70 Mhz to 6 GHz being able to adapt to any communications network or application, 512GB of storage, 50W power delivery up to 100W peak power for 2.5 seconds and able to operate in temperatures between -50 C and +125 C; it has an inertial measurement unit with a 6-axis Motion Tracking Device for ADCS precise operations, includes 4 UMPPT channels, each one with 16 V @ 2A and with a total of 20 internal sensors for data collection and system monitoring purposes. It has been designed to be on the cutting edge of modern mission requirements, with a total height of 25 mm and a total mass of 100 grams in a single board. The native architecture of the entire digital system is USB 2.0 due to the high mission requirements of IRVINE-03. This enables the use of more modern devices and components with a much faster data rate than traditional CubeSat digital systems. The system core includes the capability to mount a 2W communication laser with a speed of 10Mbps and supports a 5W laser at 100 Mbps, which enables CubeSats to perform previously unattainable communication goals and data transmission requirements due to slow data download rates. Its first technological readiness test will be IRVINE-03, and has become the default system core of all the next IRVINE missions. It will also be used in the upcoming Spacebit's Asagumo robotic walker as a payload on Astrobotic's Peregrine lunar lander on 2021. This paper will describe all the features and characteristics of ICEPS, along with all electrical and dimensional specifications, and its potential for expansion and improvement.

Ultra-lightweight, 200-grams CubeSat Deployer for LEO to Lunar Missions - IAA-LA2-09-04

Mr. Jules Nader Drouet, Cdr. Ronnie Nader / Ecuadorian Civilian Space Agency (EXA)
*rnader@exa.ec

Spacebit's (UK) Asagumo robotic lunar mission will launch on 2021 as a payload of Astrobotic's Peregrine lander. EXA is the main contractor for the mission's hardware and one of the key elements of this mission's success is the payload deployer and one of its key features is to reduce the mission cost by reducing the total mass budget, since the cost of a kilogram to the lunar surface is significantly higher (USD 1.2M) than a kilogram to LEO; this constraint calls for the development of a payload deployer that is adaptable to various missions and launch platforms, theoretically scalable to larger CubeSat sizes, a minimum clearance of 10mm and a top clearance of 15mm, includes the full functionality of normal deployer systems, and ultra-lightweight (less than 300 grams) deployer that can withstand heavy mechanical loads, a temperature range of minus 100C to plus 120C, and higher levels of radiation that are not present in LEO including cosmic radiation and exposure to van Allen belts. The mass of the deployer's structure was drastically reduced by using a skeletal circular cavity framework, optimized for stress resistance and vibrational displacement reduction through the use of SolidWorks 2017 analysis software in an iterative design process. The deployer is primarily made of titanium alloy and ECT-1719F, a low-density, high strength composite material developed by EXA during the development of its first satellite, NEE-01 PEGASUS; to reduce the mass of the deployer while retaining the necessary shape and tolerances. This technology has the potential and capacity to significantly reduce costs in CubeSat LEO to lunar missions by reducing the total mass budget and provide an affordable solution to missions beyond LEO. If successful, the use of this deployer enables CubeSats access to other environments through an economically achievable solution to payload manufacturers. This paper will characterize the capabilities and features of the lunar deployer as they have been designed and planned for general use, as well as analyzing the environments and loads the payload deployer will be subjected to during its maiden voyage and the industry standards it must follow to be fully compatible with all CubeSats.

Spectral and Radiometric Calibration Procedure for a SWIR Hyperspectral - IAA-LA2-10-01

Christian G. Gomez*, Sergio Masuelli and Leandro F. Rocco, / CONAE
*cgomez@conae.gov.ar

Short-wave infrared (SWIR) hyperspectral imaging systems are increasingly available on the market, allowing integration into unmanned aerial systems, airborne, satellite systems or even cubesat.
Hyperspectral cameras allow to obtain the spectral signature of the measured surface of each pixel in the image. However, each pixel is usually composed of several types of surfaces, so the measured spectral signature is a function of the amount of materials present in the scene and their relative abundance.
From the spectral signature measured with these instruments, and by using algorithms and spectral libraries, it is possible to determine the number of components that make up each pixel and their respective abundances, for example by applying demixing algorithms. Therefore, to apply these algorithms correctly, it is necessary that the instrument is absolutely calibrated according to international standards.
The objective of calibration of an instrument is that it can be considered a measuring instrument of a given physical magnitude, in accordance with international standards. The process itself is basically a comparison of the instrument's response to calibration against a known physical value, i.e. an invariant physical property (fixed point), or against a very precise calibrated instrument (standard instrument), having both the same stimulus of the environment. This process quantifies the instrument's response, assesses systematic errors that could exist, and establishes traceability to national and international standards by calculating associated uncertainties. For this, it is necessary that all the instruments involved are certified, as well as the procedures applied. The calibration of the instruments must be valid in the time specified by your certificate, after this time the instrument must be recalibrated.
Spectral calibration basically consists of determining the corresponding wavelength for each row of the CMOS sensor. To do this, we seek to establish such correspondence by using standard lamps that have spectral lines at known wavelengths. In addition, this process determines the spectral resolution of the instrument. Unlike spectral lines generated by standard lamps in the VNIR range, it is observed that those in the SWIR range are weaker, less defined, and with significant gaps in that range. This poster develops a special processing method by using a Mercury-Argon (Hg-Ar) gas discharge lamp first to define the spectral line itself and then model its response for a SWIR camera.
On the other hand, the poster describes the steps to carry out the radiometric calibration of the camera using a spectroradiometer and an integrative sphere, reference instruments used by CONAE. This will allow the correspondence between the digital numbers generated by the sensor with respect to the incident energy.

The Hyper-angular Imaging Polarimeter (HARP), pushing the limits to fit an Atmospheric Science Polarimetric Imager with "global" coverage in a Cube-Sat Mission - IAA-LA2-10-02

Roberto Fernandez-Borda*, J. Vanderlei Martins, Brent McBride, Anin Phuttukkudy, Richard Xu, Lorraine Remer / Department of Physics - UMBC, Earth and Space Institute - UMBC, Joint Center for Earth Systems Technology - UMBC
Henrique M. J. Barbosa / Department of Physics - UMBC, Earth and Space Institute - UMBC, Joint Center for Earth Systems Technology - UMBC, Instituto de Física - Universidade de São Paulo
*rfborda@umbc.edu

The Hyper-Angular Rainbow Polarimeter (HARP) is an ambitious science payload on board of a 3U CubeSat satellite, designed for multispectral polarimetric measurements of aerosol and clouds developed at the Earth and Space Institute (ESI) at University of Maryland, Baltimore County (UMBC). HARP telescope has a wide cross track field of view (94 deg) which potentially could provide global coverage in 1 to 2 days with higher downlink capabilities, and up to 114 degrees along track, which allows for multi-angle viewing of the surface and the atmospheric column.
HARP evolved from a family of Polarimetric Multispectral and Multiangle Imagers that have flown in different Airborne platforms, allowing us to package an optimized system within the envelope of a 3U CubeSat without major losses on science requirements. HARP CubeSat is a technology demonstration sponsored by NASA's Earth-Science Technology Office and as such will acquire a limited data set from space, consisting of individual daily targets covering cloud and aerosol events, as well as multiple surface types.
HARP's 3U spacecraft was built at the Space Dynamic Lab (SDL) in Utah, while the payload was entirely developed at UMBC fitting 1.5U, and allowing multiangle images with up to 60 along track viewing angles, in four polarized spectral bands (nominally 440 nm, 550 nm, 670 nm and 870 nm) without any moving parts. Although the current HARP CubeSat is limited to the VNIR range, its modular design has also been envisioned and designed to cover other spectral bands (UV, SWIR) utilizing the same measurement concept and custom control electronics, in anticipation for future space missions.
The HARP development faced many challenges in order to provide high polarization accuracy and full multiangle/multiwavelength sampling of science targets to uniquely characterize the microphysical properties of clouds, aerosols, and their interaction. HARP's custom optical design and innovative data schemes, as well as results from demonstrations with the NASA ER2 and UC12 aircrafts will be summarized in this presentation. Preliminary science results from AirHARP will also be discussed. HARP CubeSat is currently slated from launch to the International Space Station on October 2019, followed by its subsequent released for autonomous operation in space.
Following the HARP heritage, the Earth and Space Institute at UMBC is currently developing its successor, HARP2, which will be integrated to NASA's Plankton, Aerosols, Clouds and ocean Ecosystems (PACE) mission to launch in the 2023-time frame. HARP2 will have enhanced capabilities including improved signal to noise ratios, onboard optical flat-fielding, and full global coverage in 2 days, while maintaining a similar form factor as the HARP CubeSat payload.

Mapping High Temperature Events with a Small Satellite Constellation – Results from DLR's FireBIRD Mission - IAA-LA2-10-03

Fischer, C., , Halle, W.*, Säuberlich, T. , Terzibaschian, T. / German Aerospace Center: DLR Institute of Optical Sensor Systems
Frauenberger, O. / German Aerospace Center: DLR Earth Observation Center, German Remote Sensing Data Center
*Winfried.Halle@dlr.de

The FireBIRD satellite mission for fire detection and monitoring, consists of two small satellites – ET-1 and BIROS, which have been launched in 2012 (TET-1)and 2016 (BIROS). The two satellites are operating in a sun synchronous orbit (LTDN 9:30 and LTAN 10:30, altitude of 500km). The payload includes two calibrated and qualified infra-red (IR) sensor systems for the mid-wave and long-wave infrared with a ground sampling distance (GSD) of 180m, as well as a three-channel camera for the green, red (VIS) and near-infrared (NIR) wavelength with a GSD of 40m. The sensor systems allow different modes, combining VIS, NIR and TIR for day or night time data takes. Additionally the signal dynamic range in the infra-red can be increased by operating the system in a special mode with a reduced integration time for very hot scenes to avoid information loss due to image saturation. Based on image quality assessment approaches, data radiometric and geometric correction approaches have been tested and applied and an evolving monitoring process of the sensor systems allow post-launch calibration, once necessary. As a result standardized L1- and L2-data products are available.
Even the constellation allow for repetition rates of less than 5 days, depending of the geographical latitude of the location observed, some limitations due to the size and orbit of the satellites have to be considered. On the other hand, the small satellites allow to test and to demonstrate technologies that might become features of small satellite missions in future. These technological demonstrations include components for improved agility and pointing capability and concepts supporting different communications – between satellites and to ensure a flexible data downlink.
Thus, the FireBIRD constellation allow detection and mapping of high-temperature-events (HTE) and delineating their individual fire radiative power (FRP), monitoring forest fire development in terms of intensity and spatial changes, including the opportunity to sense the area under investigation from different positions within one orbit. Together with concepts of on-board processing approaches, which are a prerequisite for a flexible data handling and for further developments of near-real-time (NRT) applications, such as information dissemination for mobile communication devices, both satellites contribute to further developments of small satellite technology within national and international cooperation activities.
The paper is focused on the data processing examples for TET- and BIROS- FireBIRD instruments especially of recent fires in the amazon region of August 2019. It will be shown that by using the bi-spectral method the effective cluster fire size can be better estimated (in the sub-pixel range) than using only the number of affected fire pixel of the cluster.

Simulation guided design of an air bearing based platform for ground testing - IAA-LA2-11-01

Esteban R. Fretes Ruiz Díaz*, Aldo J. Galeano Alfonso, Sergio R. Toledo / Asunción National University
Diego H. Stalder, Jorge H. Kurita / Asunción National University, Paraguay Space Agency
*esteban.fretesrd@gmail.com

The exponential growing society of CubeSat developers demands a realistic and objective way to test each satellite subsystem on earth. Those ground testing equipments must be capable to replicate the launching and outer space environmental conditions. The large quantity of sensors, actuators and control algorithms used on CubeSats Attitude Determination and Control System (ADCS) requires a detailed examination and validation. To test such subsystem, air bearings platforms have been widely used, because they can replicate the dynamic environment of minimal external pairs, that is found in orbit.
The basic design consists of a spherical cup, supplied with pressured air, and a semi sphere over the air film generated between these two components. This air film provides a nearly zero friction environment, which, in combination with a precise mass balance to match the center of rotation with the center of gravity, it achieves microgravity conditions. In this paper, two designs of spherical air bearings with different configurations in terms of air flow inlet and outlet are compared. The first configuration is the Mono-Flow, that have the air inlet at the center of the cup and the air outlet on the periphery of the sphere. The second design is the Multi-Flow, that have the air inlet in 6 capillary tubes equidistant from the center and the air outlet on the center of the cup and the periphery of the sphere. The dynamics of the airflow and the platform are computationally simulated using the software “SolidWorks Flow Simulation”, a general flow simulation tool that uses the Finite Volume Method to calculate the parameters related to the dynamics of fluids (which is a monophysics method) combining of successive approximations (as an alternative to a FSI which is a multi physical program that is usually more expensive). A test bench based on the specifications of one of the simulated designs is used to measure the relevant parameters in order to compare them with the data obtained in the simulation as a verification method. The design, study and implementation of this type of subsystem in Latin American universities will allow to initiate, continue and reinforce the process of capacity building.

Keywords:
Air bearing, Attitude Determination and Control System (ADCS), CubeSat, Flow Simulation, Finite Volume Method, Spacecraft Simulator.

Towards a CanSat Pico-satellite Program - IAA-LA2-11-02

Lucas D. Moreira*, José G. Moreira / Asunción National University
Diego H. Stalder, Jorge H. Kurita / Asunción National University, Paraguay Space Agency
*mlucaspy@gmail.com

In a developed country, for every 2,000 inhabitants there is at least one graduate engineer per year. However, in Paraguay for every 30,000 inhabitants, just only one engineer graduates. For a country so lagging behind in the development of infrastructure this relationship is catastrophic. Additionally, the interest on STEM (Science Technology Engineering and Mathematics) careers has decreased because of the lack of knowledge and the poor performance in subjects related on these areas. According to a PISA (Programme for International Student Assessment) test report, only 10% of the paraguayan student participants have passed the tests on reading, mathematics and science. Space-related educational programs have become a very inspiring way to implement STEM education. CanSat (Can-Satellite) training programs are clear examples of this approach. During the program, students must get over several challenges in order to build a “very small and simple satellite” (pico-satellite) that has similar function with larger ones. They learn how to plan, design and solve problems as if they were on a real space mission. That makes developed countries organize their own CanSat competitions around the world to encourage undergraduate and high school students to get interested in space science. This work makes a redesign of the cansat subsystems taking into consideration the most popular available models nowadays, so that it can be adapted to paraguayan educational needs and future programs. The methodology is carried out by performing the following steps: (1) Analyze the current designs by comparing mission requirements; (2) Idealize a new design taking into account the technical knowledge limitation that the students may have; (3) Implement the new design; (4) Organize a training course; (5) Launch the CanSats, collect the data; (6) Analyze the measured parameters such as temperature, pressure or acceleration; (7) Evaluate the experience. Besides, the comparison allow us to identify the features and restrictions in different CanSats projects. The students programming skills and electronics knowledge must be taken into account in order to select the most convenient platform to perform the new design, e.g. Arduino, PIC, Raspberry, etc. The implementation requires the integration of all the pico-satellite subsystems. Setting up the first CanSat training course for high school students in Paraguay will inspire them by providing new skills to solve real space engineering problems. During the flight, the CanSat should collect physics measurements and deploy successfully a parachute in order accomplish the planned mission. The students must analyze the collected data to perform a critical review of the design performance. Finally, the instructors, students and teachers will discuss and report the issues. Our design will be available for Paraguay Space Agency future training courses to a larger group of leaders from universities and high schools around the country.

Keywords:
CanSat, Developing Country, Pico-Satellite, Prototype design, Redesign, Space Science, STEM.

A Flexible Curriculum for Science and Engineering Courses using CanSat - IAA-LA2-11-03

Mariana Arruabarrena, Luciano Báez, Agustín Fernández, Ricardo Medel and Luciano Mori / Universidad Empresarial Siglo 21
*Ricardo.Medel@ues21.edu.ar

Satellite missions, as complex and multidisciplinary processes, are used as a teaching device for formal or extracurricular STEM courses. Small satellites models are built by students guided by teachers to learn about engineering, electronics, programming, sensors, etc. Due its low cost and simplicity, CanSats are used in education to teach experimental sciences in several settings. However, the topics taught are selected based on the knowledge and interest of the teachers or the characteristics of the CanSats models used, instead of the teaching goals or the students' interest. We propose to design a situated, articulated and flexible curriculum to be used in different teaching environments and levels, taking into account their multiple realities and necessities. Thus, we developed a matrix curriculum where columns represent the topics covered by satellite mission-based courses, and rows represent the depth in which these topics are treated, based on categories of Bloom's Taxonomy. This approach allows teachers to define the entire process by identifying sub processes associated with different cognitive requirements and lower order skills that enable higher order skills. For example, the possibility of using pre-assembled sensors is a basic step to create, install and program our own sensors.

Process Management	**Data Collection (Sensors)**	**Data Storage/ Transmission**	**On board Computing**	**Flight Control**	**Data Processing**
Following a predefined simple plan	Pre-installed on board sensors	Data stored in on board memory	Pre-programmed OB	Pre-programmed download data & telemetry	Simple spreadsheet graphs
Definition of a simple, straight plan	Selection of multiple sensors	Data stored and processed on board	Block programmed OB	Wireless reception of telemetry & data	Block programmed data display
Negotiation of a detailed, straight plan	Adaptation of sensors to be included	Data sent wireless	Simple, textual programming of OB	Wireless reception of telemetry & data. Live display of flight data	Programming of data display
Negotiation of a multiple-path plan	Creation of new sensors	Data processed and sent wireless	OB programmed from scratch		Complex data processing

Teachers can use this matrix selecting a path from left to right in order to cover all the topics but choosing the level for each topic based on some internal and external factors, such as: goals of the course, age & knowledge of students, budget & time available, number of students, teachers' expertise level, etc. Thus, the course contents are defined according to the expectations of achievement, the cognitive and practical skills they require, and the resources available.

Currently, our research team is developing a simple, preprogrammed, easy to assemble CanSat kit and associated teaching material to be used at courses that select the first line in our matrix. Afterwards, we will start using this kit at several teaching contexts, from elementary school to university, to evaluate our proposal.

BEESAT-9: A CubeSat's qualification model was launched - IAA-LA2-11-04

Sascha Weiß, Sascha Kapitola, Sebastian Grau / Technische Universität Berlin
*sascha.weiss@tu-berlin.de

BEESAT-9 is a 1U-CubeSat that was launched on the 5 th of July 2019 from Vostochny, Russia. The satellite is a successor of BEESAT, BEESAT-2 and BEESAT-4, since it uses the same satellite bus with a different payload. It was the engineering model of BEESAT-4 and was not meant to go to space, but in June 2018 the launch provider EXOLAUNCH approached the Chair with an offer for a free launch in February 2019.

The concept for a new payload, the development, manufacturing, software programming and environmental tests had to be finished within six months. This was a challenge from technological and organizational point of view. The purpose was to embed new technology on BEESAT-9 and not just send the same satellite again. Thus, the payload data handling hardware had to be changed, and was equipped with a pico-fluiddynamic actuator, a recent innovation in attitude control actuators of the Chair.

Additionally, a recent, small GNSS receiver was integrated to maintain the focus on the main objective of the project, the precise position and orbit determination. Furthermore, all electronic boards of the former laboratory model were renewed, because they were operational as a software test-bed for four consecutive years already. At the end of 2018 the satellite was fully integrated and ready for the environmental test campaign, which was passed successfully, making BEESAT-9 ready for launch.

AA delay of the launch for five months gave the project team some spare time for software development. After a successful LEOP in July 2019, BEESAT-9 is operated on a daily base from Berlin and frequently from ground stations in Buenos Aires and in the Argentine San Martin Base, Antarctica.

CubeDesign - a competitive approach for introducing smallsats projects in Latin America - IAA-LA2-11-05

Walter A. Dos Santos* / INPE
*walter.abrahao@inpe.br

CubeDesign is an open competition for promoting STEM - Science, Technology, Engineering and Maths for the smallsats area among youngsters in Latin America. It was conceived in the face of some gaps related to space activities in Brazil. Thus, the competition fulfills some
important aspects, such as: (1) arouse interest and engage society towards space activities; (2) develop human resources through the proposed activities. All tasks are aligned with the challenges considered strategic in a space program; (3) solve problems with creative proposals that meet the stated requirements. In this 2nd edition of the CubeDesign's activities are divided into three categories. (1) CubeSat: intended for undergraduate and graduate students; (2) CanSat: for high school and undergraduate students; (3) Mockup: For children from 11 to 14 years old. CubeDesign was the first initiative in Latin America to bring the community closer to the development of small satellites in a competitive environment. We were delighted to find teams fully committed to the proposed challenges and focused on solving the problems. In the second edition we had very successful participating teams from Argentina and Paraguay. This paper will describe in detail, how the competition is organized and how teams performed.

Keywords: Smallsats. Systems Engineering. Systems Design. STEMS. Outreach.

High-Altitude Balloon Launch Program for satellite instruments validation aimed on Effective Student Learning - IAA-LA2-11-06

Jean Piere Cholán, George Fajardo, Jafet Santivañez, Ramiro Tintaya*, Nataly Yauricasa, Fredy Segama / Lab Smart Machines - CTIC-UNI
Nicolas Oudart / Laboratoire Atmosphères - LATMOS, ESTACA
*rtintayaq@uni.pe

Every day the aerospace sector has new technological advances. For university students from developing countries such as Peru, access to this sector, specifically on satellites, is almost impossible due to the launch budget. Suborbital flights with high altitude balloons are nowadays one of the most affordable ways for students around the world to get involved in aerospace projects, since they are an alternative to calibrate nanosatellite systems at low cost, and can involve development of a wide variety of missions that test the creativity of the participants.
This paper aims to show the work done, the results obtained, as well as the plans of the Wanka project, a project carried out by students of the National Engineering University, together with engineers from ESTACA, France, aiming to launch a stratospheric balloon at least once a year in both countries.
The Wanka project has already made two launches. The first one in Ica, Peru, in August 2018, in which unfortunately the load could not be recovered, and the second one in Tarbes, France, in July 2019. The latter was a complete success, since the payload was retrieved, measurements from the embedded experiments were collected during the entire flight, and also was made a graph showing the trajectory during the mission.
In addition, some secondary missions were carried out during the launches, being the main one in the first launch the collection of UV intensity measurements in the stratosphere, which was made in the desert of Ica, in Peru, since it is known that in this area, as in many regions of the country, the amounts of UV radiation are exorbitant, in the second launch the mission was the dispersion of seeds in areas of difficult access for people, focusing mainly on reforesting the damaged areas for logging and mining.
Finally, it is planned, in a future third launch, to implement an automatic fall control system, because, in many cases, communication with the probe is lost, and as a result it is not found after landing. In order to do it, it is planned to place two engines on the load, which should modify the orientation of a parafoil, to make it follow a route, which has already been settled according to a path planning algorithm.

Introducing SmallSat Design Through Evolutive Science Projects – The SENAC-SJC Proposal - IAA-LA2-11-07

Jair G. M. Torres, Marco Mammoli* / SENAC-SJC
Auro Tikami, Marcus V. Cisotto, Antonio C. Julio Filho, Walter A. Dos Santos / INPE
*9marcomam@gmail.com

The Science Club is a nonprofit scientific, educational, and research entity comprised of faculty, staf , and students. Its purpose is to arouse young people's interest in science and scientific research and make them more apt to learn science and related subjects, familiarizing them with projects, research, bibliographical, laboratory and field work, as well as stimulating the team spirit. We develop projects bringing benefits and improvement in the community's quality of life through the identification of problem situations. These projects, experiments and research involve national or international partners such as research institutes, schools, laboratories, other science clubs. By 09/19 we have four partnerships, two state full schools, a technical school and the National Institute for Space Research.
We work apparently distinct projects, but with the same objectives: the study of microclimates, their possibilities and economic and environmental impacts. Our main objective, however, is to stimulate studies in the areas of mathematical, physical, biological and chemical sciences, among others, for this group of different students, in different microenvironments and with many peculiarities. The projects were presented in plenary meeting with the students of each school and were voted among other projects presented.
Initial projects for all schools involved involved the construction of two types of weather stations: the first, made with disposable and recycled materials such as pet bottles, EVA plates, plastics, rubber, among other materials, and the only industrialized instrument was the thermometer. Each school received instruction from the Science Club faculty members about the importance of the devices, the impact of the mission within the larger project of studying the city's microclimates. INPE has developed Arduino and CANSAT workshops with members of the science club, teachers and students. The second weather station is all based on prototyping in Arduino, this digitalization only started after the construction and collection of weather data with the “analog” stations. The Senac students, members of the club, developed in addition to analogue and digital stations, a system for issuing and capturing data produced by partner stations. This spurred them to build a virtual Data Sharing platform that laid the foundation for a microclimate meteorology startup. This process has developed another mission by enabling the creation of sustainable and automated vegetable gardens using sunlight and rainwater for the irrigation and power generation required for control systems and valves. Our partner schools are developing this mission. New perspectives within this partnership process have allowed the creation of a working group between INPE and Senac for other missions focused on: stratospheric balloons, mapping of larger regions focusing on microclimates and their relationships, peat land gas (methane) research and their implications on neurocognitive development of specific populations, CANSATs and future development of nano satellites.

Keywords: Ubatuba Sat. Tubesats. Smallsats. Plasma Bubble.

Session 12 – SPECIAL SESSION

SACI-E: Subjectivity, Art & Space Science - A transdisciplinary approach between Visual Arts and Space Science implemented in the context of Satellites, SmallSats and Remote sensing programs in INPE/Brazil - IAA-LA2-12-01

Fabiane M. Borges* / INPE
Artur Matuck / ECA - USP & Colabor Center for Digital Languages - SP Brazil
Walter Abrahão dos Santos / ETE - INPE (Space Engineering and & SENAC-SJC - São José dos Campos –SP –Brazil
*takebackthespace@gmail.com

This project aims to create and implement a platform of research and residency in Art/Science based on its connection with ETE department (Space Engineering and Technology) at INPE (National Institute of Space Research / Brazil). It is the creation of a transdisciplinary approach between Visual Arts and Space Sciences elaborated according to the best Art and Science programs in the world, where artists and scientists collaborate in the development of original works that enhance the artistic poetics and the scientific dissemination. National and international Art / Science researchers are invited, either by curatorship or public call, to reside for a period of time at INPE to immerse themselves in the departments available for supervision and guidance in Space Science.
For 2020 the main objectives of artistic research and production will be related to satellites held at INPE such as AMAZONIA 1 and CBERS 04A, as well as Smallsats, with the participation of the Visual Arts in the CUBEDESIGN 2020 with the ARTSAT (art-satellites) as one of the categories in the competition. As well as the exhibition of these works in academic institutions, museums and galleries in the city of São José dos Campos, São Paulo, Rio de Janeiro, among other national and international art/science spaces.
The main goals of this project are: 1- Develop the status of Space Culture & Space Art (Art / Science / Technology) in Brazil; 2- Create study groups, seminars, meetings, exhibitions and publications on Space Art/Culture; 3- Participate in the current INPE's projects in the satellite sectors of Space Engineering and Technology, as well as other sectors linked to Astrophysics, Space Geophysics, Applied computing, Meteorology, Remote sensing and Earth System Science; 4- Build and share methods of collaboration between scientific and artistic production; 5- Explore techniques in virtual models such as simulation, augmented reality, virtual reality, artificial intelligence, etc; 6- Organize spaces for access to space research for artists at ETE / INPE facilities; 7- Collaborate for a greater integration of society in INPE's research through scientific dissemination, podcasts, videos, documentaries, meetings, festivals, etc; 8- Create partnerships with others art/science communities of national and international institutes.
Keywords: Space Art, Art Science, Lightning Detection Tubesats, Smallsats, Plasma Bubble, remote sensing, science and society, scientific dissemination.

Pujllay: the first nanosatellite engineering model developed in UNSAM

- IAA-LA2-12-02

Camila Mucanna* / Escuela de Ciencia y Tecnología - Universidad Nacional de San Martín, Instituto Colomb (CONAE-UNSAM)
Tomás I. Burroni, Nicolás V. Conde, Matías I. Escobar, Luis S. López, Matías B. Penida / Escuela de Ciencia y Tecnología - Universidad Nacional de San Martín
Claus M. Rosito / Instituto Colomb (CONAE-UNSAM)
Hernán Socolovsky / Escuela de Ciencia y Tecnología - Universidad Nacional de San Martín, Departamento de Energía Solar - Comisión Nacional de Energía Atómica
*cmucanna@unsam.edu.ar

In the last years, the development of nanosatellites has taken a particular turn in the space industry. The Cubesat Specification developed by CalPoly provided a common ground for the standardization of interfaces and requirements across launch providers, space component suppliers and end customers. Commercial companies exploiting the standard to develop their business, universities with limited budgets successfully proving new mission concepts and strong support by the major space agencies boosted the popularity of the cubesat standard. By adhering to this standard, organizations that would have found the costs and complexity of traditional space projects prohibitive can now develop their own satellites. It has also become a great tool for educational purposes because it drastically reduces the degrees of freedom associated with designing a satellite from scratch while also providing implicit design guidelines, all of these within the scope of space aptness and launcher compliance. This provides an excellent opportunity for students from around the world to develop their own models and learn firsthand about the design of subsystems that make up a nanosatellite.

In this context LIT-INPE, Brazil, hosts a yearly international competition called “CubeDesign”, where student teams from different Latin American universities present their cubesat models which are put to real-life qualification tests in their SJC facilities.

With the 2019 edition of CubeDesign in the horizon, Space Engineering students from UNSAM spent from March to July working on their first CubeSat engineering model. The development was supported by Instituto Colomb and leveraged the collaboration of CNEA, Testa Brava, FAN, ECyT (UNSAM), and CONAE.

The objective of this work is to describe the process of design, construction and testing of the nanosatellite model. The aspects that will be given special emphasis are those concerning how the institutional collaborations became an opportunity of growth for the students involved. As a result, this project became a turning point in their education towards their Space Engineering degrees. In addition, an overview of the technical aspects of the nanosatellite will be described, to explain how the subsystems were designed. The experience turned out to be a significant challenge given that this was the first nanosatellite to be entirely developed in the university. Also, there will be a short but representative summary of the problems that were found during the development and how they were solved in order to comply with the requirements set by the competition, and by the team itself. At last, a roadmap for the full engineering model development and testing is presented.

Innovation in small satellites – recent activities in SSTL - IAA-LA2-12-03

Clive Oates* / SSTL
*C.Oates@sstl.co.uk

Small satellites have come a long way since their early popularity as a means to democratise access to space for much of the world, and support space education and test technology. After more than three decades of smallsat development, SSTL continues to innovate smallsat technology and missions, and increasingly supports commercial businesses to implement their plans. With 23 satellites launched in the past two years, this paper provides an overview of results and lessons learned from those missions, as well as a forward look to missions under development.

In the area of communications, the LEO Phase one satellite for Telesat and Vesta-1 satellite for Honeywell provided two pathfinder spacecraft in support of future broadband and IoT (mega)constellations. The Quantum small GEO satellite platform was also delivered

- VESTA-1 carries an IoT payload in support of the new AIS VDES messaging service, supporting ship-to-ship and ship-to-shore connectivity.
- Leo Phase One carries a Ka-band transponder to support Telesat in demonstrating its planned broadband megaconstellation, as well as claiming the necessary frequency bands. The satellite was used to support a world first 5G connectivity via satellite.
- Quantum is fully software configurable geostationary satellite, allowing it to be deployed on demand in different locations once on orbit

In Earth Observation, the six Formosat-7 spacecraft were developed to support novel operational weather forecasting services. SSTL also launched its first SAR satellite and its fourth commercial high resolution imaging satellite.

- Formosat-7 comprises six satellites in a low inclination orbit carrying Radio Occultation receivers. The constellation allows the satellites to support global measurements of a vertical air column of water vapour, pressure and temperature in a much more accurate way than conventional microwave sounders.
- NovaSAR-1 is a novel Synthetic Aperture Radar satellite operating at S-band, and thus supporting commercially viable applications in forestry, agriculture and Maritime surveillance. The satellite also employs a novel fractional ownership model allowing several operators to task the satellite.

SSTL is also working on several innovative concepts for future missions and mission concepts. It is working on a multi-sensor rapid-revisit constellation, as well as a commercial lunar communications service in support of imminent lunar exploration initiatives by various nations.

Thermo Vacuum Chamber Structure Design for a 1U CubeSat - IAA-LA2-13-01

Esteban Acosta Mellid* / Asunción National University;
Diego H. Stalder; Javier Ferrer; Jorge H. Kurita / Paraguay space Agency, Asunción National University;
*acostamellid@gmail.com

Several tests are conducted before put satellites in space in order to operate satisfactory and fulfill mission goals. One of this is, to test in operational conditions similar to space in a high vacuum and variable thermal environment, so a chamber designed to simulate these environments are required.
Before initiating any construction of this type of vacuum thermal chamber, material specs are necessary to be confirmed. For this proposed design and, considering the working pressure and mechanical stress this chamber is being subjected to, accurate information is important. The proposed design uses a cylinder as the main body. The front and back lids are flat in design with supporting ribs. These ribs improved significantly strength and deformation. This led to cost reduction from material stand point. The final design is intended for 1U CubeSat testing. The selected material is the stainless steel AISI 304L type. These among other type of stainless steels are recommended for this kind of application.
This design guide complies with two different standards. The first one, based on ASME B31.3 for pipes according to 304.1.3. In here, the condition where external pressure is higher than internal pressure is specified. In this particular case, our external pressure is equal to the atmospheric pressure and internal pressure is zero. Therefore, this also refers to ASME section VIII division 1 for boiler and pressure vessel code. Paragraphs UG-28, UG-29 and UG-30 refer to vessels subjected to external pressure and calculation required given its shape, material specs and working temperature. Another design validation process was done using SOLIDWORKS, commercial software, by applying finite element analysis. This computational tool contributed to establish material and external pressure specifications. It included a safety factor of 25% over the atmospheric standard pressure. The internal pressure was set to the worst-case scenario, this is, zero. The difference between vacuum levels from medium to ultra-high vacuum is negligible on the chamber structure stress. The particle density is more sensitive to vacuum levels variation, this is important for degasification of tested parts. Therefore, the achievement of a certain vacuum level will depend on the vacuum pump capacity. This is out of the scope of this paper.
Both validation processes resulted satisfactory. We have verified that the design dimensions, shape and material specs were sufficient for the desired operational conditions. The uses of stiffening rings are encouraged to be considered. This will provide additional structure rigidity.

CanSat Educational Kit - IAA-LA2-13-02

Michelly Dantas Guedes* / Federal Institute of education, science and technology of Rio Grande do Norte
*michelly.guedes2000@gmail.com

With the constant technologies and knowledge advance, it became necessary a deeper and earlier capacitation of the students, for they can keep up with the fast advance of the society we are inserted in. On this preparation, it is very important the school function, presenting and empowering the student to work with technologic innovations.

The present project presents itself as a didactic proposal to insert students in an environment propitious to experimentation, intellectual development and realization of testes. The goal is to teach space science, for naturally the space theme catches young people's interest in science and brings together fundamental principles from countless other areas. The main objective is to teach space technology, more specifically the satellite subarea, to elementary II school students, using the cansat educational kit as a teaching tool and as a teaching strategy the maker method, which is being widely used and enables high rate of knowledge acquisition due to its main characteristic of teaching through the practical experience of what is studied.

In this sense, the cansat educational kit materializes this first contact with the space area and, presenting the subsystems of a satellite, the programming of the kit (with appropriate language to the students' level of knowledge) and the possibility of assembly the stages. Because of the capacity of expansion, the kit still allows the student to evolve it's knowledge from using it's own ideas.

The materialization of the kit occurs through the prototyping and printing of a 3D structure, the manufacture of printed circuit boards (with three-stage grouping), containing the main subsystems of a satellite and a playful manual, which has instructions on how to handling, assembly, programming, and component details.

The kit seeks to present the main subsystems of a satellite through three printed circuit boards, the first being the on board computer, represented by the microcontroller, the second one responsible for the payload which in this case are sensors for measuring atmospheric data and the third one the power supply.

The use of the kit as a didactic tool should provide the teaching of space technologies, besides corroborating the teaching of subjects such as: Science, Technology, Engineering and Mathematics. Making the teaching-learning process more interactive and student participation in the construction of knowledge more active. The cansat educational kit, besides facilitating this process, encourages interest in this area of study and, in this sense, can be a powerful tool in the development of the space area in Brazil, contributing to the creation of new cadres of the Brazilian space program.

Relationship between the mechanical stability of an antenna and the quality of the radio link - IAA-LA2-13-03

Gutierrez Emiliano*, Marco Alvarez Reyna / UFS - CONAE
*Emi.rbmx63@gmail.com

A satellite mission has the purpose of placing in the space a equipment or payload, to carry out activities that cannot be carried out on Earth or there is an interest in carrying them out in space, this mission is typically divided into four segments: Earth Segment, Space Segment, Launch Segment, Application segment.

In turn, the phases of mission development are typically divided into: Conceptual Planning, Requirements Definition, Design, Development, Testing, Commissioning, Operations, Maintenance, Final Provision.

This work is part of a project of the academic laboratories of the UFS (earth station), within the framework of a UTN / FRC degree internship. The radio connection between the earth station and the satellite communication system is vital, of this dependence the exchange of information, both for downloading data collected by the satellite, and for sending telecommands.

The mechanical stability of the antenna with which we receive and send data is a key point to focus on the development of a satellite mission, since with certain vibrations or movements the transmission or reception power falls below the permissible minimum, below This threshold is possible to lose communication or have transfer errors, the above is what will be presented on paper.

In this article we present a theoretical analysis on the flexibility of the antennas due to the wind and the sum of strikes corresponding to the pedestal or clamping rotor. The flexibility in addition to generating deviation at the end of the antenna causes the radiation pattern of the antenna to deform, thus being under conditions not known as regards the radiation spectrum. Total rotor strikes generate a modification in the direction of the antenna, causing a loss in link gain. The aforementioned errors are taken into account in the calculation of the radio link.

In addition to the theoretical analysis, tests were performed in the laboratory regarding loss of reception power due to the controlled deviation in degrees of the antenna.

Bacteriological Mutation Experiment as a Cubesat Mission Payload

- IAA-LA2-13-04

Gustavo Santos* / UFS, CONAE - UTN
Brisa Panichelli / UFS, CONAE - UTN

*gusjavsantos@gmail.com

Since the arrival of the first human to the moon, 50 years ago, we are beginning to live a new era in space exploration, one that puts Mars as the next major objective. Achieving this goal will require the joint effort of people around the world, both to develop new and better technologies and to improve the understanding of the environment to which astronauts will be exposed. The idea behind this work it's to design a cubesat mission payload that could be implemented as a highschool activity to investigate how colonies of a harmless bacteria react to the space environment.

The main objective of this mission is academic, seeking to bring the secondary and university level students to space activity, training them in the study of space and its effect on living beings, the design of space systems and the planning and implementation of projects. The secondary objective is to develop an easy-to-implement experiment to determine the susceptibility of a bacterium to the space environment.

The experiment consists in the study of two samples of harmless bacteria placed in a petri dish with the necessary nutrients and with increasing amounts of antibiotics towards the center. One of the samples will be sent to space, to expose them to the space environment, while the other will remain on the ground as a control. Subsequently, photos will be taken as the colonization progresses, recording the levels of cosmic radiation to which they are exposed. With this information we would measure the colonization time of the bacteria in both scenarios.

The experiment is intended to develop in approximately two weeks once the orbit is reached, if during this time the bacteria suffers a mutation rate different from the control sample on land, this bacterium will be considered susceptible to the space environment. The images obtained in flight, together with the radiation and temperature readings will be used to study the causes of this mutation.

This works involve all the technical and programmatic aspects to design, integrate and operate the proposed payload. This analysis includes, the study of the space environment, a bacteria selection processes, the mission requires analysis (resources, infrastructure, OBS, etc.), experiment conceptual design and it's operational concept, mission scheduling and mission cost and risk analysis.

The CanSat project using Commercial-off-the-shelf components

- IAA-LA2-13-05

Ogata, V. O., Contieri, D. P., Lauro Paulo Da Silva Neto* / Federal University of São Paulo
Piñeros, J. O.M. / National Institute for Space Research
*lauro.paulo@unifesp.br

This paper used commercial-off-the-shelf-COTS components to build a small satellite with a shape and size which resemble a can, known as CanSat. The technologies progress becoming electronics components cheaper allowing advance in different areas of research including space missions, which are known as one of the most expensive types of research. The CanSat started in 1998 from 12 universities from Japan and United States. The Bob Twiggs Professor, from Stanford University, proposed the initial idea of nano-satellites and the first project began in 1999 called ARLISS. The ARLISS project has a volume of order of 350 milliliters and the mass near to 500 grams. Even though it was a new idea, they started to launch more CanSats throughout years this due to the price for launching into the space which was around 400$. The low price attracted many universities in view of the fact that this kind of project carries a concept of a practical opportunity for students take their first steps in space and the challenge to develop a nano-satellite, improving group work and overcoming difficult situations. The results presented in this work are part of the results get in the CubeDesign competition organized by National Institute of Space Research –INPE/Brazil. The competition used similar rules used in others world competitions such as United States, Japan and Europe.

The name of the project is “CanSat” since is the combined name of the “can” and “satellite” words, because of the size and shape of the satellite which resembles a can. The project developed was a mini model satellite that measures pressure, temperature, altitude and send the information obtained through a radio frequency transmitter, the commercial model is NRF2401. The structure has a cylinder shape and was printed using a 3D printer using acrylonitrile butadiene styrene (ABS) as material for printing. The sensor used to measure pressure, temperature and altitude is the commercial BMP280, the pressure data is used to estimate the temperature and altitude parameters. Finally the On-Board Data Handling OBDH subsystem is performed by an Arduino Nano. The main mission of CanSat is sending data (pressure, temperature and altitude) from flight to a ground station composed by a computer and a radio receiver module. The landing subsystem is equipped with a parachute activated by a servo motor.

Implementation Of A Ground Station For A Cubesat Nano Satellite

- IAA-LA2-13-06

María Edith Siñanez Vásquez* / FCEFyN - UNC
Marco Alvarez Reyna / UFS - CONAE,
*mvasquez@unc.edu.ar

The proposal of this project is the implementation of a communication system based on Software Defined Radio technology using the available peripherals in the academic laboratories belonging to the CONAE's superior training unit (CONAE - UFS, Comisión Nacional de Actividades Espaciales - Unidad de Formaci´on Superior) for the data reception coming from a Cubesat nanosatellite within the framework of my final degree integration project.

First of all, an investigation of the technology is carried out in order to provide an overview of its fundamentals and its scope relating to the communications environment. The research of this technology basics must include exploring its principles and the physical components that are involved too.

Once the point of the technology has been understood and the components that put it in practice has been identified, these will be deeply studied to give us the necessary support to all the laboratory tests including the previous work called "BPSK Demodulator for CUBESAT
platforms using USRP and GNU Radio" in which we will rely on for our particular purpose in this project generalizing the mathematical model implementation of a Ground Station for a CubeSat strongly based on those previous experiments. Afterwards, an investigation of the software tool known as GNU Radio Companion is completed done. This tool will be used to
design the entire communication system for the whole proposing.

Finally, with all the knowledge acquired and the results from the last communication experiments made, a full communication system based on Software Defined Radio will be deployed over the next few months. As we know, the idea of this kind of system is to transfer functions that had previously fallen into the hardware to be able to perform them through the software, bringing the processed software closer to the antenna and trying to get rid of analog electronics (except for converters and antennas). So, following this way we will be able to solve problems that emerge from non-ideal behaviors in mixers, filters and amplifiers minimizing the distortion introduced in the received signal and eventually we will be able to perform the conceptual, detailed design, assembly, integration and test of a system for receiving data from the Cubesat. Thus, it would be a future proposal that has a six weeks ago studies and hard work developed to make the basis which would merge all this experience to build the entire satellite ground station integrating not only the data reception, but also the transmission.

As a conclusion we can say that SDR technology and previous laboratory tests, specially the BPSK Demodulator mentioned before we based on, will help us to reach the main target of the project about an SDR-based system that consists in the implementation of a computer, an embedded system, digital analog converters and radio frequency modules using the GNU
Radio Companion software in a near future. Furthermore, there is a significant approach to make use of languages like Python and C++ to become independent of GNU Radio software, achieving the implementation of modules with these languages and the UHD driver use directly related. In fact, the reason to consider this as an important contribution is because we can make our communication system looks more like a functional operating system in which we would be able to develop software that would allow us to automate and program our own modules and use GNU Radio just in case we need it as a backup tool for fast prototyping and experimentation details. In addition, we have to say that we can present the proposal itself and the advances of the whole project or at least the phase we are in.

Keywords— Software Defined Radio, antennas, circuits, Very High Frequency, Universal Radio Peripheral (USRP), GNU Radio companion, UHD.

Multiobjective optimization methodology applied to a satellite system conceptual design - IAA-LA2-13-07

Gustavo J. Santos*, Roberto Alonso, Marco Alvarez Reyna / UFS, CONAE - UTN
Sebastian M. Giusti / CONICET, UTN
*gusjavsantos@gmail.com

The most important and crucial decisions within the life cycle of a space mission are made during the conceptual design phase. At this stage, it is ideal to incorporate all the available solutions that could allow to obtain the best mission performance with the lowest possible resource consumption.
The objective of this work is to develop a methodology for conceptual design of satellite systems where optimization techniques of multiple objectives normally opposed to each other (performance, mass, costs, etc.) are applied, looking for the topology that best suits the needs of the designer. To achieve the proposed objective, we will work on satellite modeling as a concept as well as in the study of different types of optimization algorithms and their implementation.
The modeling of the satellite system will consist of the definition of the system architecture, specifying in each subsystem its inputs, outputs and its transfer functions. It will also be necessary to define the design variables (satellite components that we seek to select), the objective functions that we want to minimize or maximize and the requirements at the system and subsystem level that will result from the definition of the mission and its payload.
The relationship between the different subsystems and their impact on others when they are designed will be analyzed using a structural design matrix (SDM). This matrix allows to analyze graphically and intuitively the input and output variables that are shared between the different subsystems and can determine quite easily which of them can be defined independently. Meanwhile, the definition of the type of mission and payload will be carried out considering the past, current and future missions of the Argentine space agency from which the highest level requirements will arise.
The study of optimization algorithms focuses on the comparison of evolutionary algorithms versus numerical simulation techniques. Also, the way to apply these algorithms will be evaluated, which can be both AAO (all-at-once) and collaborative.
This work is expected to develop a tool for selecting components that allow the satellite system as a whole to optimally fulfill different objective functions and taking into account the proposed restrictions on the system.

Dynamic modeling of a CubeSat with three reaction wheels - IAA-LA2-13-08

Pablo Raúl Yanyachi* / IAAPP-UNSA
H. Mamani / IAAPP-UNSA
*raulpab@unsa.edu.pe

This article presents the analysis of the physical behavior of the stabilized cubesat with three reaction wheels in a space with microgravity, physical behavior of the outer space. Among the physical principles considered are: the exchange of angular momentum between the reaction wheels and the cubesat, the moment of inertia of the reaction wheels, the center of mass of the cubesat and the chorioolysis effect of the distribution of the wheels of reaction inside the cubesat. The equations of motion are found by the Euler-Lagrange method. Subsequently, the physical behavior of the system is simulated by analyzing the angular displacement of the roll, pitch and yaw angles with respect to an inertial reference system, due to the angular momentum generated by the three reaction wheels located orthogonally to each other. For the simulation, the measured physical parameters of a prototype on a cubesat scale are used. The result of this work will be used for further research in the development of attitude control algorithms.

A beam line to simulate space environment at TANDAR ion accelerator

- IAA-LA2-13-09

María Luján Ibarra, J. García, M. Alurralde* / Departamento Energía Solar, CAC, CNEA, Avda. Gral. Paz 1499 (1650), Prov. de Buenos Aires, Argentina; UNSAM, Campus Miguelete, 25 de mayo y Francia, Prov. de Buenos Aires, Argentina

M. Barrera / Departamento Energía Solar, CAC, CNEA, Avda. Gral. Paz 1499 (1650), Prov. de Buenos Aires, Argentina; Instituto de Nanociencia y Nanotecnología (INN), Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Av. Gral. Paz 1499 (1650), Prov. de Buenos Aires, Argentina

I. Prario / Departamento Energía Solar, CAC, CNEA, Avda. Gral. Paz 1499 (1650), Prov. de Buenos Aires, Argentina; Now: DIIV-UNIDEF(MinDef/CONICET), Laprida 555, Vte. Lopez, Prov. de Buenos Aires, Argentina

*ibarra@tandar.cnea.gov.ar

Environmental space is extremely hostile for satellites, due to high vacuum, temperature cycling, and the presence of energetically particles. This factors can affect the performance of electronic components, reducing their in orbit lifetime. The main effects of the radiation in modern electronic components are TID (Total Ionizing Dose) caused by electron and protons of the radiation belts as well, SEE (Single Event Effects) due to cosmic rays and heavy ions solar flares, and TNID (Total Non Ionizing Dose) which is cumulative effects as TID induced by proton from Van Allen belts and solar flames.

With the aim of studied the behavior of materials and electronic devices under space environmental, a facility called EDRA (Ensayos de Daño por Radiación y Ambiente/Test of Radiation and Environmental Damage) was developed at the DES (Departamento Energía Solar/Solar Energy Department). The versatility of the irradiation facility allows us to performed qualification tests on devices, such as thermo-vacuum, thermocycling and radiation damage tests, at the 20MV Tandar Van der Graff accelerator.

At the end of the beam line, a cylindrical vacuum chamber (68 cm inner diameter) was constructed in order to test several type of devices under space-like environmental conditions.

Irradiation with different ion spectra can be performed to study the TID and TNID effects to guarantee a correct behavior of the devices under test in an ionising environment that emulates the radiation environment at space. The SEE can also be studied using a tantalum filter system to reduce the number of particle/cm2 s. A 37 Faraday Cups(FCs) array was developed to characterize and monitor high intensity beams allowing to perform multiple experiments with different particles, energies and current intensities. In cases of SEE experiments, very low intensity beams are used (below the FC sensitivity), for these studies silicon PIN photodiode detectors are employed, with conventional pulse counting electronic. Furthermore, the vacuum chamber has three flanges available for electrical connections, using DB25 and BNC connectors for in-situ measuring during experiments.

The thermo-vacuum and thermocycled experiments can be performed with a stabilized temperature sample holder connected to a liquid-nitrogen feedthrough that allows us to generate arbitrary temperature ramps from -150oC to 250oC and vacuum level of 10-6 mbar are obtained with a turbomolecular pump.

MOCHI, a Hitchhiker optical instrument for satellites - IAA-LA2-13-10

Patricio Fluxá* / CONAE - Instituto Colomb
Camila Mucanna, Norval Chenu / Escuela de ciencia y Tecnología, UNSAM - Instituto Colomb
Luís López, Tomás Burroni, Nicolás Conde, Matías Escobar, Diego Aranda / Escuela de ciencia y Tecnología, UNSAM
*pfluxa@unsam.edu.ar

This paper describes a proposal for a modular optical instrument to be built by students of Universidad Nacional de San Martín, to be mounted in any platform built by others as a cooperative project. MOCHI stands for Modular – Optical – Cooperative – Harmless - Instrument, and the objective is to develop an optical instrument to be compatible with different platforms, as much as possible, designed and built by any other University, Space Agency, Private Company, or group in the world. The main purpose for this project is educational in the area of space technologies related to optical instruments and to establish cooperations with other universities, agencies or private companies.

MOCHI is meant to be a series of optical instruments with the possibility of changing the optical module to be adapted to different areas of optical observation and educate consequently in a hands-on way. The instrument will be designed with a modular architecture that covers the optical module, a computational module, a storage module, a transmission and reception module, a thermal control module, and a power module with its own batteries.

MOCHI instruments will also have clear and documented interfaces between its own modules so the modules will be suitable of being non-implemented in the instrument, in the case that the platform can provide the services that each module is designed to provide. The baseline for the design is an instrument with 1U size, less than 1Kg of weight, less than 1W of power consumption from the platform, interchangeable optical module, and adaptable transmission and reception module in order to have Earth-Instrument communications independent of the platform.

Since there are several restrictions (electronic interface, mechanical interface, software interface, etc) in terms of compatibility when groups discuss cooperation in instrument- platform terms, this approach is intended to minimize the interfaces between the platform and the instrument. The electronic interface for MOCHI can be as simple as 5V / 1W power interface from the platform devoted to charge instrument´s own batteries and an on-off switch interface to be handled by the platform. The communication module of the instrument is envisioned to work with the already working ground station at Migueletes Campus owned by UNSAM.

The mechanical interface of the instrument will be a standard mechanical for cubesat but, in the case of a different interface, customized mechanical interfaces can be provided using adapters.

Concept, design and implementation of a 1U cubesat structure - IAA-LA2-13-11

Nicolas V. Conde*, **Tomás I. Burroni** , **Matías I. Escobar**, **Luis S. López**, **Matías B. Penida** / Escuela de ciencia y Tecnología, UNSAM
Camila Mucanna / Escuela de ciencia y Tecnología, UNSAM - Instituto Colomb
*nicolasvconde@gmail.com

On the occasion of the participation in the CubeDesign 2019 international competition, UNSAM Space Engineering students developed their first cubesat engineering model fully conceived by undergraduates following the international standards that regulate its manufacturing [1]. This work aims to describe the concept, design and implementation process carried out, as well as, all the learning that needed to be acquired for the development of the structure subsystem for the nanosatellite, being the first of its kind for the career of Space Engineering at this university.
The main focus of this paper will be on the tools and skills applied inherent to a systems engineering practice, and that were especially used to improve the mechanical performance of the structure. The consideration of the mass and costs budgets were of particular importance as they reflected the limits regarding resource availability, and the same for the tasks management and breakdown in relation to the short time of work on which the team counted with. As guidance, the ESA standards were considered for the definition of mechanical requirements and joint design, which resulted in a key point for the subsystem's robustness.
In respect of the concept and design, the theoretical basis applied and that was needed to incorporate will be discussed, such as theory and analysis of structures, simulations, safety margins criteria, among others. Also, the experience required the acquisition of some knowledge on manufacturing processes in accordance with the selected design and materials, as well as information on the advantages and disadvantages of each technique, costs, times, feasibility, and others. This was especially problematic considering the limited access to materials and resources in Argentina, that ended conditioning the final design, as this was a development in which we did not count with previous experience or heritage from university projects in the country.
In the section on implementation, the manufacturing process is addressed, including the importance of increasing the reliability of the system through the use of a mock-up. In addition, the results of the tests in both cases are examined: the tests carried out locally, as well as the tests to which it was subject to during the competition.
As a conclusion, the lessons learned and all the areas where possible improvements and optimizations where identified are detailed. This lays the baseline for the next iteration of the design, which shall be used for the newer, more advanced CubeSat, now under development.
All things considered, the experience is concluded to have been satisfactory given that all the requirements set, both by the regulations imposed by international standards, and those derived from the system engineering department regarding the mission were successfully met.

Reference:
[1] CubeSat Design Specification Rev. 13 - The CubeSat Program, Cal Poly SLO.

PocketQube SatDuino: First Pico Satellite and Development by Technical Schools of Argentina - IAA-LA2-13-12

Alejandro Cordero* / Escuela de Educación Secundaria Técnica de Mar del Plata
*acordero@innova-control.com

We present the design and assembly of a "SatDuino" PocketQube with the students of the technical schools of Buenos Aires Argentina. The modules that constitute the platform were designed and assembled completely by the students of our schools in Buenos Aires. They include an electric power subsystem (EPS), an on-board computer (OBC) with the communication subsystem (COMMS) and a payload (humidity sensor, temperature, barometric pressure, pollution).
The objective is creating the first PicoSatelite Argentine, totally made by students of state technical school, further develop it, with low cost and high impact technologies.
With this we will achieve, introduce to aerospace technologies and encourage work focused on STEAM, achieve interdisciplinary work to ensure contextualized and meaningful learning.
We stimulate the use develop digital knowledge and encourage computational thinking.
The idea is from next year, launch of the National "EduAR-Sat" program, which will develop the KIT implementation of PicoSatellites and CanSat, for the country's middle secondary schools.
We will work with Dashboard created through IBM Watson, IBM Cloud. We will analyze this data, use Machine Learning and AI to obtain predictions about weather conditions, in this case.
As conclusion, this will be the first Argentine and South American PocketQube made by students of technical schools. We have a great challenge ahead of us in the coming months, to obtain financing to finish the launch of the prototype in the stratosphere. In addition, we will create in parallel the first educational platform in Argentina for the development of aerospace technologies at the STEM secondary level to develop future scientists and engineers.

Photogrammetry - IAA-LA2-13-13

Pedro Riva* / VENG
*priva@veng.com.ar

Using photogrammetry technique, high performances 3D measurements are made in several industries fields, space industry is one of them. In the laboratory, VENG S.A. has the ability to make this measurements. During the development of SAR antenna of SAOCOM 1A and 1B, this ability were used to:
Centre of gravity measurements of structural panels.
Mechanical alignment between structural panels.
3D Characterization of service platforms and structural panels.
Planar measurement of 32 m2.
SAR antenna with 40000 points cloud.
Centre of gravity measurement of the X-band antenna (subassembly level).

The objective of this paper is to present, the measurement method applied to determine the centre of gravity of SAR antenna components, the main instrument of the SAOCOM 1A and 1B satellites of CONAE.

Thermal control coatings - IAA-LA2-13-14

Pedro Riva / VENG
*priva@veng.com.ar

Thermal control coatings, as components of passive thermal control, have a very important role in the design and engineering of satellites and their subsystems. In this context, the Integration and Testing Laboratory of the Teófilo Tabanera Space Center in Córdoba, has developed a specific laboratory to carry out this type of process, the Space Coatings Laboratory (LaRES for its acronym in Spanish).
This facility has three individual environments, connected to each other, each of them with particular work and environmental control characteristics, such as a process and materials preparation room, with ISO 8 air quality and temperature and relative humidity control; a curing room with ISO 8 air quality and the ability to set the temperature and relative humidity over a wide range according to the process requirements; and a paint booth with laminar flow air injection and a suction front designed ad hoc. A series of thermal and thermal vacuum chambers are added to this laboratory, located in an near facility, which allow to adapt the pieces to the coating process by drying or bakeout. This type of conditioning is normally required for parts made of composite materials.
The previous facilities are complemented by a technical staff specialized in this type of works with high level of customization and development associated with each piece.
Each process is designed and qualified according to the characteristics of the hardware. However, the acceptance of the product requires compliance with certain coating parameters such as adhesion, electrical conductivity, thickness and thermo optical properties. LaRES has the necessary instruments to comply with these controls, among them a coating thickness gauge by eddy currents and a total emittance/solar absorptance portable reflectometer.
LaRES has participated in the production of different components of the SAR Antenna, the main instrument of the SAOCOM 1A and 1B satellites of CONAE. The technical experience acquired in this project enhances the capacities of the laboratory and positions it as a reference for the development of these processes.

Thermal vacuum test design for testing satellites electronic boxes

IAA-LA2-13P-15

Castello Nahuel M. / Comisión Nacional de Actividades Espaciales (CONAE), Escuela de Ciencia y Tecnología - Universidad Nacional de San Martín, UTN

The two SAOCOM satellites are part of the Argentine and Italian Emergency Management System, SIASGE. The SIASGE constellation is made up of four Italian satellites, Cosmo Skymed, and two Argentinian Space Agency satellites, SAOCOM 1A and 1B. The SAOCOM satellite payload is a synthetic aperture radar (SAR antenna). The systems under study are the front end electronics of the SAOCOM SAR antenna, the Control Transmission and Reception Units (CTR). The SAR antenna front end electronic is made up of twenty-eight CTR units for each SAOCOM satellite, fifty-six in total for both SAOCOM satellites.

As part of the environmental qualification of the satellites electronic units, they have to be tested in a thermal vacuum cycling test. This test can be performed in a thermal vacuum chamber with different types of heating systems (halogen lamps, Xenon high-pressure lamps, infrared lamps, hot gaseous nitrogen). Depending on these heating systems the thermal vacuum qualification of the electronic units could experience some limitations, as the thermal balance test, the thermal vacuum cycling control, and thermal stabilization criteria. These limitations are especially important in the cases on which it is necessary to perform the thermal vacuum qualification of may units, as the SAOCOM case, on which fifty-six CTR units needed to be tested in thermal vacuum.

The complete paper will be detail the study and design of the thermal setup oriented to solve the problems of the thermal vacuum chambers with halogen lamps heating system in order to reach a correct thermal balance test and thermal stabilization and control of the device under test.

A brief description of the test setup and the Thermal Mathematical Model (TMM) as the test prediction simulation performed in Thermal Desktop and its correlation with the test results will be presented in this work.

CONTACT

Nahuel M. Castello, Senior Thermal System Engineer, Argentine Space Agency (CONAE),
ncastello@conae.gov.ar

NOMENCLATURE, ACRONYMS, ABBREVIATIONS

CONAE National Commission of Space Activities (Argentinian Space Agency)
SAR Synthetic Aperture Radar
TMM Thermal Mathematical Model
CTR SAR Control Transmission and Reception Unit
UNSAM National University of San Martin
UTN National Technological University