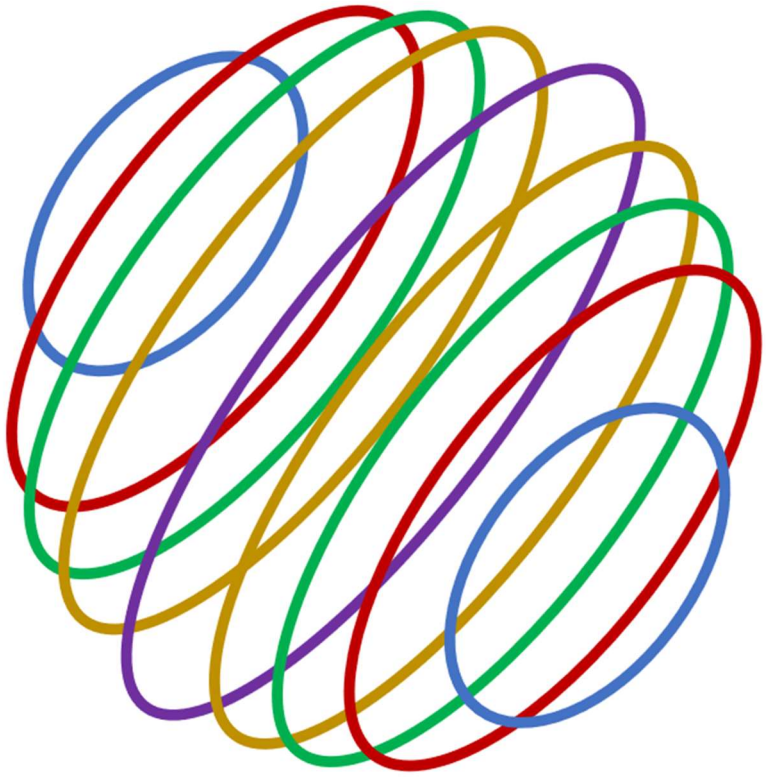
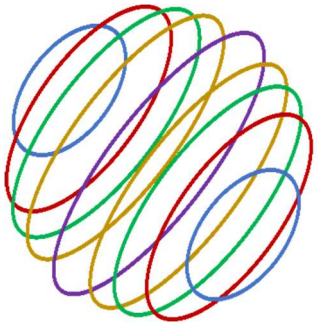
V SMALL SATELLITES & SERVICES INTERNATIONAL FORUM

SSSIF2024. FEBRUARY 20-22. MÁLAGA. SPAIN

BOOK OF ABSTRACTS



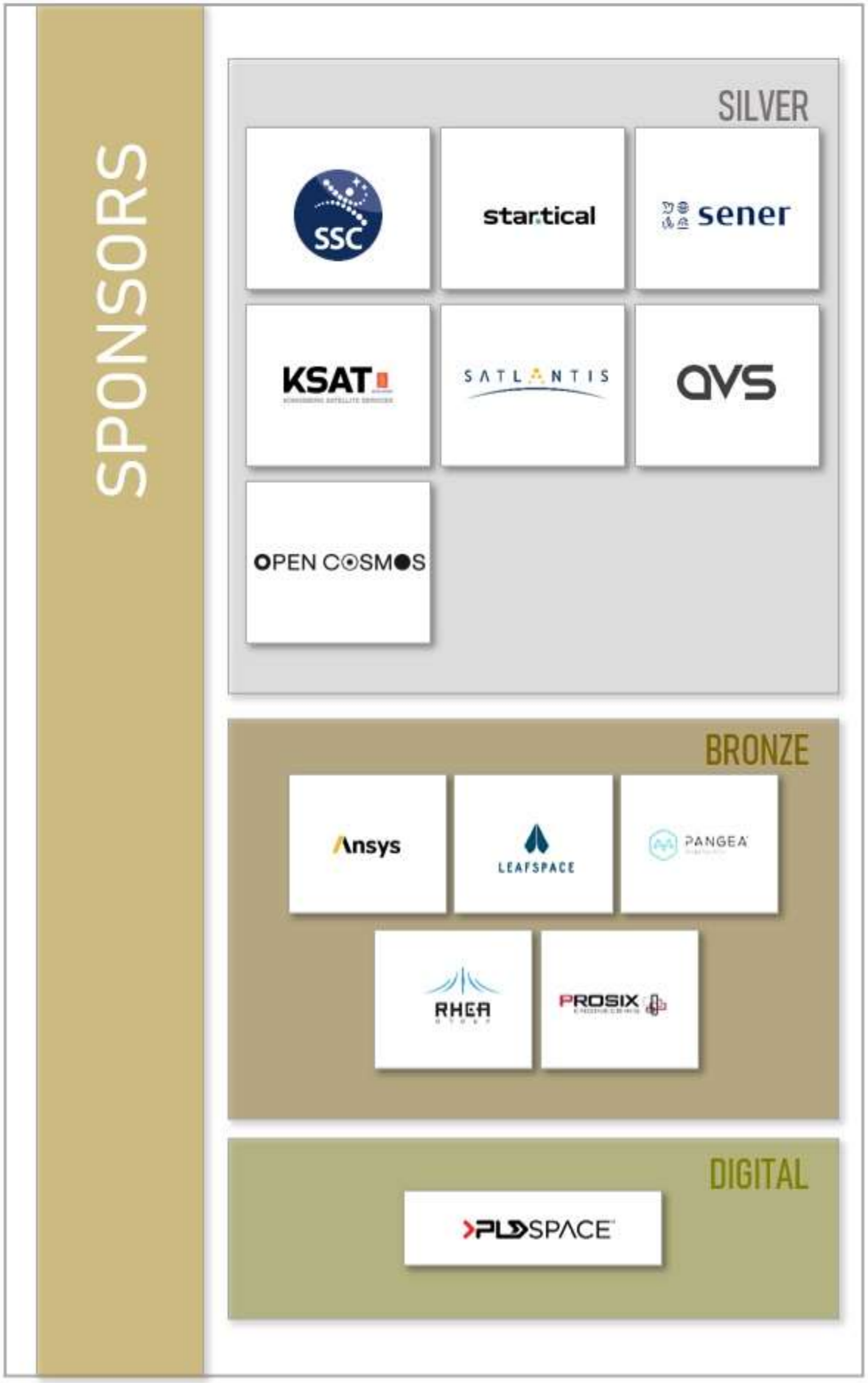


SMALL
SATELLITES
& SERVICES
INTERNATIONAL
FORUM

5th edition of Small Satellites & Services International Forum
SSSIF2024. February 20-22. Málaga. Spain

This abstract volume has been produced using author-supplied copy with no edition and gathers all abstracts accepted for presentation at the forum. All abstracts were reviewed by members of the Technological & Scientific Committee for rating of quality and presentation content.
SSSIF would like to thank all authors for their contribution to this new edition. Also add a special mention to both forum committees for their work and commitment.


SPONSORS
PLATINUM
gmv
INNOVATING SOLUTIONS
AIRBUS
GOLD
TELESPAZIO
a LEONARDO and THALES company
tecnobit
Fondos Europeos
Andalucía
TRADE
indra


SPONSORS
SILVER
SSC
startical
sener
KSAT
SATLANTIS
QVS
OPEN COSMOS
BRONZE
Ansys
LEAFSPACE
PANGEA
RHEA
PROSIX
DIGITAL
PLDSPACE

ORGANIZING committee

AGUADO, FERNANDO	PROFESSOR UNIVERSITY OF VIGO
DIAZ, EFREN	LAWYER BUFETE MAS Y CALVET
DIAZ, VICENTE	MANAGING DIRECTOR & CO-FOUNDER DHV TECHNOLOGY
HALLAK, YANINA	CEO UARX SPACE
HARILLO, RAFAEL	DIRECTOR STARDUST CONSULTING
JORDA, RAFAEL	CEO OPEN COSMOS
NODAR, DIEGO	CO-FOUNDER ALEN SPACE
MASSIMIANI, MARTA	SALES & BUSINESS DEVELOPMENT MANAGER SATLANTIS
PUIG-SUARI, JORDI	PROF. HEAD POLYSAT & CUBESAT PROGRAMS CALIFORNIA POLYTECHNIC STATE UNIV.
ROLDÁN, ANDRÉS	PROFESSOR UNIVERSITY OF GRANADA
SALAS, MIGUEL	ASSISTANT PROFESSOR POLYTECHNIC UNIVERSITY OF MADRID
TORRES, RAUL	CEO PLD SPACE
VAZQUEZ, MIGUEL A	MANAGING DIRECTOR & CO-FOUNDER DHV TECHNOLOGY
VILLAVER, EVA	OFFICE OF SPACE AND SOCIETY DIRECTOR SPANISH SPACE AGENCY, AEE

TECHNOLOGICAL & SCIENTIFIC committee

AGUADO, FERNANDO	PROFESSOR UNIVERSITY OF VIGO
CUBAS, JAVIER	ASSISTANT PROFESSOR POLYTECHNIC UNIVERSITY OF MADRID
DIAZ, VICENTE	MANAGING DIRECTOR & CO-FOUNDER DHV TECHNOLOGY
GARCIA, CARLOS	DIRECTORATE OF SPACE, LARGE FACILITIES & DUAL PROGRAMMES CDTI
GARRIDO, JORGE	ASSIST. PROF. REAL-TIME SYSTEMS RESEARCH POLYTECHNIC UNIVERSITY OF MADRID
GOMEZ, JOSE M.	PROFESSOR UNIVERSITY OF BARCELONA
GRAZIANI, FILIPPO	PROFESSOR OF ASTRODYNAMICS GAUSS SRL PRESIDENT
KENNEDY, STANLEY	CO-FOUNDER OF OTMV HOLDINGS
MARTINEZ, ANDRES	PROGRAM EXEC. SMALL SPACECRAFTS & ROBOTIC PRECURSORS. NASA ESDMD NASA HQ
PINDADO, SANTIAGO	PROF. ETSI AERONAUTICS & SPACE POLYTECHNIC UNIVERSITY OF MADRID
PUIG-SUARI, JORDI	PROF. HEAD OF POLYSAT & CUBESAT PROGRAMS CALIFORNIA POLYTECHNIC STATE UNIV.
ROIBAS, ELENA	ASSIST. PROF. ETSI AERONAUTICS & SPACE POLYTECHNIC UNIVERSITY OF MADRID
ROLDAN, ANDRES	PROFESSOR UNIVERSITY OF GRANADA
SALAS, MIGUEL	ASSISTANT PROFESSOR POLYTECHNIC UNIVERSITY OF MADRID
VAZQUEZ, MIGUEL A.	MANAGING DIRECTOR & CO-FOUNDER DHV TECHNOLOGY
VILLA, ANDRES	CTO UARX SPACE
ZAMORANO, JUAN	ASSISTANT PROFESSOR POLYTECHNIC UNIVERSITY OF MADRID

ABSTRACTS

P01

AIR TRAFFIC SERVICES FROM SPACE

Juan José Cornejo Fernández

STARTICAL (SPAIN)

ABSTRACT

Startical is a space company that will provide satellite-based air traffic management. Startical will launch more than 200 LEO satellites to provide VHF communications and ADS-B surveillance in the incoming years, this constellation will be renewed every 5 years. In this presentation we'll have the opportunity to explore in detail such an exciting project and the possibilities for the industry.

P02

10 PRINCIPLES IN THE EARTH OBSERVATION COMPETITIVE RACE

Juan Tomas Hernani

SATLANTIS (SPAIN)

ABSTRACT

THE CONTEXT

While the Telecoms space business has suffered a large disruption caused by the LEO super constellations, the EO business has behaved differently, also propelled by the offer, but with less customers response that consolidate the market efforts and challenges.

A. Only 10 years ago, the price for a space image made it a luxurious good not accessible by most customers and restricted to Defense applications. This context mobilized national projects like Ingenio, a 300 million program devoted to a satellite offering 10m multispectral resolution (which was finally destroyed in its launch in 2021).
B. The Copernicus program from the European Commission and ESA, whose first satellite started operations in 2013, started to deliver free data to the world and to all users. This paradigm brought a revolution that created a brand-new downstream services market, and of course it modified the strategy from the offer.
C. The international market has been led by Digital Globe, now Maxar after a not very successful vertical integration, with a very mature service in the very high and multispectral resolution, through its Worldview satellites, with strong control of the US government over critical areas.
D. In 2021 the boom of the US stock market, through the SPACS vehicle, closed a number of operations in the EO segment, devoted to considerably new companies. The valuations of those companies superseded de 1 billion valuation in most cases, and the cash injection was substantial, from 100 to 300 million. These were the cases of Planet, Satellogic, Blacksky as the main examples. These operations were sustained by aggressive growth business cases, in many cases starting from zero.
E. Those models responded to the company need of a fast growth by an available flying infrastructure of hundreds of satellites, and to the fact that the market was the entire planet. Such capex investments including the open expansion to cover worldwide demand have swallowed most of the generous funds that were captured by the SPACS and have also created a market expectation where smaller activities look insignificant.
F. Laterally, the Starlink and Kuiper operations of thousands of satellites, with a different financing mechanism coming from deep pockets, have changed the priorities of several players. For instance, Greece has moved its recovery funds constellation from telecom to EO. Spain and Portugal have also specified EO as their priority. And vendors who produce platforms for various applications are today focused into EO, avoiding a LEO telecom market that is taken by these players. Only the Iris_2 constellation from the European Commission can be the exception to this monopoly.

THE PRINCIPLES:

These elements have provided the elements to understand today´s competitive context. It is still characterized by the following principles:

1. Downstream and Upstream are still very different sectors, with very different accounts in terms of capex, productivity, return on investment and customers.

2. When mixing both sectors in a single model, most attempts have failed, not proving the capacity to return large constellation investments by service sales. The sole exception is those cases where an anchor governmental customer provides the business breakeven, as it has ever been the case of Maxar.

3. Therefore, existing EO satellites, large and small, fly over the planet searching for data with an unknown customer, since the flight has not been generally booked by the customer. The single point of connection is a server that stores this information, with the expectation of it being accessed later.

4. Attempts to provide subscription models have not scaled up the business, despite the fact they have eased the customer access, simpler and cheaper. In this context, the total accessed data does not represent more than 4% of the captured one.

5. But Newspace is challenged by this paradigm for a number of reasons:

- Actual lifetime is less than half of traditional satellites, and therefore the window of opportunity is far more critical to be exploited.

- Actual operation time per orbit is small due to platform restrictions (xband, power), and therefore the decision as to where to look and how to use these minutes per orbit, is needed.

- Technology evolution is trepidant. Therefore, the idea of multiplying N satellites with the same technology is facing obsolescence and can only survive if this impact is already booked by a customer.

- Cots technology is implemented in the most demanding domain, particularly optics, where size is critical for quality. Many times, cubesats are configured not taking into account operational restrictions of thermal high stability, micro vibrations, maneuver stabilization, etc.

6. Technology hype has been dominating the specifications in many missions. For instance, 8 bands is better than 4, hyperspectral is better than multispectral, AI on board etc. While it is true that these technologies have a role to play, the key and basic needs for multispectrality get diminished in this inflation of specs.

7. Satisfied users tend to be demonstrator projects, and few are related to customer solving problems like border surveillance, methane detection, disease control etc.

8. Clearly New Space is not offering the market growth that can revolutionize the sector, since it is still behaving with the inertia of the past market framework, with very few exceptions that are customer focused.

9. The stairs for growth therefore demand anchor customers, ready to play the role, and an organized industry that can blend the various competences into organized missions that are proficient. In particular, governments should express the public service need and sustain this market in environment, agriculture, defense or transport. Rather than financing

technology push, they should mature their own organizations, making a sort of Copernicus-inside policy to leverage those needs. In the end it is not that different from the US model with Maxar and now with Planet and Backsky to some extent.

10. Spain has an unveiled ecosystem of New Space companies, with proficient specialization, that can successfully compete against vertical models of companies that loose focus and competitivity in key components. This ecosystem can provide international competitive solutions.

CONCLUSION:

Today´s EO sector is the consequence of impacting events, from Copernicus to Spacs, to the fact that the public funding has been dominating this industry behavior in Europe. Spain faces the future with an industry that is showing its ability to get organized in competitive ecosystems. The glue for the next competitive industrial generation is a public sector that will work as an anchor tenant, defining and sustaining the key elements of the public service that should be satisfied through space solutions.

¬*From recent declarations from main players have stated that the EO business, estimated around 5 billion USD, is not growing as planned.

P03 – POSTER DISPLAY

DEEP SPACE 6U CUBESAT COTS PCDU DESIGN

Pablo Casado, Cristian Torres, José M. Blanes, Ausias Garrigós, David Marroquí, José A. Carrasco

INDUSTRIAL ELECTRONIC GROUP_UNIVERSITY MIGUEL HERNÁNDEZ OF ELCHE (SPAIN)

ABSTRACT

In this work the design of a 6U Cubesat Power Conditioning and Distribution Unit (PCDU) intended for deep space missions is presented. The PCDU design follows the "New Space" philosophy, maintaining a reasonable budget and a rapid development cycle, by using only Commercial of the Shelf (COTS) components. Considering that in this type of mission extreme temperatures and high space radiation doses are expected, a thorough selection of the components has been done following the "Careful COTS approach", selecting only extended temperature grade automotive components, besides protections and redundancy for critical functions are implemented.

The PCDU is based on an unregulated bus and is composed of the following modules: A Solar Array Regulator (SAR) with fully independent Maximum Power Point Trackers (MPPTs) for each solar array section; Battery Management System (BMS) with active cell balancing; Supercapacitors Management System (SMS); Super Capacitor Converter (SCC), Protection and Distribution Unit (PDU) with 5V, 3.3V and unregulated voltage outputs; Battery and a Supercapacitors Bank (SC).

On the other hand, different commercial Li-Ion batteries cells, format 18650, have been intensively tested under low temperature operating conditions. The use of cell balancing circuits and to avoid high current pulses have been identified as key elements to extend battery life and provide a protection by preventing the damage to battery cell. An active cell balancing method, based on individual flyback converters, is proposed to overcome this issue. Besides the use of a Hybrid Energy Storage System (HESS), consisting of rechargeable Li-Ion batteries and supercapacitor cells, offers benefits with respect to high current capability at lower temperatures, along with greater cycle life.

This work is supported by the European Union NextGenerationEU and the Generalitat Valenciana under grant ASFAE/2022/21.

Keywords: Cubesat, Power, Batteries, Deep Space, Low temperature

P04

EXTENSIBLE HOOK SYSTEM FOR A SWARM OF CUBESATS

Carlos J. Pérez-del-Pulgar, Jesús Juli Fernández, Levin Gerdes.

UNIVERSIDAD DE MALAGA (SPAIN)

ABSTRACT

The use of a swarm of cubesats sometimes requires them to be interconnected to create a unique structure that could be controlled efficiently, allowing them to perform communication and/or energy transfer if needed. For this purpose, the presented concept is an extensible system based on a scissor boom that would enable connecting different cubesats. This concept has been previously proposed to be used for different applications in CubeSats. One example is the use of a scissor boom to extend 13 cm away from the cubesat a set of sensors, with the objective of avoiding cubesat electronics interferences with the sensors. Another application was related to the use of this structure to deploy solar array systems.

The proposed extensible hook system will be based on a scissor boom structure with different Degree of Freedoms (DoF) according to the mission requirements and cubesat structure. Figure 1 shows an initial design of the proposed system. It has been chosen due to its mechanical simplicity, and the capacity of being extended more distance than other structures, such as simple manipulators, etc. However, it is pending of analyzing lateral stability according to the used materials for this particular application. It could be used to connect a swarm of cubesats. Installing four hook systems on each cubesat, they could be connected creating a mesh of interconnected cubesats, which together could be reorientated to point to a particular area on Earth by planning the motion as a whole structure in space, taking into account the hook system DoF to perform the motion.

Keywords: Cubesat, Docking, Robotics

P05

REGULATION APPLICABLE TO THE OBJECT, PURPOSES AND COMPETENCES OF THE SPANISH SPACE AGENCY

Efrén Díaz

BUFETE MAS Y CALVET (SPAIN)

ABSTRACT

This analysis of the object, general and specific purposes and competences of the new Spanish Space Agency (AEE) stresses the importance of knowing the current national, EU and international regulations in force in Spain, in order to promote better compliance and the deployment of competences in space matters.

The interest of this analysis lies in offering a detailed overview of the Spanish regulations in force in relation to the object, purposes and competences of the AEE, from the practical viewpoint of the practice of law, and for the purpose of providing legal advice to space companies and entities and defending the legitimate interests of various actors in the space industry in and from Spain. The regulatory scope analysed in this work could help the Spanish Space Agency to give greater legislative impetus in the field of its competences, to build on existing regulations in other areas with an impact on space, and to define, harmonise and develop space regulations in Spain that include the administrative, substantive and procedural aspects currently required by space activity and the space industry.

The purpose of this regulatory analysis, systematised on the basis of the purpose of the AEE and its general and specific purposes, within its particular framework of competence, is to identify the regulations existing at the time of the creation of the AEE, in order to delimit the current regulatory framework of the current legislation with a direct impact on the space sector and to provide a starting point for the Legislator and those responsible for the AEE, as well as for those interested in the space sector. Its specific purpose is to address further developments of Spanish legislation in the field of space activities, space public administration and the performance of its competences in outer space, ground segment and in the variety of space applications and services.

Keywords: Space Law, New Space, Spanish Space Agency, Space missions, Legal security

P06

ARCHITECTING CUBESAT CONSTELLATIONS FOR MESSAGING SERVICE

Ksenia Osipova[1], Adriano Camps[1], Alessandro Golkar[2], Joan A. Ruiz-de-Azúa[3], Lara Fernandez[1], Nicola Garzaniti[4]

[1]UNIVERSITAT POLITÈCNICA DE CATALUNYA (SPAIN), [2]TECHNICAL UNIVERSITY OF MUNICH (GERMANY), [3]i2CAT FOUNDATION (SPAIN), [4]CRANFIELD UNIVERSITY (UK)

ABSTRACT

Data collection and exchange stand as a cornerstone technology driving the advancement of technological development over recent decades. However, many remote and hard-to-reach regions remain devoid of terrestrial communication infrastructure. Telecommunication satellite systems offer a comprehensive solution to facilitating data transfer to and bridge existing connectivity gaps.

Private companies are currently developing two distinct systems to enable direct-to-handset connectivity. The first type strives to offer mobile connectivity based on 3GPP standards with unmodified smartphones, but these satellites are expensive and heavy. The second type of satellites provides low data rates connectivity using Internet of Things technologies to send and receive data packets. These satellites, in contrast, are more lightweight, cost-effective, and can take the form of CubeSats (e.g. Lacuna Space) or even PocketQubes (e.g. Fossa Systems). This study proposes leveraging the advantages of LoRa technology and CubeSats to design a constellation, offering affordable messaging services to underserved regions.

Our presentation outlines an approach to identify optimal CubeSat constellation architectures for messaging service via LoRa technology, as well as to determine the main drivers of the system's economic profitability. The multi-component model considers the potential users distribution on the Earth's surface, LoRa link design aspects and telecommunication payload sizing. Constellation design involves the sizing of the CubeSat platform, messages transmission simulation, and constellation launch strategies. Employing a trade-space exploration approach, the study identified three Low Earth Orbit constellation architectures out of a pool of 5256, capable of satisfying 99% of the demand and yielding the highest revenue.

The architectural analysis framework presented here can serve as a valuable tool for the preliminary design and sizing of a constellation for different services based on short data packets transmission, while the gained insights regarding performance drives have the potential to enrich the development of future Internet of Things connectivity projects.

Keywords: LoRa Technology, CubeSats, Messaging service, Satellite constellations, Communications

P07

MISSION ANALYSIS OF A VACUUM ARC THRUSTER SYSTEM FOR NANOSATELLITE APPLICATIONS

Kash Saddul, Alexander Wittig, James Saletes, Minkwan Kim

UNIVERSITY OF SOUTHAMPTON (UK)

ABSTRACT

We present a standalone electric propulsion package that can provide spacecraft-independent de-orbiting capacity to sub-3U CubeSats.

The rapid development and cost-effectiveness of nanosatellites, combined with their high failure rate of 41.3% from 2000 to 2016, have contributed to the accumulation of dead satellites in Low Earth Orbit (LEO). Many lack dedicated propulsion due to mass, power, and volume constraints, leading to uncontrolled satellites in LEO threatening active spacecraft. This presentation proposes a Vacuum Arc Thruster (VAT) as a compact propulsion system that can meet the stringent constraints of nanosatellites.

We use the VAT to de-orbit an under-actuated 1U CubeSat with uncontrolled spin, specialising the system into the CubeSat De-orbiting All-Printed Propulsion System (Cube-de-ALPS). It comprises a flexible substrate on which coplanar arrays of vacuum arc micro-thrusters (micro-VAT) are printed alongside small supporting electronic subsystems. In this scenario, a Faraday cup will provide coarse angle-of-attack estimates and trigger Cube-de-ALPS to ignite whenever it points in the right direction.

Our orbital lifetime simulations show Cube-de-ALPS can reliably de-orbit a 1U CubeSat from up to 1400 km, twice as high as naturally possible, while respecting international guidelines.

We will also briefly discuss the application of this propulsion technology to ongoing research on HexSats, a novel small satellite form factor featuring a flat architecture designed for high-power constellations in Very Low Earth Orbit (around 250 km altitude).

Keywords: Nanosatellite, Vacuum Arc Thruster, Electric propulsion, De-orbiting

P08

DEEP SPACE STATION 17: A UNIVERSITY-OPERATED AFFILIATED NODE ON THE NASA DEEP SPACE NETWORK

Benjamin Malphrus[1], Timothy Pham[2], Jay Wyatt[2], Chloe Hart[1]

[1]MOREHEAD STATE UNIVERSITY (USA), [2]NASA JET PROPULSION LABORATORY (USA)

ABSTRACT

With a new era of Solar System exploration catalyzed by interplanetary small satellite missions, there is an increasing need for deep space ground operations support. Ten CubeSats flew on NASA's Artemis 1 mission in 2022 following the success of MarCO, the first interplanetary CubeSats launched in 2018. These missions have opened the door for smallsat exploration of the solar system. All of these activities require ground support for communications, navigation and tracking- support that requires significant infrastructure including ground stations with large apertures, full-motion antennas and specialized deep space ranging and telecommunication instrumentation. The DSN is generally considered to be heavily subscribed, and, even with the expansion of the new antennas planned, and with the implementation of new techniques (i.e. multiple spaceraft per aperture), will be challenged accommodate the large number of missions expected as the smallsat era unfolds. To begin to address this challenge, a partnership between JPL and Morehead State University (Kentucky, U.S.A.) was initiated in 2014 to enhance DSN capabilities by utilizing existing a non-NASA asset. The team used the university's 21 m Space Tracking Antenna as a case-study to prove the validity of adding non-NASA nodes to the DSN to support interplanetary smallsat missions. The program has been successful, with the 21 m antenna now designated NASA DSS-17, and is supporting operational missions, since 2022.

Transitioning from an experimental ground station to an operational deep space station required that some unique challenges be addressed. The implementation of DSN capabilities with deep space communication and navigation tracking techniques, including Space-link Extension (SLE) protocol and CCSDS data standards, and asset scheduling capabilities required a complex set of activities, some of which had to be developed. Major challenges included achieving the spacecraft ranging precision, Doppler measurement precision, and pointing and tracking precisions required by the missions being supported. Additional challenges included incorporating a hybrid station (i.e. some elements utilized are DSN equipment, commercial instruments and in-house developed systems) into the DSN network and services. Challenges also existed associated with incorporating a smaller aperture (less gain, less EIRP than the conventional 34 meter beam waveguide antennas) into the DSN. While DSS-17's performance has proven to be highly effective in supporting lunar missions, longer tracks are required to return the same volume of data as other DSN stations. While numerous challenges existed, DSS-17 has been successfully incorporated into the DSN as an affiliated node.

Keywords: Telecommunications, Deep Space Operations, Deep Space Network, Ground Station

P09

ATHENA NANO: DEVELOPMENT STATUS AND COMMERCIALIZATION ROADMAP

Alberto Alonso, Mick Wijnen, Javier Cruz, Sara Correyero

IENAI SPACE (SPAIN)

ABSTRACT

Around 145 commercial satellite constellations world-wide are expected to be launched this decade representing a total of more than 7.000 satellites, with a large majority under 50 kg. However, one of the most critical enabling technologies is not yet suited for this new emerging market: on-board electric propulsion. Current low power solutions have very low efficiencies, low thrust-to-power ratios, a lack of scalability and customization, unaffordable costs, and lately, significant supply chain issues.

The development of the ATHENA NANO thruster seeks to solve and/or mitigate all the above issues through a single disruptive technology. ATHENA NANO is a high-efficiency, high thrust-to-power electric propulsion system for the Nano satellite class. It is also customizable so it can address a wide range of platforms in terms of available power, required thrust and total impulse. This is a huge advantage of IENAI's electrospray technology as thrusters can be adapted to client's needs.

ESA is supporting the development of ATHENA NANO through the "GSTP Element 2: Make" program. The project has successfully passed the PDR milestone which validated the market target, technical requirements and system architecture.

This paper reports on the current status of the ATHENA NANO development. It also presents the global roadmap towards commercialization. First tests results on prototypes and analyses on the flight architecture are summarized, and future activities are described. Finally, IENAI SPACE approach to thruster customization will be thoroughly described.

Keywords: Electric, Propulsion, Electrospray, Nanosatellites, CubeSats

P10

OPERATIONAL EXPERIENCES OF MOREHEAD STATION SUPPORT TO CUBESATS

Timothy Pham[1], Benjamin Malphrus[2], Chloe Hart[2], Ryan Collins[2], Christopher Smith[2], Emily Walter[2], Diddy Didier[2], E. Jay Wyatt[1]

[1]NASA JET PROPULSION LAB (UNITED STATES),[2]MOREHEAD STATE UNIVERSITY (UNITED STATES)

ABSTRACT

The 21-m ground station at Morehead State University, Kentucky, United States, has been supporting many Cubesat missions such as CAPSTONE, Lunar Ice Cube, Biosentinel, etc., since it became operational in August 2021. Prior to that, the station underwent a major upgrade with additional X-band TTC-processing capabilities necessary for supporting deep space (beyond LEO) missions. Tracking lunar missions is much different from operation with low Earth cubesats, for example, with much lower power conditions, tighter link margins, long continuous uplinks needed for accurate doppler and ranging, concurrent doppler and ranging measurements along with telemetry data return, etc.

After two years of operation, this paper examines how well the Morehead station performs in supporting lunar missions, in particular CAPSTONE. We have characterized the station's ability to service missions in terms of telemetry, tracking and command data delivery, despite its single-string configuration with limited backup equipment available.

We discuss some of the problems encountered and solutions taken by the operations team to troubleshoot and resolve them. We have found some of these capabilities are quite useful in monitoring and maintaining the system performance, for example, (1) the ability to compare system performance with the DSN site, (2) ability to isolate the cause between low gain vs. high system noise temperature when the antenna performance Gain/System Noise Temperature (G/T) is degraded, (3) ability to do an internal data flow test to check on signal continuity in the ground station, (4) the usefulness of having an openloop recording capability for post-pass analysis especially for mission's critical operation events, in addition to the realtime closeloop receiver tracking capability, etc.

We will also characterize the weather impact on the station operation since the weather at Morehead is quite different from the typical high desert weather at the NASA Deep Space Network stations which co-support these missions.

Keywords: Morehead station, Operational Experience, CubeSat

P11

USING POCKETQUBES & PICOSATELLITES FOR AGILE AND EFFICIENT INNOVATION AND IN-ORBIT TESTING

Eduardo Alonso, Marina Merchán, Pablo Durban

HYDRA-SPACE (SPAIN)

ABSTRACT

The so-called New Space philosophy has opened the doors to massive innovation in the space sector. However, proving a technology works in-orbit is still a key step for any space initiative. Investors and client's confidence leaps forward when team and technology are flight proven.

Pocketqubes (PQ's) and picosatellites offer an agile and affordable option to implement in-orbit testing and demonstrations, by significantly reducing assembly, integration and launch timing and costs.

Even if limited by platform energy and size constraints, being able to show that your technology works in-orbit and gaining insights that can feed subsequent development efforts will always prove invaluable, more so if an agile and affordable mission approach is implemented.

With a hands-on approach and based on Hydra Space team experience in different innovative in-orbit testing projects (raw materials qualification, propulsion technology, optics, electronics testing, …) this paper explores the possibilities of a very small satellite as an in-orbit testing platform, presenting a rigorous approach and project methodology, combined with lessons-learnt from specific experiences that have improved the satellite design. Key challenges, like payload mechanical integration, energy management trade-off, simplified payload operation, test plan design, test results downloading, deployer and launcher integration will be addressed, as well as innovative solutions proposed to take maximum advantage of a constrained platform.

Options for exploring, not only specific payload testing, but also constellation design, will be analysed. Trade-offs between cost and mission scope will also be explored.

Keywords: In-Orbit Testing, Payload, Pocketqubes, Smallsats, Picosatellites

P12 – POSTER DISPLAY

MISSION ANALYSIS OF THE ST3LLAR-sat1 "BOIRA" 2U CUBESAT: FROM BDR TO FDR

Fernando Solano, Andrés Infante, Verónica Sastre, Diego Navarro-Tapia, Andrés Marcos.

UNIVERSIDAD CARLOS III DE MADRID (SPAIN)

ABSTRACT

The ST3LLAR-sat1 "BOIRA" is the first student CubeSat program established at Universidad Carlos III de Madrid. This program is integrated in its Master in Space Engineering degree, and the aim for the first edition is to design, develop, and fly a 2U CubeSat with a scientific goal (measuring atmospheric water vapour) as well as several technological goals, such as in-orbit operation of an in-house state-of-art compact communication antenna and advanced ADCS algorithms.

Mission Analysis plays a fundamental role in the design of any Space mission by determining which will be the nominal orbit in which the mission objectives are achieved better. Due to the current design stage of the ST3LLAR-sat1 "BOIRA", a nominal orbit cannot be yet characterized because the launcher is still unknown. Therefore, the main objective of Mission Analysis has been to assess a wide range of orbits to understand the compatibility with different launch opportunities at different orbits.

The poster will include the analyses performed towards the final design review (FDR) in the framework of the European Space Agency Fly Your Satellite's Design Booster (FYS-DB) program. In particular, a series of Sun-Synchronous orbits varying from 350 to 600 km over Earth's surface are considered as well as three different Local Time of the Ascending Node (e.g. Noon-Midnight, Dawn-Dusk and 10:30h).

The analyses performed include lifetime, ground station contact, Spain daytime contact, region coverage, and eclipse events. The most critical one is related to the re-entry of the spacecraft. Since no propulsion module is envisioned for ST3LLAR-sat1, the orbit to target must comply with the 5-year "Zero Debris policy" that the European Space Agency will adopt soon.

Finally, an analytical methodology to quantify the performance of each orbit is presented with the aim to facilitate the mission analysis task.

Keywords: CubeSat, Mission Analysis, Sun-Synchronous Orbit, Lifetime, Space Debris Mitigation

P13

ADEO-THE DEPLOYABLE PASSIVE DE-ORBIT SAIL SUBSYSTEM ENABLING SPACE DEBRIS MITIGATION

Liesbeth Arnouts[1], Matthias Killian[1], German Puttich[1], Sun Young Joo[1], Xenia López-Corrales[1], Jannik Pimpi[1], Leonard Hofmann[1], Frank Hoffmann[1], Ernst K. Pfeiffer[1], Tom Spröwitz[2], Patric Seefeldt[2], Jim Bingen[3], Tiziana Cardone[4]

[1]HPS GmbH (GERMANY), [2]DLR GERMAN AEROSPACE CENTER_INSTITUTE OF SPACE SYSTEMS (GERMANY), [3]D-ORBIT (ITALY), [4]ESA-ESTEC (THE NETHERLANDS)

ABSTRACT

The ADEO subsystem is a fully qualified, lightweight, small and cost-efficient drag augmentation subsystem which is already available on the commercial market. For the de-orbit manoeuvre, a large surface is deployed which multiplies the drag effective surface of the satellite significantly. Thereby the drag force is increased, causing accelerated decay in orbit altitude.

Due to the fully automated de-orbiting functionality, beginning with the decision of the sail deployment, the autonomous de-orbiting phase until the complete removal of the S/C out of the crowded LEO orbits, the ADEO dragsail system is the most economical way of a space debris removal. It empowers satellite providers to meet the unquestioned demand to remove their S/C within 5 years. The ADEO subsystem guarantees sustainable, clean and green space missions.

The ADEO subsystem family currently consists of 5 different modules: ADEO-P (Pico), ADEO-C (Cube), ADEO-N (Nano), ADEO-M (Medium), and ADEO-L (Large).

During different governmental funded and commercial programs and missions the ADEO dragsail achieved its full qualification and maturity and is therefore the most advanced solution on the market. A highlight was the ADEO-N2 mission, a 3.6 m² drag sail onboard of D-Orbit's "Dauntless David" ION Satellite Carrier which deployed on the 15th of December 2022. The deployment could be recorded by the onboard camera system and the onboard telemetry data is continuously collected. The results give a lot of confidence in the ADEO subsystem and its possible contribution to the Zero Debris Policy and Requirements.

Keywords: Passive De-orbit, CleanGreen Space Mission, Dragsail, Cleanspace, Space Debris Mitigation

P14

SMALL FORM FACTORS VNX

Javier Carnero

SAMTEC (UK)

ABSTRACT

As embedded communities move to smaller platforms with higher-density processors, the requirement to build smaller systems becomes ever more critical. Recently, COTS solutions, as opposed to custom designs, have minimized the effort required to upgrade systems using common hardware, communications, and control interfaces. This approach along with conformance to MOSA standards like ANSI/VITA, SOSA, HOST, and other consortia make the goal of building smaller and faster possible. VNX+ is being designed and implemented with all these requirements in mind.

Based on a backplane architecture VNX/VNX+ offers a new approach for connecting PCBs on small satellite programmes. The VNX ecosystem is an evolution from VPX where smaller form factors are required yet offering high speed capabilities as well as the option to add fibre optic and Coaxial cables over a backplane.

Legacy systems on CubeSat applications have adopted PC/104 as a key COTS standard but integration of devices using High Speed Signalling to FPGAs have open the need for new solutions yet maintaining a high density VNX/VNX+ allow for high speed signalling up to 25Gbps and standardization of the module size. The standard builds up over the Searay connector which is already standardized by VITA on FMC/FMC+ and XMC+ standards.

Keywords: CubeSat, Architecture, High Speed Signalling, COTS

P15

LEVERAGING SOLAR SYSTEM MISSION PLANNING EXPERTISE FOR AN ENHANCED SPACE SITUATIONAL AWARENESS SOLUTION

Sara de la Fuente, Alfredo Escalante, Juan de Pablos, Iñaki Ortiz de Landaluce, Ricardo Valles.

RHEA GROUP (SPAIN)

ABSTRACT

RHEA Group is the main service provider for science operations mission planning activities of the European Space Agency's solar system science exploration programme. As part of such duties, RHEA Group has been leading for many years the ESA SPICE Service, providing mission analysis and operations support for different ESA solar system missions. SPICE is an ancillary information system developed by the JPL at Caltech, whose purpose is to provide orbital, geometrical and time correlation computations to support planning and conducting space operations.

RHEA has transferred its extensive experience in mission operations using SPICE into an innovative solution in the Space Situational Awareness domain. Leveraging the SPICE system as a foundation, this approach is rooted in scalability, modernisation, and open-source principles, ensuring adaptability to the evolving landscape of the New Space and, particularly, small satellite missions and constellations, reducing ground segment and operational costs through end-to-end automation of the different system components.

The solution is part of ASTRAL, a component-based ground segment offering, which builds on RHEA's long-standing operational heritage in ground segment development, mission automation and operations preparation, and adopts the renowned corporate security-by-design strategy. Its multi-purpose architecture facilitates seamless accessibility while enhances the user experience, being integrable, modular in nature, and features plug-ins that enable customisation to specific mission requirements.

Being the SPICE system extensively proven operationally, this solution, enhanced with state-of-the art AI/ML algorithms, empowers a robust and accurate orbit prediction model, a critical aspect of the collision risk assessment. In addition, very flexible collision avoidance manoeuvre optimisations can be carried out to improve the decision-making process of satellite operators.

This presentation aims to showcase how RHEA's enhanced solution to Space Situational Awareness can bring added value to the mission operations landscape, providing attendees with insights into the practical implementation of open, secure, scalable and modern solutions.

Keywords: Space Debris, Space situational awareness, Optimisation, AI, ML, Open-source

P16

PROSPECTS AND FUTURE OF FINITE STATE MACHINES IN NANOSATELLITE MISSIONS: STANDARDIZING MODES THROUGH OPERATIONS

Sergio Cuevas del Valle, Víctor Ribera Esplugues, César David Moreno.

FOSSA SYSTEMS (SPAIN)

ABSTRACT

Finite state machines (FSM) are fundamental in the architecting of any space mission. This is especially true in the design, implementation, verification, and validation (V&V) of embedded software, as the behaviour of the system is directly ruled by these FSM.

The most prevalent use of FSM is the implementation of the spacecraft modes, together with their transition routines, the standard paradigm within the Space Industry to delimitate the behaviour of the system during its mission. This is a primary task, which iterates over all the bus development lifetime, and compromises major efforts from the System Engineering office. Interfaces, alignment, and V&V towards mission goals are critical aspects which risk the development of FSM.

Interestingly, the use of finite modes has also become a standard for nanosatellites missions, despite being contrary to major practices in the Industry: in the end, FSM provide no flexibility in their design, and cannot be easily re-defined down into the development process. Integration of new hardware, late-time software functionalities or real testing results compromise the integrity of the FSM, leading to unforeseen, unacceptable behaviours at the risk of mission failure. FSM, conceived at early mission phases, are not in well agreement with the NewSpace trial-and-error philosophy.

This communication addresses this issue by re-defining modes FSM through a standardized behaviour scheduler, based on operations-oriented activities, common to almost all nanosatellite missions. In this way, software is fully abstracted from the mission design but in the definition of fundamental objects; mission design, SW implementation and testing is simplified; and legacy developments can be re-used in future missions, even if they have totally different objectives and spacecraft configurations. The proposed approach is applied to the real of AOCS software to illustrate its benefits from both a Systems and Software Engineering perspectives, in terms of flexibility, cost and time.

Keywords: Finite State Machine, Modes, Scheduling, AOCS, V&V

P17

INSIDE LUNAR LAVA TUBES: MEASURING RF PROPAGATION IN AN EARTH ANALOGUE CAVE

Fernando Aguado-Agelet[1], Fermín Navarro-Medina[1], Marcos Arias[1], Lorena Pérez Eijo[1], Alejandro Gómez-San Juan[1], Alejandro Camanzo[1], Susana Loredo[2], Álvaro Pendas[2], German León[2]

[1]UNIVERSITY OF VIGO (SPAIN), [2]UNIVERSITY OF OVIEDO (SPAIN)

ABSTRACT

This contribution presents the initial findings from a study focused on measuring radio propagation within Lanzarote's Los Verdes cave system—an analog to lunar caves characterized by its lava tube structure. The objective is to validate propagation models crucial for developing communication systems in lunar cave environments, addressing a key requirement for future exploration missions led by ESA and other space agencies. The emerging results provide valuable insights into the complexities of radio frequency (RF) signal propagation within cave environments, offering essential information for optimizing communication systems in lunar caves.

The research has successfully deployed a diverse set of antennas within the Los Verdes cave, capturing and analyzing RF propagation properties. The lava tube cave's unique geological features, closely resembling lunar caves (except for scale due to the reduced lunar gravity), have provided a good analog for lunar conditions. The results from these measurements offer tangible evidence of antenna performance under cave conditions, including signal attenuation, multipath effects, the impact of cave irregularities and non-line-of-sight performance.

The validation and refinement of propagation models stand as crucial milestones in enhancing our capability to predict and optimize communication systems within lunar caves—an essential element for the exploration of these subterranean structures. Lunar caves, proposed as potential sites for future human habitation, present a distinctive protective shield against radiation and micrometeoroid impacts, fostering a safe and stable environment for astronauts. Nevertheless, successful robotic exploration of the lunar lava tubes is a prerequisite before planning future manned missions to accommodate the specific requirements associated with settling these underground structures.

Keywords: Communications, Antenna, Propagation, Moon, Exploration

P18

CUBESATS AT EARTH-MOON L_4/L_5: ASTRODYNAMICS AND TECHNOLOGY FEASIBILITY FOR STUDYING CISLUNAR ENVIRONMENT

O. Fors[1], J. M. Gòmez[1], A. Aran[1], R. Bevilacqua[2], D. Canales[2], S. S. Eikenberry[3], A. Richichi[4]

[1]INSTITUT DE CIÈNCIES DEL COSMOS_UNIVERSITAT DE BARCELONA IEEC-UB (SPAIN), [2]EMBRY-RIDDLE AERONAUTICAL UNIVERSITY, DAYTONA BEACH, FL (UNITED STATES), [3]UNIVERSITY OF CENTRAL FLORIDA, ORLANDO, FL (UNITED STATES), [4]INAF_OSSERVATORIO ASTROFISICO DI ARCETRI, FIRENZE (ITALY)

ABSTRACT

Technological and scientific communities are becoming interested in the unexplored and unique Cislunar region. Our team proposes a CubeSat orbiting the Earth-Moon L4/L5 points, by describing close Short-Period Orbits (SPO). Our motivation is to boost the required technology (instrumentation, sensors, propulsion, and orbit keeping), providing information about the Cislunar region, and to tackle science cases not available from Earth and other orbits. Space Weather in the Cislunar environment can provide a deep hindsight of the possible effects on the Moon human exploration. Also, study of the solar corona using the Moon as occulter, or the resolution down to 100μmas of stellar diameters and binaries separations with Lunar Occultations (LO). We already optimized the stability of those SPO [1,2]. In addition, a first preliminary VIS/NUV sensor was considered, and we showed that the LO science case perfectly suits the mission [3]. A thoughtful study of the Space Weather science case and its associated sensors is undergoing. Earth-Moon transfer orbit and other mission planning items will be soon defined.

Keywords: Lagrangian points, Short-Period Orbits, Cislunar environment, Space weather, Lunar occultations.

P19 – POSTER DISPLAY

IMPLEMENTING THE CUBESAT SPACE PROTOCOL FOR MULTIPLE EMBEDDED SYSTEMS IN SATELLITE APPLICATIONS

Ignacio Gonzalez-Rua, Manuel Diz-Folgar

UVIGO SPACELAB (SPAIN)

ABSTRACT

In the realm of space missions, effective communication amongst satellite components is paramount. These components encompass both subsystems and payloads, each integral to mission success. Low-level communication protocols are pivotal in facilitating the collection and transmission of data across these elements. These protocols are essential in ensuring the timely and precise relay of information, a necessity in the hostile and technically demanding environment of outer space.

To enhance the management of these communications, the Cubesat Space Protocol (CSP) was developed. As a network layer protocol tailored for embedded systems, such as microprocessors, CSP effectively addresses the unique challenges of space communication. It offers a standardized method for data transfer within the satellite architecture, utilizing packet-based communication. CSP is specifically engineered to accommodate the constraints inherent in space systems, including energy efficiency and the capacity to operate under extreme conditions.

This article underscores the significance of deploying CSP across diverse platforms and embedded systems. Advocating for a cross-platform strategy, the article elucidates how CSP's implementation in any space subsystem or payload is streamlined. Implementing CSP on various low-level platforms endows the system with remarkable flexibility and adaptability, enabling swift and seamless integration into assorted satellite configurations. Such adaptability is crucial for meeting the evolving demands and technological progressions in space exploration.

CSP is emerging as an indispensable tool in augmenting satellite communication, thereby leading to more efficient and successful space missions. Its application across various platforms demonstrates a remarkable capacity for adaptation and enhancement in space communication management, markedly advancing satellite technology and operational efficiency in space missions. Ultimately, CSP stands as a fundamental element in the onward journey of space exploration and operations, heralding a new era of technological advancement in the cosmic frontier.

Keywords: Protocol, Communications, CAN, I2C, Embedded

P20

MAIN ELECTRONICS FOR GLOBAL ACCES (MEGA) POWER CONDITIONING AND DISTRIBUTION UNIT (PCDU)

Marcos Núñez, Luis Alonso Gómez, Pablo López, Víctor Romero.

AIRBUS CRISA (SPAIN)

ABSTRACT

Over the past years, a new space market have been created for low and medium spacecraft constellations for both Earth observation and communication applications.

For those missions, drivers are: cost, reliability, quality and massive production within a very challenging schedule constraints.

In that environment, electronic systems plays a main role and Electrical Power Subsystem elements like solar array, battery and PCDU are one of the main drivers.

Airbus Crisa, as a key player, has developed a product line called MEGA (Main Electronics for Global Access). 1200 flight models flying with a cumulated heritage of more than 2000 years demonstrate that Airbus Crisa is a reliable partner applying its innovative COTS and industrial setup approach.

MEGA provides a modular and scalable solution.

First MEGA product is the PCDU, a modular and scalable power conditioning and distribution solution.

The proposed paper will provide heritage, design, development status and industrial setup of this successful unit.

Keywords: Power, Conditioning, Distribution, Constellations, Electronics

P21

PROJECT OF TRAINING LEARNING SURROUNDING SMALL SATELLITES CAPABILITIES AT SPANISH AIR FORCE ACADEMY

Francisco Ángel Espartero Briceño[1], David Alarcón Matencio[2], Juan Antonio Vera-López[3], José Luis Roca González[3], Alejandro López-Belchí[4], Jacobo Rodríguez Otero[5]

[1]IDR/UPM (SPAIN), [2]ACADEMIA GENERAL DEL AIRE (SPAIN), [3]CENTRO UNIVERSITARIO DE LA DEFENSA ACADEMIA GENERAL DEL AIRE (SPAIN), [4]ETS DE INGENIERIA NAVAL Y OCEANICA. UPCT (SPAIN), [5]ETS DE INGENIERIA AERONÁUTICA Y DEL ESPACIO. UPM (SPAIN)

ABSTRACT

Technological updating and development of the next space academic framework is a constant matter of consideration at the Spanish Air Force Academy (SAFA) and the University Centre of Defence at SAFA (Jefe del Estado Mayor del Ejército del Aire y del Espacio, 2022). For such reason a bottom-up action has been carried out by the multidisciplinary team of "SAT-SHIELD Think Tank" members, to design an "Educational Space Immersive Room and Training Proposal (ESIR-TP)" based on Small Satellites and ground tracking technologies. The aim of this action is to lead the future officers of the Spanish Air Forces, to a higher technological environment within the bachelor's degree in technology and aerospace military operations.

This communication summarizes three examples that take into consideration the limitations of the complexity of Space Technologies. Mainly, by developing immersive learning actions where STEM studies may be oriented to experimentation with small satellites and ground tracking technologies.

More specifically these actions are:

1) "The implementation of the educational ESAT of THEIA SPACE"; (ESAT) is an educational nanosatellite based on CubeSat standard, that aims at becoming the perfect tool for hands-on training in space engineering at all levels.

2) "Immersive practice in Heat transfer systems through heat pipes applied to Small Satellites". Thanks to a previous experimental design, students can develop an immersive training experience in how this passive thermal transfer technology may transport the excess heat via temperature gradients from small satellites electrical devices to a colder surface as an example.

3) "Introduction to ground tracking technologies based on autonomous mini observatory to capture and analyse specific space artifacts". Previous knowledge developed to set an autonomous mini observatory allows to propose a new system based on three stations where students may learn to interact whit this units to track specific space artifacts. Finally, the framework is expected to be completed thanks to a "STK course" for Digital Mission Engineering and System Analysis, what may extend the initial scope statement to a continuous technological capacitation.

Keywords: Educational CubeSat, Small Satellites Technologies

P22 – POSTER DISPLAY

DESIGN AND TESTING OF A GROUND STATION FOR COMMERCIAL S-BAND RECEPTION

Pablo Francisco Fernández[1], Alfredo Ivorra[1], Manuel Diz-Folgar[1], Guillermo Calvo[1], Ignacio González[1], Andrés Vieitez[1], Alejandro Camanzo[1], Manuel Vale-Xoubanova[2], Marcos Arias-Acuna[1], Fernando Aguado-Agelet[1]

[1]UVIGO SPACELAB (SPAIN), [2]CERN (SWITZERLAND)

ABSTRACT

This study elucidates the progression and modernization of ground stations for satellite communications within Low Earth Orbits (LEO), particularly focusing on CubeSat-type satellites. Initially, these stations harnessed Very High Frequency (VHF) communications. However, technological advancements have steered a transition towards Ultra High Frequency (UHF) band, now the predominant medium. Recently, to augment communication quality and data download efficiency, the S-band has been incorporated into small satellites, signifying an emergent trend in this domain.

The paper highlights a specific endeavour: the development of a novel S-band ground station for the BIXO mission. This project is distinguished by its innovative conversion of a former NOAA communications parabolic dish, property of the University of Vigo, for S-band operations. This conversion necessitated an upgrade of the antenna's tracking and control system and the establishment of a novel radio frequency component chain. This modernization adhered to an intricate link budget analysis tailored for the BIXO mission, ensuring the station's aptitude and effectiveness in receiving signals in this newfound band.

The establishment of this S-band ground station marks a substantial progression in the satellite data retrieval capabilities of the University of Vigo. With this enhancement in data download rates, the university is poised to utilise satellite resources more efficiently, thereby enriching its Information Technology (IT) infrastructure. This development is not only indicative of the practicality of repurposing and enhancing existing infrastructure for novel applications but also underscores the imperative of continual innovation in satellite communication, particularly for diminutive satellites in LEO, such as CubeSats.

Keywords: Satellite, Ground Segment, Ground Station, Communications

P23

FLYING ZYNQS: A YEAR IN ORBIT

Màrius Montón[1,4], Daniel Ferrer[1], Jan Gómez[1], Carles Sierra[1], Lucas Juvero[1], Jose María Gómez[1,2], Juan Ramos Castro[1,3]

[1]INSTITUT D'ESTUDIS ESPACIALS DE CATALUNYA IEEC (SPAIN), [2]UNIVERSITAT DE BARCELONA UB (SPAIN), [3]UNIVERSITAT POLITÈCNICA DE CATALUNYA UPC, [4]UNIVERSITAT AUTONOMA DE BARCELONA UAB (SPAIN)

ABSTRACT

This communication reports the in-orbit experiments performed to the C3SatP platform, based on a ZynqUltrascale+ and a SAMV71Q21. The devices have been flying as a secondary payload in the Menut (NORAD ID: 55010) satellite in LEO orbit since January 2023.

C3SatP is formed by two boards, one with a ZynqUltrascale+ with 2 GB of RAM acting as an OBDH and one board with a SAMV71 acting as an OBC. The OBC controls and manages power for both subsystems and gathers telemetry of all the components.

The sub-system as a whole communicates to the satellite platform using a Ethernet-over-USB with IP as the main protocol for TC/TM and a UART interface as a system log and debug.

In-orbit tests performed run some CPU demanding applications (i.e. data compression) meanwhile monitoring all subsystems. These tests last for about 15 minutes each, but some full-orbit tests were done. These parameters are sampled at 1 Hz and sent to the satellite platform once the test is completed.

The results indicate that the Zynq+ can run in space with no faults and the behavior in orbit is quite similar to that observed in the laboratory. We estimate that the total ionizing dose (TID) received by the PCB boards until now is approximately 2.2 krad. The C3SatP sub-system has been powered on for 7 hours in total without any SEE detected.

To our knowledge, the following parts are never reported to be used in orbit and are of special interest to follow up their performance during the lifetime of the satellite:

- ZynqUltrascale+ XCZU4CG-L1SFVC784I
- DDR4 SDRAM MT40A1G8WE-075E IT:B
- PMIC IRPS5401
- USB Transceiver USB3341

By the time of the oral presentation, we are confident that about 100 hours of runtime will be achieved and a total TID of 2.3 krad

Keywords: Satellite, FPGA, Utrascale+, In-Orbit Demonstrator, COTS

P24

DISTRIBUTED SATELLITE SYSTEMS SIMULATOR (DSS-SIM): A SIMULATION ENGINE TO ASSESS THE DESIGN AND VALIDATION OF COMMUNICATION PROTOCOLS OVER SATELLITE SYSTEMS

Joan Pagès, Arnau Dolz, Joan A. Ruiz-de-Azua

SPACE COMMUNICATIONS RESEARCH GROUP, i2CAT FOUNDATION (SPAIN)

ABSTRACT

In the last years, satellite systems have transitioned from monolithic to distributed architectures to overcome the limitations that those first systems were constrained by. Distributed Satellite Systems (DSS) have emerged as a potential architecture, characterized by distributing the responsibility to accomplish a specific mission among a set of satellites. Aiming to amend the limitations of one-hop strategies, further research pursued Inter Satellite Communications (ISC), allowing establishing communications between adjacent satellites. An example of this ISC application can be found in some commercial satellite constellations, which define point-to-point communications between adjacent satellites by using Inter Satellite Links (ISL). These structures are achieved by defining specific orbit planes and custom satellite distributions. A step forward in the research of these architectures by novel spatial entities has led into a paradigm focused on the heterogeneity of a future scenario, with satellites equipped with different resources, and dynamic availability. As a result, defining new strategies to optimize the available resources is crucial. For that purpose, access to the proper tools has become a requirement. Under this premise, a software called Distributed Satellite Systems Simulator (DSS-SIM) has been developed. The DSS-SIM has been designed to simulate novel protocols in large satellite systems, taking in consideration their impact on satellite resources and operations. The simulator is based on the Network Simulator version 3 (ns-3) which provides an event-based simulation engine. This simulation approach is suitable to evaluate network behaviors, although may imply some challenges when representing satellite dynamics. That is the motivation for DSS-SIM to be built upon the ns-3 core, so satellite behavior aspects (e.g. orbit trajectory, attitude, memory usage, etc.) can be covered. DSS-SIM is integrated with this ns-3 layer, and it has the ability to represent satellites in different orbit regions such as Low-Earth Orbit (LEO) or Geostationary Equatorial Orbit (GEO).

Keywords: Satellite, Communications, Network, Simulator

P25

THE FLEXIBLE PAYLOAD – FLEXIBLE HARDWARE ARCHITECTURE FOR A MULTI-PAYLOAD AND RADIO-FREQUENCY MULTI-BAND

Marc Badia[1], Adrià Amezaga[1], Roger Jové[1], Víctor Montilla[2], Joan A. Ruiz-de-Azua[2]

[1]MICROWAVE SENSORS AND ELECTRONICS MWSE (SPAIN), [2]SPACE COMMUNICATIONS RESEARCH GROUP, i2CAT FOUNDATION (SPAIN)

ABSTRACT

The flexible payload concept presents a modular and flexible framework that enables to dynamically deploy and execute software-based payloads. This concept emerges from the need for unifying software developments in different hardware systems and the integration of virtualization mechanisms with satellite systems. With these capabilities, this single payload can execute tasks for passive remote sensing (GNSS-Reflectometry and microwave radiometry satellite communications (Telemetry, tracking & control, communications relay -VHF, UHF, S, X and K-bands-, Inter Satellite Links), heat maps of radio frequency interferences, and serve as a test bench for 5G and future 6G communication technologies. These are just examples of the potential software-based payloads executed on top of this framework.

The concept and software framework is presented in another submitted abstract [5]. This one presents the hardware implementation for a radio-frequency flexible payload. The system is built around a Software-Defined Radio (SDR) platform with an FPGA/CPU core and an expansion module. The core processing power is capable of running configurable environments. The expansion module increases the SDR radio-frequency capabilities by offering transmission and reception bands from 70 MHz and up to 26 GHz. The system hardware architecture and the main budgets of the payload are described.

Keywords: Flexible, Radiofrequency, SDR, Satellite, Virtualization

P26

LUMIO, A LUNAR CUBESAT FOR METEOROID IMPACTS DECTECTION

Lorenzo Pattanaro[1], Lorenzo Provinciali[1], Giorgio Saita[1], Giovanni Fumo[1], Francesco Topputo[2],

[1]ARGOTEC (ITALY), [2]POLITECNICO DI MILANO (ITALY)

ABSTRACT

Meteoroids represent a potential safety issue for human Lunar exploration and play a critical role in space equipment survivability. Nevertheless, scientists require experimental data to validate and expand the current meteoroid's impact prediction models.

Currently, ESA and NASA rely on ground-based observations of the lunar surface for meteoroids impact detection and characterization. However, many limitations affect ground-based observations like atmospheric attenuation, illumination, geometric and weather conditions.

As such, a lunar satellite would allow for higher observation periods and monitoring of sub-millimeter meteoroid impacts.

The scientific objective of LUMIO is to complement and expand ground-based observations: it detects and characterizes meteoroids impact on the Lunar far side. LUMIO consists of a 12U CubeSat platform operating around the Earth-Moon L2 point. The LUMIO mission is under ESA General Support Technology Programme (GSTP) funding with a target launch date between 2026 and 2027.

The payload of LUMIO is an optical instrument capable of detecting faint flashes on the Lunar surface both in the visible and infrared portion of the spectrum. A dedicated algorithm processes in real-time the high data volume produced. Only relevant frames are kept, thus reducing the spacecraft's onboard memory requirements and the downlink rate of scientific data.

Furthermore, LUMIO performs an autonomous optical orbit determination experiment through the onboard identification of the Moon disk. The spacecraft reaches the operative orbit through a Weak Stability Boundary trajectory relying on its onboard propulsion system.

This mission will act as technological demonstrator of the effectiveness of small satellites in deep space.

Keywords: Deep Space, CubeSat, Moon, Meteoroid, Autonomous

P27 – POSTER DISPLAY

S-BAND FRONT-END DESIGN AND TESTING IN ORBITAL ENVIRONMENTS FOR SIGNAL CONDITIONING OF SOFTWARE-DEFINED RADIOS

Mauro Carballo, Guillermo Calvo

UVIGO SPACELAB (SPAIN)

ABSTRACT

Front-Ends and other signal conditioning instruments have set themselves as a necessity for modern electronics, specially in high-speed, high sensitivity applications and RF devices due to remarkably delicate signal integrity, meager input levels often difficult to discern from ambient noise and a myriad of casuistries relative to dealing with high frequency-low input amplitude transmission lines. As the Software Defined Radio TOTEM provided by Alén Space, used as the S-Band interface in the BIXO (Bacteriological Intercommunication eXperiment in Orbit) satellite, lacks a Signal Conditioning Device better suited for our specifically assigned frequencies, a compatible module had to be engineered to ensure good communication in the aforementioned. It's conception revolved around following the design philosophy of the CubeSat standard by the use of COTS (Commercial-Off-The-Shelf) components capable of withstanding launch and orbital conditions, which in its first iteration has been decided to be composed by a regular PA (Power Amplifier) circuit for downlink and as for uplink, we skewed towards a more convoluted, yet highly advisable for this application, circuit that implements a VGA (Variable Gain Amplifier) coupled with a detector that will work both in manual mode, where one Digital to Analog Converter will shift the gain directly in response to the input signal's intensity but also it can be set in Automatic Gain Control, which consists in switching the VGA gain pin to the output of our detector in a Closed Feedback Loop, to guarantee a faster response time and having in essence, an immediate and continuous NP-complex correction that will amplify the signal to a set level for processability and integrity. Applying this heuristic, BIXO will be able to transceive in our S-Band assigned frequencies with adequate signal integrity no matter the elevation and ionospheric conditions.

Keywords: CubeSat, Communications, Radiofrequency, Antenna, Signal conditioning

P28

THE FLEXIBLE PAYLOAD – A VIRTUALIZATION FRAMEWORK TO AUTONOMOUSLY DEPLOY SOFTWARE-BASED PAYLOADS ON FPGA SoC PLATFORMS

Víctor Montilla, Alessandro Villegas, Joan A. Ruiz-de-Azua.

SPACE COMMUNICATIONS RESEARCH GROUP, i2CAT FOUNDATION (SPAIN)

ABSTRACT

The high costs of equipment, tests and maintenance of hardware is a limiting factor when planning satellite missions in LEO. Recently, the NewSpace industry is exploring a new business model whose major achievement is linked to the cost reduction of missions by relying on the use of standard commercial off-the-shelf components for satellite construction instead of space-grade solutions that require sophisticated testing. In LEO, current CubeSat missions are typically planned under a fixed-services vision where upgrades are possible, but the procedure is limited and typically focused on debugging. During design, electronic components and software are chosen specifically to accommodate desired functionalities generating a strong dependency between services and platform resources. In this context, this paper presents the architecture details of a flexible payload framework that is a software and hardware-based environment that enables the deployment of software-controlled payloads. The specific hardware implementation is described in a separate paper. The framework offers mechanisms to in-flight expand or update satellite functionalities by executing third party software-controlled applications and services. This approach adds an abstraction layer to services that become platform-independent and can be optimally deployed based on different premises such as geographic area, resources occupancy, number of users or expected energy waste. To deploy the concept in a real platform, the framework runs on an embedded Software-Defined Radio platform based on FPGA technology as a core. This technology offers an excellent high computation and power consumption balance at a low-cost if compared to Application-Specific Integrated Circuit or other market alternatives. As services requirements are different depending on their complexity, the framework offers up to three levels of flexibility:

(1) Hardware exchange relying on logic cells reconfiguration,

(2) Software reprogramming using modern virtualization techniques and

(3) Service orchestration to manage remote deploying of Virtual Network Functions from ground stations.

Keywords: Satellite, Virtualization, SDR, FPGA, Communications

P29 – POSTER DISPLAY

DESIGN AND TESTING OF A FLATSAT PLATFORM FOR THE BIXO MISSION, A 2U CUBESAT APPROACH

Guillermo Calvo, Mauro Carballo, David Bernárdez

UVIGO SPACELAB (SPAIN)

ABSTRACT

This article underscores the escalating significance of Assembly, Integration, and Verification (AIV)processes in the design and evolution of space systems, notably for Low Earth Orbit (LEO) satellites. Initially devised as educational platforms in 1999, CubeSats have evolved into an instrumental resource for enterprises, aiming to execute high-impact space missions. Within this medium, the flatsat concept, pivotal for the assessment and authentication of satellite subsystems and payloads, has materialised.

Flatsats are engineered as platforms for testing subsystems and payloads, enabling the interconnection of these elements in a manner that mirrors their operational state within an assembled satellite. This design offers straightforward access to all interfaces, facilitating comprehensive testing without necessitating direct interaction with the subsystems. This approach is vital for mitigating wear and fatigue of components during testing phases.

In our research, a specific flatsat is conceptualised and designed for the BIXO mission, a two-unit CubeSat. The architecture accommodates subsystems such as the Pico EPS (Electrical Power System) and solar panels provided by DHV Technologies, in conjunction with a TOTEM SDR (Software Defined Radio) and Triskel OBC+TTC (On-Board Computer & Telemetry, Tracking, and Command). This arrangement not only enables the emulation of operational interplay among subsystems but also safeguards them from wear and tear due to frequent connections throughout testing.

The implementation of this flatsat is crucial for the AIV process of the BIXO mission subsystems, as it permits the simulation of the satellite's total behaviour without necessitating its complete assembly. This proves exceptionally beneficial for pinpointing and addressing issues in the developmental nascent stages, thereby guaranteeing a more dependable and efficient mission. Moreover, this methodology substantially diminishes the risks and costs linked to comprehensive system testing, signifying a notable progression in the realm of space systems engineering and CubeSat project management.

Keywords: CubeSat, Flatsat, Ground Support Equipment, Integration

P30 – POSTER DISPLAY

ST3LLARsat1 BOIRA: DESIGN AND VERIFICATION OF THE ELECTRICAL POWER SYSTEM

Daniel Jiménez, Gabriele Dessena, Andrés Marcos, Ekain Gómez, Pablo Nicolás Villalba

UNIVERSIDAD CARLOS III DE MADRID (SPAIN)

ABSTRACT

The ST3LLAR-sat1 "BOIRA" is the first student CubeSat program established at the Universidad Carlos III de Madrid (UC3M). This program is integrated in its Master in Space Engineering (MISE) degree, and the aim for the first edition is to design, develop, and fly a 2U CubeSat with a scientific goal (of measuring atmospheric water vapour) as well as several technological goals, such as in-orbit operation of an in-house state-of-art compact communication antenna and advanced ADCS (attitude determination and control system) algorithms.

One of the most critical spacecraft subsystems is the power subsystem. The subsystem includes the Electrical Power System (EPS) and related components, such as batteries, solar panels, and all the electrical connections to other subsystems.

It is common to involve the use of Commercial Off-the-shelf (COTS) components in the design of the power subsystem. The design process starts by performing a deep review of previous missions and their power systems. Then, environmental considerations and power needs of the spacecraft are considered for sizing up the subsystem, and, in the case of employing COTS, selecting the relevant components. To achieve this, a design framework featuring all the considerations above with energy generation and storage solutions must be established.

This poster will show the detailed design of the EPS for ST3LLArsat1 BOIRA, starting from requirements definition, moving to components selection, and discussing applicable strategies for its development, together with a set of analyses typical of the sizing process for EPSs in educational nanosatellites platforms.

Keywords: CubeSat, University, EPS, COTS, Power Budget

P31

LUR-1 AVS PATHFINDER MISSION, A STANDARD PLATFORM FOR EO CONSTELLATIONS

Rainer Diaz de Cerio, Cristina Ortega, Mónica Martinez

AVS (SPAIN)

ABSTRACT

LUR-1 is a complete space mission including the Space Segment (SSEG), Ground Segment (GSEG) and User Segment (USEG), under development by AVS. The mission encompasses the design, assembly, test, launch and operations of a microsatellite with an Earth observation payload as the SSEG, a GSEG to interface the satellite and a USEG to process and create products using the satellite images.

LUR-1 spacecraft, scheduled to be launched in June 2024 in Space X's Transporter-11, is a ESPA class microsatellite, with a 58 kg wet mass which will carries as a main payload an EO VNIR camera. Other payloads integrated in LUR-1 spacecraft include: a retroreflector for laser ground tracking, a QKD communication Physical layer IOD payload, a selfie stick and a passive interface and series of markers to enable a future servicing of LUR-1. Additionally, LUR-1 mission is a combination of IODs for different subsystems and an IOD of AVS's microsatellite platform which will reach TRL 9 and will be ready to be used in future missions.

Named after its IOD mission, LUR platform, AVS' standard platform, was designed to be cost effective, modular and scalable, targeting a range of satellite wet masses between 50 and 600 kg and a range of payload masses between 25 and 400 kg. The platform includes an advanced arsec capable ADCS, a kilowatt capable EPS and a powerful payload dedicated processing unit. It is envisioned to support complex missions requiring high performance and data throughput across various space applications. For instance, supporting LEO Earth observation constellations has been a key aspect in the development and design of LUR platform, allowing for versatile interfaces and efficient manufacturing, assembly and testing.

Keywords: Microsatellite, Platform, Earth Observation, IOD, Constellation

P32

AIRBUS CRISA'S SOLUTIONS FOR LAUNCHERS

Jesús Ortiz

AIRBUS CRISA (SPAIN)

ABSTRACT

Airbus Crisa has been actively working in the last years in supporting autonomous European access to space, increasing also the competitiveness of the European institutional launchers.

Thanks to the know-how built-up with Ariane 5 and Vega, key equipment has been developed and qualified for the next generation of European launchers: Ariane 6 and Vega-C. They have been devised to be industrial-wise, allowing high production cadences with attractive costs. This has been achieved, among others, by means of the following:

- Design to cost, design to manufacture and design for testing considered since the first steps of the development.
- Use of industrial electronic parts, carefully chosen to withstand the mechanical, thermal and space environments. Airbus Crisa has qualified, for launchers and commercial constellations, many types of parts, covering all the functionalities requested to the units produced for these market segments.
- Deployment of a lead-free, highly automated production line, oriented to produce electronics with commercial components at medium and high cadences and with attractive costs. Digital continuity between design and production is guaranteed by means of SW tools.

The products developed for Ariane 6 and Vega-C play a key role in the electrical system of these launchers, covering the following functions:

- Power conditioning and distribution.
- On-board processing, including the central and the telemetry computers for Ariane 6.
- Management of the communications.
- Driving of actuators, such as non-explosive ones (NEA), pyrotechnical initiators or electrovalves.

In addition to the electronic equipment, Airbus Crisa will produce two types of Li-ion batteries for Ariane 6, totaling an average of 26 batteries per launcher, starting from the 17th launcher. Currently Airbus Crisa is setting up the Batteries Assembly Line (BAL) in Tres Cantos (Madrid, Spain), with the goal to have it operational beginning of 2025.

Keywords: Launcher, Processing, Power, Battery, Avionics, Communications

P33

ALPHA MISSION: THE FIRST ANDALUSIAN SATELLITE

Alba Collado, Darío González

INDAERO GRUPO EMERGY (SPAIN)

ABSTRACT

Nowadays, space is accessible for anyone. There are a lot of countries launching satellites to orbit our planet. Spain is included in this list that is growing fast.

There is a region in Spain that has enough technology and potential to be part of this group, but which has not completely reached space: Andalusia. There are several well-known companies that develop satellite components, but there is not experience in satellite integration.

Andalusia has facilities enough (universities, companies and professionals) that combine necessary knowledge to place a satellite in orbit. However, due to economic reasons or prejudices, people are not conscious about the huge quantity of knowledge there exists in this region.

At this point is where Alpha Mission was born. An altruistic initiative in which four companies with base in Andalusia formed a consortium that, with the help of Andalusian universities, pretend to mark a milestone in Spanish NewSpace history: the first Andalusian satellite. There are several companies that have joined this project in a selfless manner.

The payloads will study electromagnetic fields, as well as radiation levels and single events. The space to locate payloads is given freely to universities and the collected data will be access free for anyone. Every company is collaborating voluntarily in this project: they are providing material or components, offering consulting services or publishing this initiative.

Alpha cubesat pretends to be the first satellite of a very long space route to be built. This technology demonstrator will be the seed and many other innovative opportunities and projects with cutting-edge technology will bloom due to it.

Alpha Mission is an example that space is accessible to everyone. From students that work in this project to big companies.

Alpha is the milestone that Andalusia needs to consolidate space sector in the region and point even higher.

Keywords: CubeSat NewSpace Altruist

P34 – POSTER DISPLAY

^{3}CAT-8 MISSION: A 6-UNIT CUBESAT FOR IONOSPHERIC REMOTE SENSING AND TECHNOLOGY DEMONSTRATION TESTBED

Luis Contreras, Ksenia Osipova, Guillem Gracia, Adriano Camps

UNIVERSITAT POLITECNICA DE CATALUNYA (SPAIN)

ABSTRACT

In recent years, small satellites for Earth Observation and communications have become a preferred cost-effective solution for private companies and research institutions. 3Cat-8 is a 6U CubeSat mission, the most recent one from the UPC NanoSatLab, and it has two main objectives:

1. As a scientific mission, it aims to characterize ionospheric effects on the propagation of radiofrequency signals by means of GNSS Radio Occultations (GNSS-RO), GNSS Reflectometry (GNSS-R), and multi-spectral imaging of the auroral emissions.

2. As a Technology Demonstration test-bed, it carries several novel systems onboard:

The first subsystem is a deployable Fresnel Zone Plate Antenna (FZPA). Occupying two CubeSat units, it uses a two-stage deployment system composed of melt-line that releases a spring mechanism, and motor driven stages. The melt-line system is derived from the 3Cat-4 mission NADS antenna and pushes the deployable arms out of the CubeSat structure. Then, three CFRP telescopic arms extend the reflector mesh. The FZPA has two RHCP beams in the fore and back directions for rising and setting GNSS-ROs. Other potential uses of this antenna include inter-satellite link communications and other remote sensing applications.

The second system is CuPID, an integrated dispenser for PocketQubes. CuPID will deploy two PoCat's for radio frequency interference (RFI) monitoring at L- and Ka-bands. It uses the same melt-line system for the actuation as the FZPA. Once deployed, they will support the continuation of the pioneer work on Federate Satellite Systems (FSS) started in the FSSCat mission. The PoCat's will use LoRa to communicate between them, the mother satellite, and the UPC Ground Station.

Finally, a novel multi-frequency L-, S- and X-band nadir-looking antenna will be used for GNSS-R and data downlink purposes. TT&C will be performed at UHF band: 435 MHz – radio amateur band- and 868 MHz -LoRa, ISM band.

Keywords: CubeSat, Nanosatellites, Earth Observation, Ionosphere, Technology Demonstration

P35 – POSTER DISPLAY

CORRELATION OF VIBRATION TEST RESULTS AND NUMERICAL SIMULATIONS OF A 3U CUBESAT STRUCTURE

Oscar Bouzas, Manuel Diz-Folgar, Lorena Conde, Alejandro García, Brais Fortes, Isaac Salgueiro, Alejandro Camanzo, Fernando Aguado-Agelet, Uxia García-Luis, Alejandro M. Gómez-San-Juan, Carlos Ulloa, Fermín Navarro

UVIGO SPACELAB (SPAIN)

ABSTRACT

Numerical finite element models are crucial in modern aerospace engineering for structural analysis. Their application enables the prediction of critical points within the actual structure, identified as areas that endure the highest stresses and strains during their operational life. In certain cases, it becomes essential to modify the structural elements at these critical points to ensure the structure's resilience under anticipated operational conditions.

However, to enhance computational efficiency and reduce costs, simplifications in the numerical model are often required. These simplifications, along with the inherent uncertainties in the materials and manufacturing processes of the actual structure, frequently result in discrepancies between the observed response of the structure and the numerical predictions. Such disparities could lead to potentially inaccurate evaluations of the structure's true mechanical capabilities.

To address this issue, it is vital to ascertain whether the developed numerical model accurately mirrors the real structure. In the research presented here, results were obtained from an experimental vibration campaign involving a 3U CubeSat dummy for the Wiptherm project at the University of Vigo. One of the main aims of these tests was to qualify the cubesat-format structure designed by UVigo SpaceLab for the BIXO mission. The collected data have been correlated and contrasted with numerically derived modal properties. The insights gained from this comparison are crucial in determining the fidelity of the numerical model, and whether the implementation of model updating techniques is justified prior to its application.

Keywords: Structures, AIV, Testing, Vibrations, CubeSats

P36

MARS SMALLSATS AND INSTRUMENTATION: SPANISH SCIENCE CONSORTIUM FOR METEOROLOGY AND SPACE WEATHER MONITORING

Alejandro Cardesin-Moinelo, Luca Montabone, The Spanish Science Consortium for Mars Meteorology & Space Weather

EUROPEAN SPACE ASTRONOMY CENTRE (SPAIN), IAA-CSIC GRANADA (SPAIN), PANEUREKA AND LABORATOIRE DE MÉTÉOROLOGIE DYNAMIQUE IPSL, SORBONNE UNIVERSITÉ (FRANCE)

ABSTRACT

We present here a Spanish consortium of Martian atmospheric and magnetospheric scientists, part of a larger international group, supporting the study and development of future mission concepts with small satellites and instrumentation that could be flown in orbit around Mars for meteorological and space weather monitoring, in line with the science and exploration priorities of ESA (SciSpaceE White Papers & TerraNovae2030+) and NASA (MEPAG Future Program).

Past and present Mars orbiters have provided great information on Mars surface and atmosphere, but focused mostly on targeted high-resolution measurements, lacking continuous global coverage. Mars atmospheric phenomena (clouds and dust storms in particular) and space weather (solar wind, aurorae, radiation, …) require global, continuous, and simultaneous observations to fully understand the dynamic variability of Mars climate and environment.

Several mission concepts involving satellite constellations have been studied in past years [Cardesin 2023, Montabone 2022&2021, Parfitt 2021]. These include satellite networks in different high-altitude orbit configurations, with great advantages for meteorology, space weather monitoring, and extra communication and navigation capabilities that could pave the way for future human exploration, providing services to other orbiters and surface assets.

We summarize here the science case study for a minimal mission concept, based on [Montabone 2021], defining scientific priorities and requirements for a network of 3 low-mass, low-cost small satellites in areostationary orbit (equatorial, circular at ~17000km altitude). The small scientific payload would monitor atmospheric and surface parameters, aerosol (dust & ice) clouds, magnetic field and solar wind interactions. The nadir-viewing remote sensing payloads should at least include a visible camera (<5 km resolution), and a thermal infrared multi-band imager (<60 km resolution), potentially enhanced with a UV mapper or a near-IR high-resolution spectrometer. The basic space weather package would consist of a magnetometer, solar wind ion and/or electron detectors, and a space radiation monitor.

Keywords: Small Satellites, Remote Sensing Instruments, Satellite Constellations, Mars Meteorology, Space Weather

P37 – POSTER DISPLAY

ST3LLAR-sat1 "BOIRA": OBC DEVELOPMENT BY INTEGRATING ON-BOARD DATA HANDLING AND COMMUNICATIONS

Antonio Hernández-Rodicio, Julia Schieffer, Eugenio Vladislav, Javier Palacios, Diego Navarro-Tapia, Andrés Marcos

UNIVERSIDAD CARLOS III DE MADRID (SPAIN)

ABSTRACT

The ST3LLAR-sat1 "BOIRA" is the first student CubeSat program established at the Universidad Carlos III de Madrid (UC3M). This program is integrated in its Master in Space Engineering (MISE) degree, and the aim for the first edition is to design, develop, and fly a 2U CubeSat with a scientific goal (of measuring atmospheric water vapour) as well as several technological goals, such as in-orbit operation of an in-house state-of-art compact communication antenna and advanced ADCS algorithms.

Within the CubeSat design process, the On-Board Computer (OBC) development is a key work line, as it is the system that will interface with the rest of the subsystems. One goal of the program is to perform the in-house design of the OBC of the satellite, as opposed to relying on a commercial-off-the-shelf (COTS) solution. This approach provides invaluable learning opportunities, but also comes with enhanced complexities such as component selection, adoption of radiation mitigation techniques and the design of an architecture that satisfies the mission needs.

The poster will include the design steps performed towards the final design review (FDR) in the framework of the European Space Agency Fly Your Satellite's Design Booster (FYS-DB) program. In particular, the on-board data handling (OBDH) hardware suite selection and the proposed physical architecture for the CubeSat ST3LLAR-sat1 "BOIRA" will be discussed.

Great care was taken on the selection of the microcontroller unit (MCU). The team performed a thorough literature review and trade-off analysis considering the MCU choice of previous CubeSats missions, particularly focusing on flight heritage, performance, available references and radiation tolerance data/resources. Also, other components such as external memory, RF transceiver and watchdog have been selected and will be integrated in a custom designed PCB board.

In addition, hardware/software mitigation techniques were researched, focusing on Single Event Effects, which are the primary concern.

Keywords: CubeSat, University, ESA FYS, OBC

P38

AUTONOMOUS FLIGHT TERMINATION SYSTEMS BASED IN SMART AVIONICS

Sergio Ramírez, Rafael Polonio, Alba Rozas, Jesús Zurera, Mariano Sánchez

SENER AEROSPACE AND DEFENCE (SPAIN)

ABSTRACT

Safety regulations identify the mission abort when the nominal flight envelope is potentially violated, resulting in unacceptable human risk levels. A traditional flight termination architecture ensures independency from the vehicle functional chain using a radar and telecommunication networks with human intervention in the decision-making process. This means: (i) considerable budget share for infrastructure and operations, (ii) limited flexibility (radar network needed), (iii) vehicle monitoring restricted to LOS conditions and (iv) delay inherent to communications and human reaction.

Thanks to the maturation of several technologies, it is possible to overcome those limitations by targeting autonomous concepts to move the termination decision on-board:
1. Improvement in GNSS technology and hybridization techniques.

2. Increase of computational capabilities to implement complex algorithms on-board.

3. Utilization of an efficient avionics SW execution platform based on emerging standards (e.g., NASA CFS) to isolate SW safety critical applications.

Within Europe, there is no clear standard on the design nor operation of an AFTS. The critical part of this type of standards is related to the management idiosyncrasy of the flight regulation in each country. The definition of non-flight areas and corridor is a task performed by range safety officer which should guarantee that a faulty launch could not endanger human lives. These tasks are obviously closely related own country regulations, making it difficult to have a common standard in Europe. It is proposed a highly configurable unit, in which the range safety officer could even include proprietary software for the termination logic.

The paper describes the general problem and the proposed solution for a European Autonomous Flight Termination System highly configurable by the user, which make is suitable for a broad range of launchers and countries. Sener is developing a AFTU demonstrator in the frame of the R&D EC Horizon Europe programme.

Keywords: Launcher, Software, Avionics, Autonomous Flight Termination System, Safety

P39

INTERNATIONAL USE CASES FOR QUANTUM KEY DISTRIBUTION – INT UQKD

Juan José Garrido[1], Pascal Rogiest[1], Rubén Pérez[2]

[1]RHEA SYSTEM (LUXEMBOURG),[2]RHEA SYSTEM (SPAIN)

ABSTRACT

The computational power of anticipated Quantum systems within the next 15 years stresses the requirement to prepare for increasingly sophisticated threats to the cyber systems that our critical infrastructure and democratic institutions rely on. Notwithstanding the tremendous opportunities and advances offered to contemporary society by quantum-based technologies, unfortunately, powerful quantum computers will also enable the ability to break today's "unbreakable" encryption in a matter of minutes thereby placing at risk sensitive information of vital interest to western governments and commercial entities.

Communication privacy is a legislated citizen's right, a security and defence tool, a driver for economic growth, and a vital factor for the smooth functioning of markets. The vision for the INT-UQKD is to provide a set of global operational End-to-End secure hybrid Space-Terrestrial network quantum communication use cases tailored to actual commercial user needs, permitting the secure exchange of information and data, the long-term protection of stored data, and the protection of critical infrastructure through using QKD technology, but not limited to it, but leveraging Quantum Cryptography with other classical and post-quantum cryptography tools to provide a practical system that can be used in the current commercial context. The backbone of the key distribution is based on a fibre terrestrial network and in a LEO based Space Segment, with free space optical communications capability to ground stations. The system is designed to provide maximum scalability and interoperability, allowing future incorporation of potential additional 3rd party GEO and MEO satellites with the possibility to interface with other QKD initiatives.

The ultimate goal of INT-UQKD is to implement a flexible, resilient and accessible system with global coverage that can enable quantum secure communication and cryptographic services for private and governmental users.

Keywords: LEO, Quantum Key Distribution, Optical communications, Secure communications

P40 – POSTER DISPLAY

CONTROL OF SMALL SOLAR SAILS BY MEMS ACTUATION FOR EARTH ESCAPE TRAJECTORIES

Alexander N. Alvara[1], Kristofer S. J. Pister[2]

[1]DEPARTMENT OF MECHANICAL ENGINEERING, UNIVERSITY OF CALIFORNIA, BERKELEY (UNITED STATES); [2]DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE, UNIVERSITY OF CALIFORNIA, BERKELEY (UNITED STATES)

ABSTRACT

We have previously proposed the use of MEMS motors to control an autonomous ten-gram interplanetary spacecraft. The motors are used to pull on the carbon fiber lines running from the spacecraft body to the solar sail. Adjusting the length of these lines controls the center of mass of the spacecraft relative to the thrust line of the sail, thereby providing control of the pitch and roll of the spacecraft. Pitch and roll control are sufficient to allow the spacecraft to navigate near earth and in interplanetary space.

MEMS electrostatic inchworm motors are millimeter-scale linear motors capable of milliNewton forces and many centimeter per second speeds. They provide position control of fiber displacement with two-micron accuracy.

We demonstrate simulations of earth escape trajectories using a continuous time dynamic model of the spacecraft orbital parameters and orientation coupled with a discrete time model of the MEMS motors. We assume perfect knowledge of the current orbital parameters. The MEMS motors are modeled as displacement generators with 2-micron resolution, +/-10 centimeter maximum displacement, and +/-1.0 mm/s maximum velocity. The orbital rate control law from McInnes [4] is used with a modification to limit the maximum cone angle to +/-70 degrees so that the spacecraft can always maintain control authority. A PID controller is used to generate motor control signals, which are then subject to the limits above.

Simulation results show that a ten-gram spacecraft with a 1 m2 sail should be able to reach interplanetary space from GEO in ~125 days. Other simulation results include variations in parametric analysis of the effect of initial radial position, orientation, and lightness number.

Additionally proposed is a conceptual integration of the findings into a civilian science-to-reinforcement learning workflow and broadening the applicability of the research to cometary sample collection beyond its immediate scope.

Keywords: Solar sail, MEMS, COTS, Earth-Escape, Femto-spacecraft

P41

S-BAND COMMUNICATION SUBSYSTEM FOR LEOpar, A COLOMBIAN CUBESAT-TYPE HYPERSPECTRAL MISSION

Joe Rolando Salas[1], Julián Rodríguez[1], Ignacio Acero[2], Sonia Rincón[3], Francisco L. Hernández[4]

[1]UNIVERSIDAD INDUSTRIAL DE SANTANDER (COLOMBIA), [2]UNIVERSIDAD SERGIO ARBOLEDA (COLOMBIA), [3]CITAE FUERZA AEROSPACAIAL COLOMBIANA (COLOMBIA), [4]UNIVERSIDAD DEL VALLE (COLOMBIA)

ABSTRACT

Satellites are fascinating but expensive, generally affordable exclusive for governments, the military industry, and, recently, billionaires and big companies. However, the CubeSat standard has encouraged universities and small businesses to develop, build, and launch in orbit their space experiments. Recently, a joint initiative between the Colombian government (Ministry of Sciences and Colombian Air Force) and academic researchers from the diverse universities, has sought to develop LEOpar: a scientific mission for Earth observation using a CubeSat 3U (1U = 10x10x10). LEOpar's main objective is the detection of deforestation and illegal logging through hyperspectral image cubes captured by a payload subsystem designed explicitly for this purpose, called ANFA, a hyperspectral camera developed in the country. ANFA, the payload subsystem could produce at least 300 MB per day, prompting the need for a dedicated communication link to download scientific data between the spacecraft and a ground station. This article presents the selection of the communication subsystem for LEOpar's S-band at 2.2 GHz, composed of the radio transmitter, our low-profile antenna, and its respective connectors, using commercial off-the-shelf (COTS) electronic components. The subsystem must consume less than 12 W and be compatible with the satellite bus hardware based on the PC104 standard. The available space is less than 0.14 U, making the design and selection challenging. The study delves into the implications of path attenuation and other link deficiencies encountered along the communication path for the 550-kilometer low Earth orbit (LEO) space mission. To analyse and evaluate these aspects, advanced simulation tools such as Systems Tool Kit (STK) and ANSYS are employed. These tools allow for a thorough examination of the transmission quality, determining the Bit Error Rate (BER). This quantitative measure serves as a key indicator in evaluating the overall effectiveness and reliability of the communication link under the identified conditions.

Keywords: CubeSat, Satellite, Communications, STK, Earth-observation

P42 – POSTER DISPLAY

ST3LLARsat1 “BOIRA” CUBESAT: STRUCTURAL ANALYSIS AND SELECTION

María R. Villar, Brais Garcia, Gabriele Dessena, Andrés Marcos

UNIVERSIDAD CARLOS III DE MADRID (SPAIN)

ABSTRACT

The ST3LLAR-sat1 “BOIRA” is the first student CubeSat program established at the Universidad Carlos III de Madrid (UC3M), as part of the Master in Space Engineering (MISE) course. The aim is to design, develop and fly a 2U CubeSat. The scientific goals are to measure atmospheric water vapour for meteorological conditions assessments, to test the in-orbit operation of an in-house state-of-art compact communication antenna and to employ advanced Attitude Determination and Control System (ADCS) algorithms.

The frame is the primary structure of the CubeSat providing mechanical support to the subsystems boards and payload. In Baseline Design Review (BDR), the in-house development of the structure was foreseen to improve the students’ experience in designing space structures. However, this was later changed in favour of an off-the-shelf component to reduce risks and the production timeline. The NPC Spacemind 2U frame was selected after iterating with several available options by analysing their technical specifications against the project requirements. Then, feedback from ESA prompted a change to the CubeSat internal configuration, improving the subsystems location.

At this moment, the structure dynamics are being analysed to consolidate the selected configuration and to plan the test campaign. Analyses of the structure and the antenna are carried out under identical conditions to demonstrate that they can be tested in the same shaker simultaneously. The expected loads are obtained from several launchers manuals, such as Vega-C, Ariane 6, Falcon 9 and PSLV, and the worst-case loads during flight have been considered.

In conclusion, an accurate verification process is being performed to design and run a successful testing campaign, preventing mechanical failures during flight and ensuring the safe operation of the craft.

Keywords: CubeSat, Structure, Dynamics, Loads, Finite Element Analysis

P43

ST3LLARsat1 BOIRA: FROM BDR TO FDR, A SUCCESSFUL UNIVERSITY HAND-OVER ITERATION

Andrés Marcos, Diego Navarro-Tapia, Gabriele Dessena, Andoni Moral, Carlos García, Daniel Jiménez, Vládik Cegarra, María Rodríguez, Andrés Rabuñal, Fernando Solano, Jaime Ruiz, Antonio Hernández-Rodicio, Brais García, Julia Schieffer, Ghasem Sharifi

UNIVERSIDAD CARLOS III DE MADRID (SPAIN)

ABSTRACT

The ST3LLAR-sat1 "BOIRA" is the first student CubeSat program established at the Universidad Carlos III de Madrid (UC3M). This program is integrated in its Master in Space Engineering (MISE) degree, and the aim for the first edition is to design, develop, and fly a 2U CubeSat with a scientific goal (of measuring atmospheric water vapour) as well as several technological goals, such as in-orbit operation of an in-house state-of-art compact communication antenna and advanced ADCS algorithms.

The ST3LLAR-sat1 program started in September 2022 and was selected by ESA in December 2022 to participate in its first Fly Your Satellite's Design Booster (FYS-DB) program. This program lasts 1.5 years and is roughly divided into two phases: Baseline Design Review (BDR) and Design Consolidation (FDR). The first phase concluded in March-May'2023, and the second phase will end in March-May'2024. The goal of this ESA time-constrained, pilot program is to support European university teams to consolidate a detailed CubeSat design. The first call was participated by 12 teams of which 5 were selected.

Two critical, inherent, and unavoidable risks for any university CubeSat program are the work continuity and student hand-over. In ST3LLARsat1 case, these risks were compounded in that alignment with ESA FYS-DB program created a continuity gap during the summer months.

In this article, a presentation of the current status of ST3LLARsat1 is given, highlighting the modifications performed between BDR and FDR, and demonstrating how alignment with a formal educational degree has helped to successfully avoid (but not without effects) the aforementioned continuity and hand-over risks. Currently, the phase-II UC3M team is composed of 3 professors, 1 research associated, 2 PhD students, 3 undergraduate students, and 33 MISE students. The previous risks were avoided by using a sequential structure of the MISE courses plus overlap of student work.

Keywords: CubeSat, University, ESA, FYS, Climate Change

P44

CHALLENGES AND OPPORTUNITIES IN LUNAR CUBEST LAUNCH PROCUREMENT

Daniela Jovic, Jakub Kapus

SPACEMANIC (CZECH REPUBLIC)

ABSTRACT

The increasing interest in lunar exploration has sparked a demand for launching satellites to lunar orbits. However, procuring launch opportunities for these spacecrafts poses significant challenges. Spacemanic's presentation explores the obstacles and complexities involved in booking a launch for future lunar missions.

The presentation will address technical hurdles such as launch vehicle readiness, payload capacity, and trajectory requirements, along with regulatory frameworks and legal matters beyond LEO.

Practical experiences in booking launches for lunar orbits involve comprehensive mission planning, detailed risk assessments, and early engagement with launch providers. Understanding the specific requirements of lunar missions, fostering partnerships, and leveraging innovative solutions are key factors in successfully procuring launch opportunities for CubeSats destined for the Moon.

Spacemanic, as a turnkey nanosatellite solutions provider, highlights the multifaceted nature of lunar CubeSat launch procurement, emphasizing the need for a holistic approach to overcome challenges, explore commercial avenues, and facilitate future lunar exploration.

Keywords: Lunar, CubeSat, Launch, Procurement, Nanosatellite

P45

DEPLOYABLE NAVIGATION CAMERA MAST FOR LUNAR ROVER

Gorka González, Eduardo Urgoiti

SENER AEROSPACIAL (SPAIN)

ABSTRACT

A Deployable mast for small lunar rover has been designed, implemented in the rover and flown in the last year in a low-cost mission to the moon showing a different way of implementing space projects for space exploration. The mast is stowed for launch and once deployed on the moon surface is in charge of pointing a navigation camera in two axes with customized actuators and electronic drivers. The design and construction of all elements, structure, mechanical or electronics have been selected among novel technologies which, at the same time, show good confidence in the predicted performance of the unit.

Keywords: Deployable, Gimbal, Pointing, Navigation

P46

ALISIO-1 COMMISSIONING AND OPERATION

Ynigo, A.; Colodro, C.; Sidrach-Cardona, I.; Sordo, Sanluis, J.C.; Rodríguez, D.; González de Chaves, P.; Delpueyo, X.; Alonso, J.; Oscoz, A.

INSTITUTO DE ASTROFÍSICA DE CANARIAS IAC (SPAIN)

ABSTRACT

The satellite ALISIO-1, launched December 1st, 2023, will enter in nominal operations in February 2024. Since it was launched, it has completed a successful commissioning in orbit and both payloads are in their way to start the nominal operations phase.

ALISIO-1 is devoted to the monitoring of natural disasters, such as wildfires, oil spills and flooding events. Furthermore, during routine operations it will also has the capability of supporting in the creation of humidity maps, which are very relevant for the creation of wildfire risk maps and for the monitoring of wetlands and crops.

The proposed talk will focus on demonstrating these use cases using the first images obtained during the commissioning of DRAGO-2 onboard the satellite ALISIO-1. It will also show, if they are available, the first results of the optical communications link between ALISIO-1 and the Optical Ground Station in Tenerife.

The creation of an affordable constellation of these satellites will be also analyzed. This constellation could ensure a revisit time of one day at a very low cost, providing accurate and updated information to emergency response teams.

Keywords: Satellite, Operations, SWIR applications, ALISIO-1, Constellation, SWIR

P47

NOVEL APPROACH TO RADIATION TESTING ON SMALL SATELLITES

Manuel Morales, Manuel Domínguez, TBDz

ALTER TECHNOLOGY (SPAIN)

ABSTRACT

The growing demand for small satellites has emphasized the need for reliable and cost-effective methods of radiation validation. This proposal introduces a novel approach utilizing the CHARM (CERN High-energy AcceleRator Mixed-field) facility for the radiation testing of small satellites. CHARM, a mixed-field irradiation facility, closely replicates the complex radiation environment encountered in space, making it an ideal platform for this purpose.

CHARM's ability to generate a mixed-field radiation environment through the interaction of a 24 GeV proton beam with a metallic target enables a comprehensive assessment of cumulative radiation effects, including Total Ionizing and Non-Ionizing Doses. Unlike conventional irradiation facilities, CHARM provides a homogeneous high-energy radiation environment covering its entire irradiation hall. This unique feature facilitates the testing of full satellite systems, not just components, in a realistic spatial radiation distribution. The spatial homogeneity of the radiation field in CHARM allows for a more realistic and thorough testing process, which can significantly enhance the reliability of satellites in space.

Furthermore, CHARM's capability to mimic the proton environment in space, with a focus on Single Event Effects (SEEs), is particularly advantageous. By scaling observed experimental results to space conditions, CHARM offers similar levels of assurance as conventional high-energy proton testing. This method not only ensures the reliability of satellite systems against radiation effects but also reduces the need for expensive and time-consuming in-orbit testing. This directly correlates to the space environment, allowing for precise emulation and testing.

The use of CHARM for small satellite radiation validation presents a cost-effective and time-efficient alternative to traditional methods. It reduces the need for multiple testing setups and allows for more comprehensive testing within shorter timeframes. For budget-conscious projects, this approach can be a game-changer, offering high levels of performance assurance without the hefty price tag and extended timelines of traditional space radiation testing methods.

In conclusion, leveraging CHARM's advanced radiation testing capabilities for small satellites represents a significant step forward in the space industry. It offers an effective solution for the validation of satellite resilience to space radiation, ensuring reliability and performance while minimizing costs and testing durations.

Keywords: Radiation, TID, SEE, CHARM, Cost-effective

P48

THERMAL INSIGHTS: CUBESATS'S REDUNDANCY IN ORIENTATION DETERMINATION

Yanina Hallak[1], Fermín Navarro[2], Andrés Villa[1], Alejandro Gómez[2], Uxía García[2], Carlos Ulloa[2]

[1]UARX SPACE (SPAIN), [2]UNIVERSITY OF VIGO (SPAIN)

ABSTRACT

CubeSats have emerged as indispensable tools in academia and as technological demonstrators, playing a crucial role in space exploration. Their low cost has significantly reduced the likelihood of redundancy in any subsystem, making them an attractive option for various missions. One critical subsystem is the attitude determination system, which faces constraints in terms of the number and precision of sensors it can accommodate. Typically, CubeSats rely on a few fine or coarse sun sensors and occasionally a magnetometer with less-than-optimal precision, except in the case of fine sun sensors. Otherwise, thermal analysis may become a standard practice in CubeSat design in near future, due to is relatively cheap cost. An additional application to thermal control, thermal analysis may involve estimating orientation. By leveraging time-series temperature data of target orientation and current orientation, CubeSats can estimate their orientation with an error comparable to than that of coarse sun detectors or magnetometers. Some authors propose a model-based approach for CubeSat attitude estimation, leveraging onboard temperature sensors to enhance accuracy. Others, addresses attitude estimation enhancement by combining temperature sensors and magnetometers. Finally, some others propose a method integrating sun sensors and temperature sensors, showcasing the potential of combining multiple sensor types for precise orientation estimation. Our approach advocates for the utilization of the thermal model developed in ESATAN, originally developed for thermal analysis. Through an iterative process, we calculate temperature differentials concerning the target orientation. This method also serves as a sensitivity study, probing how the thermal model responds to deviations from the target orientation. By systematically assessing temperature variations in relation to the desired orientation, our iterative process enhances our understanding of thermal performance under different orientation scenarios.

Keywords: Attitude determination, Thermal analysis, Small satellites, CubeSats

P49

COMMUNICATION ANTENNAS FOR LUR-1 MISSION

Fernando Teberio, Itziar Maestrojuán

ANTERAL (SPAIN)

ABSTRACT

The LUR-1 mission includes a 50 kg microsatellite. For this microsatellite, Anteral has developed several planar antennas covering the S- and X-band. In the case of S-band, two different antennas have been developed.

The first S-band antenna covers the Tx and RX bands with two different patches. These patches provide more than 5dB gain and operate in circular polarization with axial ratio levels better than 1.5 dB typical value.

The second S-band antenna is a wideband (2-2.3GHz) and wide beam antenna which provides more than 6.5dB in boresight and whose beamwidth is around 90°. In addition, this antenna offers circular polarization of high purity in a wide beamwidth, giving values of 1.5db typical in boresight and <5dB in angle.

In the case of the X-band antenna, a flat antenna array has been developed that offers more than 18.5dB gain and circular polarization. The axial ratio of the antenna is less than 1 dB.

Finally, Anteral has also developed a UHF monopole antenna operating at 400MHz.

All these antennas have been qualified and will flight in 2024.

Keywords: Antennas, Communications, Small Satellites

P50

SPACE-GRADE OPTICAL FIBRE FLEX CIRCUITS AND MULTI-FIBRE CONNECTORS FOR HIGH-SPEED PAYLOAD DATALINKS

Davinder Basuita

GLENAIR (UK)

ABSTRACT

Next generation space platforms are becoming increasingly reliant on high speed and high-density communications with the demand for bandwidth being driven by emerging data hungry protocols such as 10 Gigabit/s Ethernet, Fiberchannel, ARINC 818, sRIO, SpaceFibre, the adoption of FPGAs with I/O rates up to 28Gbps and increasing requirements for the use of high-definition video formats. Numerous applications within the space sector within high throughput satellites and spacecraft payloads are driving the need for ultra-reliable and high-speed datalinks for both digital and RF signal transmission over optical fibre. This presentation will showcase a number of advances in the development of fibre optic interconnects including optical flex circuits combined with multi-fibre array optical connectors for high density board to board and board to backplane applications. These solutions are highly tolerant to the adverse environment of space applications and are key enablers for future high performance high data rate systems.

Keywords: Satellite, Communications, High-speed interconnects, Small fast and compact

P51

NON-EXPLOSIVE LIGHT, MEDIUM AND HEAVY-DUTY HDRMs, PIN PULLERS AND PIN PUSHERS FOR SPACECRAFT SATELLITE HOLD DOWN AND RELEASE

Ana Fernández

GLENAIR (SPAIN)

ABSTRACT

Hold-Down and Release Mechanisms are electromechanical devices used in the deployment of satellites and other payloads in space. Supplied in various formats and measured-release preloads, the devices are optimized for foolproof release-reliability with built-in mechanical and electrical redundancy. In non-pyrotechnic HDRMs, the planned release of the deployable satellite/payload is activated by a pre-determined value of electrical current to a fuse-wire system which causes the wire to break under tension and allows a pre-loaded mechanical bolt to actuate. The Technology is extremely reliable, offers an exceptionally favourable ratio of its weight to the load it can hold, features extremely fast release time and correspondingly low energy consumption. Many of the units on offer already have flight heritage, all of them have successfully completed an extensive qualification process. Glenair's line of low-shock, redundant and non-redundant space mechanisms includes both HDRM devices as well as a family of pin pushers and pin pullers. Customer-defined housing and mounting configurations are available.

Keywords: Satellite, Launchers, Release mechanisms

P52

ANSER CLUSTER – FIRST IN-ORBIT RESULTS OF A DEMONSTRATION OF RESILIENCE AND FLEXIBILITY

Santiago Rodríguez, César Arza

INTA (SPAIN)

ABSTRACT

The three 3U Cubesats that at first would comprise the ANSER cluster where launched on 2023/10/09 to their sun-synchronous initial orbit. Although one of them was unfortunately lost due to a launcher failure, the mission is by no means lost and the first months in orbit of the two remaining satellites are an "in practice" proof of the resilience and flexibility that small satellites clusters can provide as a new approach to contemporary space missions.

This presentation will show how the in-orbit satellites have been able to cope with the mission despite the loss of one of the components of the cluster by means of a flexible approach, as well as a summary of the actions performed during these first months, including the first water quality scientific results provided by the CINCLUS payload (high spectral resolution spectrometer) and how the innovative passive formation flight control is being tested in orbit while at the same time it is used to bring the satellites to their definitive operative orbit and geometric configuration.

Finally, and flying the flag of the resilience of small satellites clusters, the future of the mission, including the fast and efficient reposition of the lost component of the cluster will be outlined, as an example of how small satellite clusters can present an operative and innovative approach with respect to monolithic mission.

Keywords: Cubesat, Cluster, Passive flight formation, Water quality, Spectometer

P53

EFFICIENT AND SUSTAINABLE "ACTING" IN SPACE

Fernando Gandía, Joaquín Estremera, Manuel Prieto, Mariella Graziano

GMV (SPAIN/ITALY)

ABSTRACT

The European space sector is experiencing an unprecedented era of awareness regarding the need for long-term sustainability of space projects. A real commitment towards a socially and environmentally responsible development of space activities will be needed in all areas.

The assumption of a Zero debris policy by ESA is one of the pillars of the space sustainability. To cope with this objective, it is key to guarantee successful disposal of all space assets in any condition. In the latest years ESA has taken a proactive role in the area of Active Debris Removal (ADR) by preparing the new generation of Earth Observation satellites for a potential removal as part of their End-of-Life management. In this respect, the six Copernicus Sentinel Expansion Missions have adopted the Design for Removal Interface Requirements Document produced by ESA and are taking the required actions to implement it. As part of the technology development required to equip these satellites, GMV and AVS have designed, manufactured, and validated a passive capture interface: MICE, which has recently finalised its qualification and will be onboard the new Copernicus, enabling its uncooperative capture and deorbiting at End of Life.

In parallel, the same consortium led by GMV is developing the technologies for capture and removal at the servicer satellite side, including the development of a compatible end-effector, clamping devices, optical navigation, avionics and control functions required to perform all the associated operations. Most of these elements have undergone development and functional verification in the frame of recent activities and are now being consolidated and integrated within a single/unified system: CAT – the Return Capture Payload Bay, which is intended to become the key payload onboard a future ADR servicer satellite. The baseline ADR Mission concept considered by ESA consists of capturing and carrying out a controlled deorbit of the Sentinel failed in orbit, potentially using a vehicle (or even a modified upper stage) launched together with the replacement Sentinel satellite. CAT role in this scenario is that one from a specialized payload acting in coordination to the servicer GNC to perform the last approach navigation (from 5m up to capture), capture, stabilization and securing of the stack for de-orbiting the failed/uncontrolled S/C.

On-orbit servicing and on-orbit assembly are also expected to have a significant and growing impact in the space industry in the next years and will significantly contribute to a more efficient space ecosystem by optimising launch costs and making possible new Mission schemes. In particular, the deployment of large structures in orbit is expected to be an essential and recurring operation for future efficient space ecosystem. The capability to assemble large structures in orbit would allow deploying arbitrarily large telescope mirrors and radar/communication reflectors, which parts could be disposed by one or several launchers. The capability to provide in-orbit servicing could increase

lifespan, performance or even change the mission objective of a space system using modular spacecraft designs. The Multi-arm Installation Robot for Readying ORUS and Reflectors (MIRROR) is an ESA-funded activity lead by GMV, that has produced the first ever European prototype of a self-relocatable robotic system for on-orbit operations, particularly on-orbit large structure assembly and spacecraft servicing for maintenance, repairs or upgrades.

Keywords: Zero Debris, Active Debris Removal, IOS, IOA

P54

DEVELOPMENT OF NOVEL LOW-PROFILE AND HIGH SURFACE EFFICIENCY ANTENNAS FOR SMALL SATELLITES

Miguel A. Salas-Natera, Carlos Martínez, Ramón Martínez

UNIVERSIDAD POLITÉCNICA DE MADRID (SPAIN)

ABSTRACT

In the development of this work, a study and design of a low profile and high gain antenna for small satellites integrated with power sub-system in the Ka band has been carried out. To achieve this, an innovative design is proposed that includes a specific methodology for the type of mission and antenna technology, and specific novel unit cells that make up the antenna surface. In the literature several works about solar-panel integrated antennas are presented but any with high polarization purity and high gain performance using ITO material.

After reviewing the current industry and future missions needs requirement such as those for cis lunar communications in small satellites is proposed. Furthermore, it is concluded that the antenna to be carried out is a reflectarray surface that can achieve reconfigurability by different techniques analysed. In this sense, phase array and digital antennas are considered as feed antenna elements.

In the design, a proprietary methodology has been created and several prototypes have been designed, starting with simple elements used nowadays, gradually increasing complexity to obtain better results, and ending with a proposal to improve current designs. Following we present one implementation example for Ka band antenna system. Blue box represent a proposed location for the feed element. This can be modelled for different Cubesat configurations.

The results show high performance in polarization purity as well as in antenna efficiency. This technology permits the development of optimum gain for mission depending on the available surface at the time that for LEOP mission phase or low accuracy attitude control this technology make large distances and high data-rate communications feasible. The prototype for technology validation will be presented during the conference.

Keywords: CubeSat, Smallsats, Power and antenna sub-systems

P55

PROGRESS ON HIGH-POLARIZATION PURITY ANTENNAS FOR CALIBRATION OF CMB INSTRUMENTATION ONBOARD CUBESATS AT X, KA AND 0.22 TP 0.27 Thz BANDS

Miguel A. Salas-Natera, Carlos Martínez, Álvaro Fernández, Julio Gallegos, Marcos López, Xavier Dupac

UNIVERSIDAD POLITÉCNICA DE MADRID (SPAIN), EUROPEAN SPACE AGENCY (ESA), EUROPEAN SPACE ASTRONOMY CENTRE ESAC (SPAIN)

ABSTRACT

This work gives an overview the main aspects concerning the design of ultra-low-profile CubeSat antennas for the scientific mission with high-polarization-purity calibration payload within CUBIQU (CUBesat for I.Q.U) program from ESA. However, this paper is focused on the proposed ultra-low profile and high-polarization purity antennas based on microstrip patch antenna array technology at Ka band and on novel frequency selective surface (FSS) for high purity instrumentation at 0.22 and 0.27 Thz.

This antenna is an on-board Cubesat polarization source for astronomical instrumentation operating at 30 GHz. In this sense, the cross-polar discrimination required is 42.9 dB and 55.2 dB for 0.2° and 0.1° of precision, respectively. During this work it has been successfully proposed an approach regarding the current distribution for the enhancement of the linear polarization purity, allowing values of XPD in printed microstrip antennas around 50dB for more than +/-50° of off-axis angular range.

For future works, it has been analyzed FSS technologies that provides also high performance in terms of polarization purity thanks to the optimized design at the time that large bandwidth is achieved. This technology survey for CMB instrumentation is made at the frequency bands above 0.17 Ths where two specific bands at 0.22 Thz and 0.27 Thz are analysed.

During the conference, measurement results of prototypes will be presented. The results validate the expectation from design as well as confirm the manufacturing technologies used. Following we present two examples of the elements manufactured. At left, manufactured ka band antenna. At right, 0.2 to 0.3 Thz high polarization purity FSS (manufacturing deviation less than 1um). Prototypes will be presented in the conference.

Keywords: CubeSat, Smallsats, Scientific missions, CMB

P56

0.1 TO 0.3 Thz ANTENNA TECHNOLOGY FOR SCIENTIFIC, INTERPLANETARY AND LUNAR MISSIONS ON BOARD SMALL SATELLITES

Miguel A. Salas-Natera, Carlos Martínez, Álvaro Fernández, Jorge Teniente

UNIVERSIDAD POLITÉCNICA DE MADRID (SPAIN), UNIVERSIDAD PÚBLICA DE NAVARRA (SPAIN)

ABSTRACT

In this work, a study and design of a low profile and high gain antenna for small satellites and Thz communication systems has been carried out. Note that deep space CMB measurements system also operates at this frequency range. To achieve this, an innovative design is proposed, and specific novel unit cells that polarize the field obtaining high purity circular polarization performance has been developed and validated. In the literature, several works about quasi-optical antennas are presented but any with high polarization purity and high gain performance at this frequency band.

The capacity of the future systems is expected to be much higher, while terabits per second (Tbps) is the call into sixth generation (6G) systems. Regarding satellite communications systems of the future, it can be expected to operate in the Thz challenging frequencies. However, there are many enabling technology to be optimized such as new modulation equipment, signal regeneration, antennas, and power systems. Improved quasi-optical higher-gain antenna are key corner components in the roadmap.

The concept of quasi-optical antenna design is not new as early high gain microwave antennas were mainly derived from their optical counterparts. Since Thz antenna systems operating wavelengths are small, their low-profile fits into small platform achieving compactness, low weight and cost (depending on electrical-mechanical design and manufacturing). On the other hand, manufacturing and measuring quasi-optical antennas are more complex. New technologies, materials and processes are needed to overcome actual bottleneck.

Following we present a scenario of interplanetary communications where Thz are proposed to support several links. In Figure 2 results show high polarization purity as well as the large frequency band obtained. This design provides CP and XP mode with extreme large bandwidth. The prototype for technology validation will be presented.

Keywords: CubeSat, Smallsats, Interplanetary, High Datarate, Low latency

P57

FROM LOW EARTH ORBIT TO THE LUNAR SURFACE – 23 YEARS OF SMALL SATELLITES AT MONTANA STATE UNIVERSITY (USA)

David Klumpar, Larry Springer, John Sample

DEPARTMENT OF PHYSICS, SPACE SCIENCE AND ENGINEERING LABORATORY, MONTANA STATE UNIVERSITY (UNITED STATES)

ABSTRACT

The Space Science and Engineering Laboratory (SSEL) immerses students directly in the development of small space systems. Mentored and tutored by faculty and a small engineering staff, student teams develop CubeSat-class systems from the ground up, performing all elements of design, development, fabrication, testing, spaceflight qualification, launch, and in-space operations and data analysis. Experiential learning and professional development for undergraduate and graduate students are fundamental to the program, and the space systems they develop perform targeted scientific measurements that contribute to the understanding of the space environment. Thirteen CubeSat-class objects have been developed and delivered for launch since the laboratory's founding in 2000. New space systems awaiting launch include a CubeSat-class experiment that will monitor solar flare hard X-rays from the International Space Station at unprecedented time scales, and another experiment is being carried to the lunar surface by Firefly Aerospace's Blue Ghost Lander in late 2024. This presentation will briefly summarize SSEL's history and provide perspectives on the past, present, and future of small satellites. Lessons learned--of value to academic as well as to commercial developers--will be offered.

P58

SOLAR ARRAY TECHNOLOGY QUALIFICATION FOR LEO SMALLSAT MISSIONS

Miguel Ramiro, Ismael Sánchez, Vicente Díaz, Miguel A. Vázquez

DHV TECHNOLOGY (SPAIN)

ABSTRACT

DHV Technology, with the aim to provide the most reliable power solutions to its customers, has ventured to qualify its solar array technology for current and future market demands. The space environment is inhospitable for humans, more so for solar arrays which are left unprotected from the heat of solar radiation and the emptiness of space often experiencing both extreme heat and cold thousands of times per year. Representative solar array samples (DVT) are subjected to these conditions in cryogenic temperature chambers, closely monitoring their health. The aim of DHV is to ensure the safety of its products, providing an ever-growing space market thoroughly tested solution. DHV expects to qualify its technology for 5 yearlong missions at the end of 2024.

Keywords: Qualification, Thermal Fatigue Tests, Solar arrays, SmallSats

P59

SCHUMANN – SATELLITE CONSTRUCTION KIT FOR NEW SPACE ECOSYSTEMS

Pierre Letier[1], Andres Martin[1], Jeremi Gancet[1], Daniel Silveira[2], Carolina Serra[2], Hugo Castaing[2], Giuseppe Mistritta[3], Ignacio Chechile[4], Theodor Neacsu[4], Carsten Plasberg[5], Martin Schulze[5]

[1]SPACE APPLICATIONS SERVICES NV/SA (BELIGIUM), [2]GMV (PORTUGAL), [3]ARIANEGROUP BREMEN (GERMANY), [4]REORBIT OY (FINLAND), [5]FZI FORSCHUNGSZENTRUM INFORMATIK KARLSRUHE (GERMANY)

ABSTRACT

NewSpace, beyond its trendy tone, denotes a fundamental transformation of the space industry and applications landscape – a deep paradigm shift, which was initiated a few years ago and operates progressively. Applications such as life extension, by means of Orbital Replacement Units (ORU), refuelling, in-space assembly and reconfiguration, in-space recycling are promising New Space applications.

SCHUMANN is a Horizon Europe research activity aiming to strengthen the foundations of future space ecosystems for modular spacecraft and the perspective of their assembly, servicing and reconfiguration in space.

The first objective of the project targets to develop and mature a functional Spacecraft module consisting of a Refuelable Tank (RTa), along with a Refuelling Experiment setup to support the testing and the qualification of this module to TRL-6. This task will demonstrate that a "side", standalone module development, by following appropriate design rules and leveraging previous building-blocks developments, can be integrated at a late stage into an in-Orbit Demonstration (IOD) mission. The module will implement the HOTDOCK standard interconnect, as the refuelling interface.

The second objective aims at establishing a reference "Satellite Construction Kit" (SCK), primarily to the attention of Functional Spacecraft Module (FSM) builders, to guide them in the selection of components and help create a unified ecosystem for space applications. SCK target users are the manufacturers of spacecraft modules. It aims to increase the modularity of NewSpace spacecraft by establishing a set of guidelines and norms supporting FSM developers. As part of this project, the SCK will be implemented as a software tool which will facilitate the process of selecting compatible components for FSM, and ensuring that resulting "SCHUMANN certified" modules can be conveniently and effectively integrated in a spacecraft ecosystem.

Keywords: Spacecraft Modules, Refuelling, In-Orbit Servicing, ISAM

P60

SPANISH TECHNOLOGY: KEY CONTRIBUTIONS TO NASA'S ARTEMIS LUNAR PROGRAM

Fernando Gómez-Carpintero

AIRBUS-CRISA (SPAIN)

ABSTRACT

NASA led Artemis program will take humanity back to the Moon. Technology made in Spain is present in this new era of human exploration in Space. Airbus Crisa provides key elements to the Orion Spacecraft and the lunar Gateway, two major components of the Artemis program.

Orion is a manned vehicle whose primary mission is to send up astronauts into Space, beyond the Moon, and return them safely to Earth. Orion has a European contribution, the European Service Module, responsible for providing with propulsion, power, consumable storage and thermal control.

For the ESM Airbus Crisa has developed the Thermal Control Unit, vital for Crew's survival during the journey. The TCU acquires the parameters of the service module related to thermal control and also to air and water supply. It measures temperatures, pressure, quantities of gas or liquid in tanks, sends this data to the computer for it to generate the necessary commands and send them to the TCU, which will be in charge of opening or closing valves, turning on and off the heaters and commanding the pumps used to inject water or air into the manned module.

Gateway is the station that will be orbiting the Moon. For the lunar Gateway Airbus Crisa is providing the Power Management and Distribution Subsystems for HALO and iHab modules. These subsystems ensure that the power needed for all Gateway elements is available at all times and with the right electrical conditions and characteristics to guarantee their optimal operation with maximum efficiency. The units we are developing are the largest we have made so far in the order of 100kg, very compact and light considering the power density provided. These developments make our units the reference for power subsystems in human rated applications and open a whole range of new business opportunities.

Keywords: Moon, Power, Subsystem, Human Exploration

P61

ISAR AEROSPACE'S LAUNCH SERVICES

Johanna Pardo

ISAR AEROSPACE TECHNOLOGIES (GERMANY)

ABSTRACT

Isar Aerospace Technologies is a launch service provider, commercially developing a new European launcher tailored for small and medium payloads and constellation deployment.

ISAR was founded in 2018 and since then has been developing its launcher, Spectrum, capable of bringing up to 1 tonne to LEO. ISAR's solution is EU-based and entirely in-house. ISAR has developed not only design capabilities, but the entire chain of manufacturing, testing and assembly.

In April 2021, Isar Aerospace was the winner of the DLR Micro launcher competition which lead to a contract within the European Space Agency Commercial Space Transportation Service programme also called Boost. For the first time ever in Europe, the European Space Agency is offering a programme focused on the service rather than on the development of a product.

In addition, ISAR is the winner of the EIC Low Cost Prize of the European Commission awarded in 2022. Recently ISAR has been awarded a frame contract to launch EC and ESA payloads in the Frame of the Flight Ticket Initiative.

The recognition received from European institutions side with the private capital raised by ISAR have allowed them to develop a launch vehicle in a very short time, which is schedule to launch 2024 from Andoya in Norway.

This paper/presentation introduces ISAR's launch service, their company and the next steps towards their first test flight.

Keywords: Rocket, Launch Service, Launch Vehicle, New Space, Spectrum, Commercial launchers, Small launchers, SmallSats

V SMALL SATELLITES & SERVICES INTERNATIONAL FORUM

SSSIF2024. FEBRUARY 20-22. MÁLAGA. SPAIN