Open Source CubeSat Workshop 2021

Report of Contributions

https://events.libre.space/e/oscw2021

Contribution ID: **1** Type: **talk**

An Intuitive Tool to Design Relative Orbits for Formation Flying

Friday, 10 December 2021 16:00 (20 minutes)

Relative astrodynamics is often an opaque subject for most spacecraft engineers who do not deal directly in the guidance and control of formation flying or distributed satellite systems. Designing relative orbits itself is often a daunting task, even in the two-body-only sense, as the mission designer needs to select the correct set of Keplerian (or other suitable) orbit elements for the deputy and chief spacecraft. In this open-source project, QLUSTER allows for the layman to design the formation geometry directly, by specifying the radial, in-track, and cross-track design baselines, as well as two angular parameters. QLUSTER then takes these parameters, and works backwards to solve for the desired initial osculating orbit elements of the deputy instead, using the eccentricity-inclination vector separation framework proposed by D'Amico et al (2010). This is a lot more efficient than beginning with the traditional orbit elements, and also gives the user a lot more visual feedback in how the selected formation geometry parameters influences the orbital elements.

Primary author: Mr LOW, Samuel

Session Classification: Talks

Contribution ID: **2** Type: **lightning talk**

Leantime - Open Source Innovation Management for Distributed Teams

Friday, 10 December 2021 13:35 (5 minutes)

Leantime is an open source project management system that has gained attraction in recent years. Teams can manage their project starting from ideation to execution. It includes rarely seen features such as the Lean Canvas and Ideation Boards and marries them with "standard" project management tools such as Kanban Boards, Gantt Charts and Milestone Planning.

This lightning talk will give attendees an overview of Leantime and how it benefits innovative teams.

https://leantime.io
https://github.com/Leantime/leantime/

Primary author: FOLARON, Marcel (Leantime)

Session Classification: Lightning Talks

Contribution ID: **3** Type: **talk**

Progress Report from Open Research Institute, Inc.

Friday, 10 December 2021 16:40 (20 minutes)

Open Research Institute, Inc. (ORI) is a non-profit 501(c)(3) research and development organization which provides all of its work to the general public under the principles of Open Source and Open Access to Research. Focused primarily on the amateur satellite service, this presentation summarizes all current technical and regulatory work at ORI. ITAR/EAR Regulatory Relief, Debris Mitigation Rules Negotiation, Phase 4 Space Digital Multiplexing Transponder progress, Phase 4 Ground Station (SatNOGs compliant) work, Public Access Interferometer plan, End-to-End FPGA based multiple-access digital broadband demonstration, DVB-S2 multimedia beacon demonstration, GNU Radio DVB-S2/X receiver block publishing schedule, space-appropriate microwave beacon work, OpenCPI FPGA integration, funding status, government grant status, and more.

Primary author: THOMPSON, Michelle (Open Research Institute)

Session Classification: Talks

Contribution ID: **4** Type: **lightning talk**

PICOBUS the open hardware deployer for pico-satellites

Thursday, 9 December 2021 17:00 (5 minutes)

A quick review on the first iteration of the first open source satellite deployer that (almost) gone in space, the second chance, and the feature development.

Primary author: PAPAMATTHAIOU, Manthos

Session Classification: Lightning Talks

Contribution ID: **5** Type: **talk**

LibreCube - Overview of Activities

Thursday, 9 December 2021 14:00 (20 minutes)

LibreCube's vision is to enable everyone to get involved in building systems for exploration of Earth and Space using open source hardware and software.

LibreCube is resting on these three pillars:

- Open Source: Everything we do at LibreCube is made available to the public as free and open source. And we only use free and open source tools; this way, really everyone can get involved and contribute!
- Free and Open Standards: We rely on proven and tested standards for our system designs, with preference to standards from the space domain.
- Reference Architecture: Defining a generic architecture of system of systems that have standardized interfaces makes it possible to combine and reuse elements for various applications.

In this presentation, you will be given an overview on some current LibreCube projects conducted during this year with examples on their utilization. You will also learn on how you can actively join LibreCube and what practical space engineering skills and knowledge you can expect out of it - next to a lot of fun!

Primary author: SCHOLZ, Artur (LibreCube Initiative)

Session Classification: Talks

Contribution ID: **6** Type: **talk**

sdr-server - improving hardware utilization for passive spectrum monitoring

Thursday, 9 December 2021 11:20 (20 minutes)

Sdr-server is a project designed to provide access for multiple users to a single rtl-sdr stick. This allows running several concurrent observations within 2Mhz bandwidth of rtl-sdr. This turned out to be a very useful feature for satellite communications. Many cubesats transmit data on a very close frequencies, which allow communication with several satellites at once. This feature is widely used in r2cloud project: https://github.com/dernasherbrezon/r2cloud/wiki/sdr-server. Sdr-server is an open source software available on GitHub: https://github.com/dernasherbrezon/sdr-server. It has been evolving for the last year, but now mostly stable. However there are several more features planned: support for other sdr hardware, offload DSP algorithms onto GPU.

Key points:
- Share single hardware between multiple users
- Reduce bandwidth for streaming raw I/Q data from remote locations
- Open source project from Github: https://github.com/dernasherbrezon/sdr-server
- Support by a single person
- Future: support more SDR hardware

Primary author: RODIONOV, Andrey

Session Classification: Talks

Contribution ID: **7** Type: **talk**

Satellite Event Detection

Thursday, 9 December 2021 12:00 (20 minutes)

With the increasing number of satellites launched into space, it has become essential to anticipate disastrous space events and formulate effective policies based on the observations. As part of the Google Summer of Code program 2021, we developed a set of event detectors under the two-body problem by implementing orbital mechanics algorithms from the literature. We developed a point-by-point event detection approach that is accelerated using the numba package and configured in a flexible API. To ensure the correctness of the code, we validated all the added event detectors against the Orekit library. The added functionalities enable users to track one or more events during the propagation of an orbit. This, along with the perturbations already present in poliastro, makes the perfect combination to study the dynamics of non-keplerian satellite orbits. We believe this event detection module would be a good fit for real-life satellite orbit analyses and a potential integration tool for satellite missions.

Primary authors: GONDHALEKAR, Yash (BITS Pilani, Goa); Mr CANO RODRÍGUEZ, Juan Luis; Mr GARRIDO, Jorge Martinez (poliastro)

Session Classification: Talks

Contribution ID: **8** Type: **talk**

Open Space Data Link Protocol – An open-source implementation of the CCSDS TM/TC Directives

Friday, 10 December 2021 11:40 (20 minutes)

In a time when satellite deployments in space have increased dramatically and the collaboration between different parties involved in the operation of a satellite is imperative for a successful mission, standarization can pave the way towards the realization of a mission's goals. Often though, it is not only about willingness of a team to use standard protocols, it is also about the availability of implementations of such protocols and the overhead of implementing one themselves, considering the amount of time required for implementation and testing. In this presentation we will talk about the Open Space Data Link Protocol (OSDLP). It is a platform-independent implementation of the TM/TC Space Data Link Protocols of the CCSDS committee, implemented as a library, suitable for running on embedded processors. It is used on the QUBIK pocketqube missions and the accompanying tool for operating the OSDLP instance running on QUBIK, the osdlp-operator, will also be presented.

Primary author: VARDAKIS, George (Libre Space Foundation)

Session Classification: Talks

Contribution ID: **9** Type: **talk**

IPFS-tiny in orbit – Enabling new concepts

Thursday, 9 December 2021 13:20 (20 minutes)

IPFS has proved itself to be a secure & scalable distributed file system which utilizes a smart data model, IPLD. IPLD defines data to be self-descriptive and self-verifiable, allowing you to receive them in a trustless way. Considering distributed ground station networks to be the future, this data model greatly serves satellite communications in this context. A satellite transmitting data that comply with the IPLD specifications can carelessly provide information to unknown / malicious ground stations, knowing that they cannot edit & broadcast false data. This is a key point to scaling ground station networks while maintaining security towards open data.

In Libre Space Foundation, we're making an effort in bringing IPFS closer to embedded systems and space applications. Our project, ipfs-tiny, is our open-source solution to this problem. It is still under development, and we are going to cover the main characteristics of this implementation as well as the major difficulties related to it.

Primary author: TSAGKARELIS, George (Libre Space Foundation)

Session Classification: Talks

Contribution ID: **10** Type: **talk**

DOCKS – An open-source software suite for space mission profiles

Thursday, 9 December 2021 12:20 (20 minutes)

At CENSUS, the space pole of PSL Université hosted at the Paris Observatory, we are developing an open-source software suite called DOCKS for analyzing scientific nanosatellite mission profiles. DOCKS is a Python-based software that computes the major contributors in the system budget for the probe's entire mission profile, i.e., trajectory, intervisibility with sun and ground stations, onboard data volume, pointings and power budget. It will be composed of seven thoroughly validated modules, which can also be used as standalone. An additional advantage of DOCKS is that it is compatible with VTS, the French space agency's (CNES) software for visualizing and animating satellites in a 3d simulation.

So far, three modules have been developed: the deep-space trajectory Propagator, Intervisibility, and Energy Power Simulator (EPS). These are operational and are regularly updated on the public GitLab with new features and improvements based on user feedback. The most recent development in DOCKS is the fully operational remote service from our servers, which has been extensively tested by internal users. Besides, the propagator has been improved by the addition of an efficient adaptive-step integrator, IAS15, for trajectory propagation and a time-step manager to handle continuous propulsion burns. The talk will cover the latest developments in DOCKS along with our future perspectives. Furthermore, CENSUS also provides Model-Based System Engineering (MBSE) support to various CubeSat projects in the early phases of mission profile modelling, so the use of DOCKS in this context will also be presented.

Primary authors: Ms JAIN, Rashika (Observatoire de Paris); Dr SEGRET, Boris (Observatoire de Paris)

Session Classification: Talks

Contribution ID: **11** Type: **talk**

MetaSat: Open Metadata for Small Satellite Missions

Friday, 10 December 2021 17:40 (20 minutes)

MetaSat is an open metadata toolkit used to describe the hardware, software, and data associated with small satellite missions. Through its metadata vocabulary, or list of unique and machine-readable concepts, MetaSat helps facilitate information sharing among ground station networks like SatNOGS, in addition to mission teams and the greater small satellite community as a whole. In this presentation, the MetaSat team will provide an update on its current stage in development and also introduce attendees to ways they can help shape the project's future through open collaboration and feedback.

Primary author: CHIVVIS, Daniel (Harvard-Smithsonian Center for Astrophysics)

Session Classification: Talks

Contribution ID: **12** Type: **talk**

Luplink, an Open Source Web Application for an Ergonomic Link Budget Analysis

Friday, 10 December 2021 12:20 (20 minutes)

Computing a link budget allows to determinate the possibility to communicate with a satellite. This is done by accounting for all the power gains and power losses encountered by a signal along its transmission path. Due to the numerous amount of such gains and losses, computing a link budget can prove to be a difficult and tedious task, especially to students and newcomers.

Some tools to compute link budgets exist and can help mitigate these issues. Luplink uses web technologies and already existing open-source software to provide a simple and ergonomic interface allowing the user to easily compute such link budgets. Luplink is Open Source (AGPL v3) and available here: https://gitlab.isae-supaero.fr/jsatorb-dev/luplink.

For this project, we used the Angular framework to build a frontend that allows the user to provide data. The frontend communicates with a REST API in order to transmit data to the back-end. The backend handles the link budget calculation. For this backend, we used an already existing open-source project called python-linkpredict (https://gitlab.com/librecube/lib/linkpredict).

Taking advantage of Angular's modular architecture, it becomes possible to ship Luplink as an Angular library which can then be integrated into other Angular applications. This is what we did by integrating Luplink inside JSatorb, an already existing tool dedicated to mission analysis used for pedagogical purposes (https://gitlab.isae-supaero.fr/jsatorb-dev/).

Primary authors: PRISSIMITZIS, Julien; GATEAU, Thibault (ISAE-SUAPERO)

Session Classification: Talks

Contribution ID: **13** Type: **talk**

OreSat CubeSat System Overview

Thursday, 9 December 2021 14:40 (20 minutes)

This talk will give an overview of the OreSat CubeSat system, a fully open source 1U - 3U CubeSat system meant to be built, modified, and flown by student teams. OreSat has everything you would expect from a CubeSat system: a scalable 1 - 3U structure, multi-band deployable antenna, solar array, battery pack, on-board computer, radio system, star tracker, reaction wheels, magnetorquers, SDR GPS receiver, and capability for a high speed S band radio system. OreSat is built around a high density card-cage system with a 40% higher packing density than PC-104. Each system is a "card" based on inexpensive 2 and 4 layer PCBs that uses a common CAN and Ethernet-based backplane with RF, data, and power. Existing cards use standardized processors, ranging from small pin count, low power Cortex M0 microcontrollers up to a full Linux installation running on a Cortex A8. The first OreSat CubeSat is scheduled for first flight in early-2022 (OreSat0, a 1U technology demonstrator), and will be fully deployed in mid-2022 as the 2U OreSat mission, accepted into the 2017 NASA CSLI. For more information, please see https://www.oresat.org/

Primary author: GREENBERG, Andrew (Portland State University)

Session Classification: Talks

Contribution ID: **14** Type: **talk**

OreSat Electrical Power System

Thursday, 9 December 2021 15:20 (20 minutes)

The OreSat electrical power system is a fully modular and scalable CubeSat EPS designed to support a wide array of payload power demands. We will start with OreSat's modular solar panel system, which includes an embedded high frequency switching-power-supply and software-defined maximum power point tracker. We will then discuss the OreSat battery card, which is a redundant 7.2V 35 Ahr Li-ion pack with integrated nanoracks/ISS compliant inhibit switches; multiple cards can also be added in parallel to increase capacity. Finally we'll discuss the OreSat backplane and the OreSat Power Domain, which gives the onboard computer card the ability to independently power each card and has built-in current monitoring and circuit breaker capabilities.

Primary authors: LAY, David (Portland State Aerospace Society); GREENBERG, Andrew (Portland State Aerospace Society)

Session Classification: Talks

Contribution ID: **15** Type: **talk**

OreSat Firmware and Software Architecture

Thursday, 9 December 2021 15:40 (20 minutes)

This talk will give an overview of the software and firmware running the OreSat CubeSat system's microcontrollers and microprocessors, and their development environment. We'll discuss the three levels of computing onboard (ARM Cortex M0, M4F, and A8), our use of the ChibiOS real time operating system on the M0 and M4F systems, and our use of Linux on the A8 systems. We'll talk about the CANopen communication we use between the nodes, and a bit about the various forms of over-the-air firmware updates we have, over a debug channel and over the CAN bus. Finally we'll discuss the "FlatSat" integration workbench we use to do remote software development and integration testing.

Primary author: GREENBERG, Andrew (Portland State University)

Session Classification: Talks

Contribution ID: **16** Type: **talk**

OreSat Communication Protocols and and Ground Stations

Friday, 10 December 2021 17:00 (20 minutes)

This talk gives an overview of the OreSat CubeSat system's communication system. We'll discuss the onboard amateur radio L band uplink and UHF downlink. We'll touch on the UHF G3RUH beacon, and the transition to an Engineering Data Link mode, that is all CCSDS compliant. We'll also discuss the University Class Open Ground Station (UniClOGS), which is an TX/RX system that is a local ground system for engineering data link TX/RX that we hope will eventually be a TX-capable extension to SatNOGS, although regulatory compliance issues will complicate this.

Primary author: LEBRASSEUR, Glenn (Industry Adviser)

Session Classification: Talks

Contribution ID: **17** Type: **talk**

OreSat Mission Planning with Eclipse Papyrus SysML

Friday, 10 December 2021 17:20 (20 minutes)

This talk gives an overview of OreSat from a mission planning perspective. We'll discuss the factors that go into educational CubeSat mission planning, and show how the Eclipse Papyrus SysML (specifically v1.6) add-on can be used to track mission requirements and to aid in the analysis and design of the mission architecture leading to a Concept of Operations and other important early-phase documents. The presentation will be focused on the products of a workflow that will be available to interested parties via an open source tutorial to be published on the OreSat GitHub account.

Primary author: RUSHFORD, Risto (Portland State Aerospace Society)

Session Classification: Talks

Contribution ID: **18** Type: **talk**

OreSat Mechanical Architecture

Thursday, 9 December 2021 15:00 (20 minutes)

The OreSat mechanical architecture is a scalable 1 - 3U aluminum CubeSat structure designed to be easily manufactured in-house by university teams. OreSat takes advantage of a card cage construction for greater flexibility in the CubeSat development process. A simplistic yet effective card wedge system is incorporated into the structure to provide a modular alternative to the traditional PC/104 CubeSat stack. The mechanical architecture employs the card cage clamping mechanism for improved thermal and electrical versatility. The system also utilizes a unique approach to integrating ISS/Nanoracks compliant rail-based inhibit switches with the modular architecture. OreSat0, a technology demonstrator mission scheduled for launch in early 2022, will be the first of many CubeSats to utilize the 1U variant of the OreSat mechanical architecture. During this talk, we will discuss key structural, vibrational, and thermal considerations in the design process. Furthermore, design challenges presented in subsystems with high thermal load, rigid mounting requirements, and outwards-facing sensors will be discussed.

Primary authors: LIN, Marvin (Portland State Aerospace Society); REINHOLD, Hayden

Session Classification: Talks

Contribution ID: **19** Type: **talk**

Progress and Developments in Open Source Electric Propulsion for Nanosats and Picosats at AIS

Friday, 10 December 2021 15:00 (20 minutes)

AIS is currently the first and only open source, open development based electric propulsion (EP) effort in the field. Over the past year, significant progress has been made on a number of micro ion and plasma thruster technologies for nanosats and picosats.

First, in March 2021, the first ever fully open-source electric propulsion system, the AIS-gPPT3-1C Micro Pulsed Plasma Thruster, successfully made it to orbit aboard the Care Weather Hatchling Veery 1U Cubesat, marking the first time an open-source thruster has ever been flown. While current development on this system has been retired, the design has been released under the CERN-OHL-S V2 license.

In addition to the original pulsed plasma thruster initiative that AIS was born from, AIS has been conducting a number of tests on the development of low-cost ionic liquid ion source (ILIS) electrospray thruster technology. This past year, breakthrough performance was established with the prototype ILIS1 emitter, which was hand modified from the original linear ridge design to a single spike, achieving up to 3uN of thrust for the single spike emitter at over 4500s ISP, operated stably in bipolar mode for a period of 30 minutes. These results confirm the direction moving forward for spike emitters, and work is underway to establish a larger 2D spike array of emitters to achieve full performance. Both the V1 and V2 prototype designs of the ILIS1 have been released under the CERN OHL-S V2 license.

AIS has also been pioneering work utilizing advanced molecular fuel for the development of ultra-compact, low power Hall thrusters for Cubesats and PocketQubes. Significant progress has been made with Adamantane fuel, a solid diamandoid hydrocarbon that exhibits direct sublimation in vacuum at low temperatures. Currently AIS is the only entity in the world specifically developing Adamantane fueled micro ion thruster technology. Initial tests verified very low power and temperature requirements for sublimation, and demonstrated ionization of the fuel from less than 1W to 2W of power with HV input. In addition, glow discharge, positive and negative charge extraction, and neutralizer plume extraction was demonstrated.

Moving forward, AIS has developed an ultra-low power glow discharge hollow cathode neutralizer for Hall thrusters, requiring only 2W of power, utilizing stainless steel and Somos PerFORM 3D printed parts, operated on Adamantane fuel. This first hollow cathode, the AIS-GDN1, was successfully run in self-ignition mode, as well as with a prototype micro Hall thruster. Work is currently underway for the next iteration of the cathode.

Several tests were also successfully conducted on the first ever AIS Hall thruster, the AIS-EHT1 Micro End Hall Thruster, a 0.3U size Hall system run on sublimated Adamantane fuel. Successful ignition was demonstrated with both a tungsten filament neutralizer as well as the GDN1 hollow cathode. The current V1 design of the EHT1 has been retired, and will be released under the CERN-OHL-S V2 license.

Finally for Hall thrusters, AIS has developed the smallest full Hall thruster system ever designed, the AIS-AHT1-PQ Pico Anode Layer Hall Thruster. At only 0.1U total volume (24x42x56mm), including fuel tank, fuel management, valve, thruster, and electronics, and nominal 10W power the AHT1-PQ is the first Hall thruster compatible down to PocketQube class satellites. The Hall thruster is also run in a unique neutralizer-less configuration, eliminating conventional neutralizers used for Hall thrusters, making the system more compact. Recently, successful ignition of a stable anode layer plasma was demonstrated, and work is currently underway to achieve full system ignition and testing.

Lastly, AIS has recently started a new vacuum arc thruster (VAT) initiative, with the first prototype AIS-VAT1 thruster system. The thruster measures only 42x42x16mm in size, rated to 2.5W nominal power, and leverages off-the-shelf components, extremely simple electronics, 3D printing, and triggerless operation to make it the simplest and lowest cost thruster developed yet at AIS. The thruster was successfully demonstrated to 10k pulses from 1-10 Hz at up to 5W power using solid titanium fuel. Additional work is being done to begin preparing the first off-the-shelf flight systems.

Primary author: BRETTI, Michael (Applied Ion Systems)

Session Classification: Talks

Contribution ID: **20** Type: **lightning talk**

CubeCrypt - An Open-Source Implementation of Self-Signed ECC Certificates for CubeSat Telecommunication

Thursday, 9 December 2021 17:10 (5 minutes)

Despite the CubeSat industry becoming increasingly dominant within the space sector, it falls behind in one critical section: Cryptography. Current CubeSat security issues are often underestimated or neglected, despite the existing CCSDS standards for (all) satellite telecommunication. This is due to the fact that current CubeSat implementations simply do not require such strict security measurements. Nevertheless, due to the constant innovation within the space sector and the new threads these innovations could impose, cybersecurity in CubeSats will become crucial in the near foreseeable future. However, as security implementations on conventional satellites generally rely on hardware-based (FPGA / μ-controller) cryptography, the need for software-based cryptographic security solutions for the NewSpace industry have increased significantly.

This is where CubeCrypt comes into view: by creating a lightweight and open-source approach to satellite cryptography, it aims to become an software-based asymmetric cryptographic system suitable for CubeSat implementation. More specifically, the CubeCrypt system operates by utilizing ARMmbed's open-source mbedTLS library, by extending it to ensure no dynamic memory allocations are applied. In addition, CubeCrypt will be compiled for and implemented in bare-metal environments, ensuring its compatibility with space-grade on-board computers.

As an initial proof-of-concept, the CubeCrypt project will be used to establish the first foundation of cryptography: Authenticity. Rather than encrypting the data sent between a CubeSat and its ground-station, cryptographic certificates will be used to verify whether the CubeSat was truly sending the data, or whether someone else was trying to impersonate it. This will be done by creating self-signed X.509 ECC certificates and implementing them in the TRUST (Tamper-proof RandomnUmber generator from SaTellite) system, designed by the Department of Complex Systems Engineering (DISC) at ISAE-SUPAERO.

Primary author: ROELVINK, Yannick (ISAE-SUPAERO)

Co-authors: DETCHART, Jonathan (ISAE-SUAPERO); LACAN, Jérôme (ISAE-SUPAERO); GATEAU, Thibault (ISAE-SUAPERO)

Session Classification: Lightning Talks

Contribution ID: **21** Type: **talk**

Astrometry on board OPS-SAT1?

Thursday, 9 December 2021 13:00 (20 minutes)

Astrometry of celestial bodies is strategic in various scientific or engineering applications. We have designed an experiment with OPS-SAT1 to assess the feasibility of optical astrometry with simple CubeSat hardware. OPS-SAT1 is a 3U CubeSat designed and operated by ESA/ESOC in Darmstadt with an imager and an ADCS by Berlin Space Technology. Then, there is an entry barrier: can we at least see stars and process their images on board? We will present the scope of our experiment and the first pictures we have got from OPS-SAT1, with a special focus on the ADCS and imager requirements. Acknowledgement: special thanks to ESA's OPS-SAT team for the great support in providing the first pictures.

Primary authors: Dr SEGRET, Boris (Paris Observatory - PSL); Mr DIAW, Youssoupha (Paris Observatory - PSL)

Session Classification: Talks

Contribution ID: **22** Type: **talk**

The open-source approach to on-board data processing. A view from the perspective of OHB-Hellas

Friday, 10 December 2021 12:00 (20 minutes)

The open-source approach in the space industry is of well-understood benefits in the context of small companies and new players in the space domain. Large companies are however often still hesitant to follow this route.
OHB-Hellas, a Greek company and a fully-owned subsidiary of the multinational OHB Group, was established in the country with the goal of establishing expert competence in the group, in the domain of on-board data processing. As a still small company, with a vision of being in the very front of the on-board data processing developments in Europe, OHB-Hellas has identified specific needs and trends in the domain and has laid-out a strategy of developing solutions based on an innovative approach. One of the main topics OHB-Hellas is aiming to address is the need of developing flexible satellites; flexible satellites building upon both state-of-the-art and open SW approaches as well as modern and open HW architectures. This is a competence that is planned to be built in Greece addressing both institutional and commercial markets.
In parallel, it is intended to take advantage of the developed flexibility and provide satellite-as-a-service where any kind of satellite can be connected to the proposed platform. The commercial viability of this concept will start with a CubeSat, developed with a completely open-source approach. This approach will lay the ground for further developments, cultivating the culture of a sharing-economy for owners and maximizing the use of resources in orbit.

Primary author: VELLAS, Simon

Session Classification: Talks

Contribution ID: **23** Type: **lightning talk**

New opportunities for student CubeSat teams within ESA's Fly Your Satellite! educational programme

Thursday, 9 December 2021 16:50 (5 minutes)

'Fly Your Satellite!' (FYS) is a recurring hands-on programme conducted by ESA for University student teams developing a CubeSat with an educational scope. Through the Fly Your Satellite! programme, ESA supports university students in the development of their own educational CubeSat, by offering dedicated trainings, supporting project reviews, and enabling the transfer of expertise from ESA specialists to the students. These university led projects are guided through the different programme phases, following the typical development cycle of a space mission. Access to environmental test facilities, such as the CubeSat Support Facility in ESEC, is also offered throughout their participation in the programme. Eventually , a launch will only be offered by ESA to those teams that demonstrate the readiness of their spacecraft and ground segment and compatibility with the technical and safety requirements. These elements and the structure of this unique educational programme for CubeSats are presented.

The Call for Proposals for the fourth edition of Fly Your Satellite! is currently open to university teams composed of bachelor, master and PhD students from eligible states, who are close to integrating their satellite. The specifics of the proposal submission process are outlined together with some practical advises.

Additional educational CubeSat opportunities for university developers at different stages of the project lifecycle are expected to open soon. These new pilot programmes will also be advanced explained during the presentation.

Primary authors: MAASS, Jan (European Space Agency); DEL CASTILLO SANCHO, Cristina (ATG EUROPE B.V. for ESA)

Co-author: KINNAIRD, Alexander (European Space Agency)

Session Classification: Lightning Talks

Contribution ID: **24** Type: **talk**

Passive Satellite RF Tracking using the SatNOGS Network

Friday, 10 December 2021 15:20 (20 minutes)

The SatNOGS Network performs hundreds observations per day, each producing a waterfall diagram which shows the Doppler curve caused by the transmitting satellite flying over the station. By analyzing multiple of these curves the satellite orbit can be determined. The new SatNOGS Artifacts allows the extraction of precise frequencies and timestamps. For this "Spectranalysis" was developed, an interactive web service for extracting Doppler curves from SatNOGS Artifacts, which can then be used by the existing open source tools like STRF for orbit determination.
In this talk the concept of passive RF tracking is introduced, thew new SatNOGS Artifacts format and the tool "Spectranalysis" for analyzing Doppler curves is presented.

Primary author: Mr SCHMIDT, Fabian (Libre Space Foundation)

Session Classification: Talks

Contribution ID: **25** Type: **lightning talk**

In-situ Space Debris detection with the MOVE-III CubeSat in LEO

Friday, 10 December 2021 13:30 (5 minutes)

The past few decades, numerous artificial objects have accumulated in orbits around the Earth. While a portion of the defunct objects are large enough to be tracked by surveillance networks, the vast majority is non-trackable debris. With the increase of space debris in orbit, several models have been developed, aiming at modelling the dynamic space debris and meteoroid environment. The modelling of the environment is not an easy task, especially when we consider the non-trackable population. On-orbit remote sensors have the potential of detecting non-catalogued objects, but up to now, the sub-millimetre realm has only been studied with in-situ impact techniques.

Various space agencies have worked to build models to characterize the space environment. Prominent space debris models include ESA's MASTER and NASA's ORDEM. Such models typically depend on in-situ measurement data to validate their small object population estimates. For ESA's MASTER model, the main validation source is impact features from spacecraft or components exposed to the space environment for a period of time and brought back to Earth. In the same way, NASA's software ORDEM has used impact analysis measurements from STS windows and radiators to validate particles smaller than 3.16 mm in LEO. Returned surfaces can provide invaluable information but they depend on missions to return them and are characterized by limited orbital coverage and time of exposure. A potential validation source for models like MASTER and ORDEM is data from active in-situ detectors.

MOVE-III is a CubeSat project of the Department of Aerospace and Geodesy at the Technical University of Munich. To goal of the mission is to provide in-situ measurements of sub-millimetre space debris and meteoroid impactors in order to support the validation of space debris models and the characterization of the space debris and meteoroid environment in LEO. The main payload of MOVE-III consists of an assembly of impact ionization DEDRA (DEbris Density Retrieval and Analysis) sensors, carried on a 6U Platform. The design of the sensor is based on the legacy of the MDC (Munich Dust Counter). The basic information provided by the sensor is the number of impacts encountered at a specific location and time. Additional processing may determine the mass and speed of each single impactor, which could allow the classification of the impactor's origin. Directional information provided by the advanced DEDRA sensor design could be used to recovers the full velocity vector, allowing a first order approximation of the impactor's orbit.

Space is a harsh environment, and in the new era of satellite technology CubeSats can provide a robust and, at the same time, low-cost platform, which can be employed to collect in-situ space debris and meteoroid impact data using dedicated impact detectors. Well-established sensor technologies and data processing chains may open a new path to continuous in-situ data collection that can support the efforts of modelling the small space debris and meteoroid environment and contribute the validation of space debris models like MASTER or ORDEM. Better knowledge of the space debris environment may benefit future missions and play a crucial role in optimal spacecraft design and traffic management in the next decades.

Primary authors: OIKONOMIDOU, Xanthi (Department of Aerospace and Geodesy, Technical University of Munich); Mr KARAGIANNIS, Eleftherios (Department of Aerospace and Geodesy, Technical University of Munich)

Co-authors: Mr HACKER, Alexander (Department of Aerospace and Geodesy, Technical University of Munich); Mr PUCKNUS, Paul (Department of Aerospace and Geodesy, Technical University of Munich)

Session Classification: Lightning Talks

Contribution ID: **26** Type: **tutorial**

Practical mission analysis with Python

Friday, 10 December 2021 14:00 (1 hour)

In this tutorial, we will go over basic topics about orbit analysis in a practical way, aiming to address some common misconceptions. In particular, we will cover

- How to visualize osculating orbits and ephemeris,
- What a TLE is and is not,
- How to fetch TLE and ephemeris data from open sources,
- How to propagate osculating orbits and TLEs,
- How to design transfer orbits and maneuvers,
- How to compute satellite sensor coverage metrics.

We will use a cloud environment, so no installation is required. Basic understanding of the Python programming language is required to effectively follow the tutorial, and we will use libraries like poliastro, orbit-predictor, and Plotly.

Primary author: Mr CANO RODRÍGUEZ, Juan Luis

Session Classification: Workshop

Contribution ID: **27** Type: **lightning talk**

Arenal Board: an open-hardware single-board OBC-COMs board.

Thursday, 9 December 2021 16:55 (5 minutes)

After working in the Irazú project, a basic store-and-forward and Costa Rica's first satellite, and reviewing documentation for the BIRDS projects from Kyutech, Japan, we found a potential project in the design of an open-hardware OBC and a LoRa-based COMs on a single board, using a specific microcontroller: the STM32WL series, a powerful MCU with an SX1276 integrated on a silicon level. This reduces the board's complexity, and by combining the two boards in one, volume is saved. LoRa is chosen for this since the expected use case is basic telemetry and commands; mission data such as imaging should be sent through a dedicated mission COMs module, which should be easier to implement given the increased space.

Primary authors: RODRÍGUEZ BLANCO, Jairo (Tecnológico de Costa Rica); QUIROS JIMENEZ, Olman (University of Wuerzburg)

Session Classification: Lightning Talks

Contribution ID: **28** Type: **lightning talk**

The OpenSource for Space Podcast - An Update

Thursday, 9 December 2021 17:15 (5 minutes)

I would like to submit an application for an lightning talk to give a small update about the podcast project I proposed last year.

The podcasts is about making open source projects public and having an easy/verbal/central place to inform the community

Primary author: CEGLAREK, Jan-Peter (polaris, TUDSaT)

Session Classification: Lightning Talks

Contribution ID: **29** Type: **lightning talk**

MindaSat-1 – a 3U cubesat for STEM, peace, and science

Friday, 10 December 2021 13:40 (5 minutes)

Project Persephone aims to repeat the KickSat-2 mission, as MindaSat-1, with fixes and modifications as needed, to put up to 100 Filipino schools into orbit, each with its own Sprite "chipsat". Two KickSat Sprite development kits have been delivered to a school in Marawi (Mindanao), a post-conflict zone. Aside from the obvious educational goals, student teams will be interfaith as much as possible, to help heal the wounds of division in Philippine society that were only widened by the Siege of Marawi. By headquartering the satellite effort in Bangsamoro, that autonomous region may not only gain in regional pride but also establish representation in the Philippines' new space agency, to help knit the formerly-separatist ethnic Moros further into the nation even as they enjoy new independence. A repeat of KickSat-2 should also be an opportunity to conduct scientific investigations at LEO altitudes that relate to problems of space traffic management. In particular, such a mission may enhance our understanding of atmospheric gravity waves (possibly important for calculating de-orbit trajectories) and perhaps electrical (plasma) variation in the ionosphere as well, to help answer questions about how to design electrodynamic tethers to be more robust. In the meantime, Sprite-oriented curriculum elements can be developed and released under a Creative Commons license.

Primary author: TURNER, Michael (Project Persephone)

Session Classification: Lightning Talks

Contribution ID: **30** Type: **talk**

Cronos Sounding Rocket

Friday, 10 December 2021 15:40 (20 minutes)

Cronos is the first hybrid rocket designed by our team and the first attempt to create such a rocket inside the Greek student community. We decided to build Cronos, in order to test our knowledge, skills and eventually improve them through the process of making each and every part in house.

By choosing to do so, a wide variety of engineering challenges became obvious after the first weeks of design and eventually manufacturing.
The lack of previous experience with such engines and lack of usage knowledge upon a wide variety of tools (mills, lathes, CNC's etc) capable of cutting such large pieces were the two major issues we encountered. Thus, we had to find ways to bypass the tool-related technical difficulties in order to manufacture our parts. However, after countless hours of learning, modifying our designs to fit the available tools, practicing our machining skills and (admittedly so) a lot of failures, we are currently at the point of being able to use the tools we have in our advantage, and cut every piece of the rocket by ourselves.

The MK2 engine, the run tank, the test stand structure, the control box as well as every other part of the rocket that is tested now and will fly at Cronos' first launch attempt, is a "product" designed and manufactured by the team, with the tools we have, available to every person around the globe, regardless of age or previous experience, to see, ask questions about, and get educated further. Through our open source repositories (https://gitlab.com/librespacefoundation/cronos-rocket) , one can view every step we took from the start, engage with us directly through comments and given the experience and certificates, even build and fly themselves. Now, after almost 2 years into the development of Cronos, we have reached a level where we can predict the outcome of various tests, use the available tools in order to rapidly prototype and test parts and of course, use our acquired knowledge to review our mistakes and learn from them. We are really satisfied with the progress we've made so far, (considering that we started from scratch without any previous experience) and the fact that we have already passed so many tests (e.g. hydros, successful recovery firings, various avionics tests) makes us extremely happy.

It is important to say that the team has embraced the open source philosophy from the start.
Due to the difficulty of manufacturing this type of rocket (especially in the student community) our team members considered that Cronos deserves to be easily accessible to the community. In this way, anyone who wishes to learn and advance their knowledge upon such subjects is able to get information about our research and tests, come in close contact with our team and ask questions about what concerns them.

Moreover, the open source philosophy can motivate and encourage people who want to engage with this sector but they have no previous experience or knowledge as happened to us. Space technologies should be accessible to the community, and by sharing our work, we hope to contribute to this cause.

Primary author: Mr PATSAS, Thanos (White Noise)

Session Classification: Talks

Contribution ID: **31** Type: **talk**

OpenSATCOM update and initial results

Thursday, 9 December 2021 11:40 (20 minutes)

OpenSATCOM is an ESA ARTES activity implemented by Libre Space Foundation in collaboration with inno3 exploring the relevance of open-source development methodologies in the satellite communication sector.

This year's talk will be a follow-up to last year's talk, this year we will follow up with a focus on active and implemented sub-activities.

Primary authors: KOSMAS, Eleftherios (Libre Space Foundation); Mr PAPADEAS, Pierros (Libre Space Foundation)

Session Classification: Talks

Contribution ID: **32** Type: **talk**

State of Polaris, more visualization in using ML for space operations

Friday, 10 December 2021 11:20 (20 minutes)

Satellite constellations are growing at the fastest rate ever. Small teams of satellite operators now monitor the satellite health of dozens to hundreds of satellites as a part of missions like starlink, project Kuiper and OneWeb constellation. The Polaris project provides an open-source machine learning tool for easy analysis of telemetry to find dependencies between satellite parameters as well as a behaviour analysis tool (BETSI) to learn from any spacecraft behaviours and automatically detect anomalies.

This presentation gives an update to the community on the progress made to integrate a browser-based frontend for the information detected by Polaris, such as anomalies, and the possibility to explain the root cause by comparing the dependency graph generated by Polaris before and after any detected anomalies.

A ReactJS based frontend for visualizing the telemetry overlayed with the anomalies detected was developed thanks to the support of the Google Summer of Code 2021. The latent representation from the deep learning model can also be visualized along with the actual satellite health parameters to make it easy to understand what the model has detected as the changing parameters.

Currently the project is being redesigned to increase modularity and interfacing capabilities. Discussions are open on feature requests, useful ways to visualize output of machine leaning tools for spaceops.

Primary authors: Mr VENKATESWARAN, Adithya (Polaris); CEGLAREK, Jan-Peter (polaris, TUDSaT)

Co-authors: BOUMGHAR, Red (Libre Space Foundation); BANSAL, Ayush (Polaris); BROWN, Hugh (Polaris); CRESPO, Xabier (LSF Core Contributor); FLAWINNE, Julien

Session Classification: Talks

Contribution ID: **33** Type: **talk**

SatNOGS - State of the Union

Thursday, 9 December 2021 13:40 (20 minutes)

An overview of the SatNOGS project, a network of satellite ground stations around the world, optimized for modularity, built from readily available and affordable tools and resources.

Low Earth Orbit (LEO) satellite launches rate increases with the participation of old and new entities. In this growing environment SatNOGS provides a scalable and modular solution to track, identify, receive telemetry, monitor and command & control satellites.

SatNOGS global community, dedicated to its free and open source values, develops hardware ground station designs (antennas, rotators, electronics), software for SDR-based communications, satellite scheduling and mission monitoring platforms.

SatNOGS continuously develops and improves its infrastructure to allow observers use this networked ground segment and remotely operate SatNOGS ground stations around the world. It provides also an easy way to store, access and view increasingly received satellites data, by supporting VHF, UHF, L and S bands.

This is a proposal for a "state of the union" talk about SatNOGS focusing on what has happened since previous OSCW, growth, development and trajectory for features and expansion.

Primary author: DAMKALIS, Alfredos Panagiotis (Libre Space Foundation)

Session Classification: Talks

Contribution ID: **34** Type: **talk**

QUBIK Mission

Friday, 10 December 2021 12:40 (20 minutes)

- An overview of testing and integration of QUBIK 1,2 and upcoming QUBIK 3,4,5 missions.
- How SATNOGS is used during development and testing
- QUBIK 1,2 launch update

Primary authors: Mr DARADIMOS, Ilias (Libre Space Foundation); PAPAMATTHAIOU, Manthos; SURLIGAS, Manolis (Libre Space Foundation); ZISIMATOS, Agis

Session Classification: Talks

Contribution ID: **35** Type: **lightning talk**

SatNOGS-COMMS transceiver: Update on the latest development

Thursday, 9 December 2021 17:05 (5 minutes)

The SatNOGS-COMMS transceiver is a turnkey solution enabling robust and reliable communication for LEO Cubesats. It operates in the UHF and S frequency bands, providing uplink and downlink capabilities on both of these spectrum regions. Demodulation and decoding of telemetry and payload data produced by SatNOGS-COMMS is fully compatible with SatNOGS ground stations. SatNOGS-COMMS also integrates tightly to SatNOGS Network, supporting a mission control system for TC&C and real-time dashboards.

In OSCW 2019 we presented the transceiver early on its development. On this lightning talk we will present the latest updates on the development of the board, the challenges that we faced so far, as well as our initial performance data.In addition, we will present our next steps, the availability date and our future plans for further development and enchantments.

Primary authors: SURLIGAS, Manolis (Libre Space Foundation); ZISIMATOS, Agis; DARADIMOS, Ilias (Libre Space Foundation)

Session Classification: Lightning Talks

Contribution ID: **36** Type: **discussion**

Open Source Mission Operations Systems

Friday, 10 December 2021 14:00 (1 hour)

Most space agencies and industry use custom or self-developed software applications to control their satellite missions. A prominent example is SCOS-2000, a multi-mission satellite operations system that is used for almost all ESA satellites. Most of those solutions are monolithic, large, complex, and use plain old software technologies, and they are closed-source.

Nowadays, however, a number of open source mission control systems do exist as well! For example:
- OpenMCT: https://nasa.github.io/openmct/
- YAMCS: https://yamcs.org/
- ReatMetric: https://github.com/dariol83/reatmetric
- AURIS: https://github.com/OSWALD2/AURIS
- OMC: https://openmissioncontrol.wordpress.com/
and others..

In this open discussion, participants can share their experiences with those tools and address highlights and shortcomings of available software projects.

Primary author: SCHOLZ, Artur (LibreCube Initiative)

Session Classification: Workshop

Contribution ID: **38** Type: **not specified**

Keynote: University CubeSat Programs – A (Pipe) Dream?

Thursday, 9 December 2021 16:20 (30 minutes)

Dr. Pauline Faure joined Cal Poly Aerospace Engineering Department in 2018 and teaches, among others, the department's capstone course on Spacecraft Design as well as the junior-level course on Fundamentals of Systems Engineering.

Dr. Faure's research focuses on the adaptation and usage of space systems as an educative tool to build capabilities and support sustainable space activities for local communities, first time developers, and emerging space faring nations. In 2021, to support her research vision, Dr. Faure established ETOILES, a research laboratory dedicated to the development of Educational Technologies for Open and Interactive Learning via the Engineering of Small Spacecraft. ETOILES has over 40 undergraduate students and 4 graduate students working on varied projects from a flight mission to demonstrate space-based solar power system capabilities with small satellites to the development of an educational and controlled satellite platform.

Dr. Faure obtained her Ph.D. from Kyushu Institute of Technology, Japan, in Mechanical and Control Engineering. Dr. Faure's thesis dealt with decision-making processes in non-traditional satellites program management of assembly, integration, and testing activities.

Presenter: Dr FAURE, Pauline