Open Source CubeSat Workshop 2025

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Serafio of the Municipality of Athens

Book of Abstracts

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PwnSat: A Vulnerable-by-Design Satellite hardware and platform for AeroSpace Hacking

Author: Kevin Leon Morales[None]

PwnSat: A Vulnerable-by-Design Satellite hardware and platform for AeroSpace Hacking

PwnSat is the result of more than five years of research, and seeks to bridge the gap between traditional cybersecurity and the aerospace environment, offering for the first time on the planet a platform that is vulnerable by design and allows hands-on training without the need for expensive simulators or access to critical infrastructure.

This talk will explore the technical design of PwnSat, the communication protocols it implements (including CCSDS over LoRa and AX.25), and how the system replicates real-world mission scenarios involving a vulnerable Mission Operation Center (MOC), Ground Station, and Flatsat hardware.

Attendees will gain insight into how PwnSat is used to simulate and exploit real attack vectors in satellite communications, offering an unprecedented opportunity to train in a domain that has historically been inaccessible to most security professionals. Whether you're a pentester, aerospace engineer, or educator, PwnSat opens the door to practical satellite hacking like never before.

For more information about it:
https://pwnsat.org/docs/get-started/introduction/

7th Session / **3**

libs3: A novel Parameters System for distributed space systems

Author: Olman Quiros Jimenez[1]

[1] *German Aerospace Center (DLR)*

In the context of satellite's flight-software (FSW), the so-called the Parameter System or Service (PS) is a software (SW) components, very common in FSWs, its reefers to a software service that provides capabilities for managing on-board parameters, including reading current values, setting new values and redefining parameter locations and properties. In concrete, the PS consist of a key-value storage technology, i.e.: maps a name or numerical ID to a variable. This way, it is possible to access (retrieve or modify) the value of such configuration variable from the outside-world, i.e.: by another entity. PS simplifies greatly the development and operation of the of spacecrafts. Typical PSs posses the following limitations: low user-friendliness, poor scalability, lack of flexibility, repetition of effort and configuration consistency issues. In general, complexity (i.e.: elevated number of parameters and nodes), degrades the usability and efficiency of typical PSs and middlewares.
To address these issues, we present libs3, a novel PS with the novel approach of segmenting parameter in hierarchical organized collections, called Systems. Inspirited in concepts of Systems Engineering. The idea is to reflect in the actual software, the intrinsic hierarchical structure of a space system. This simple concept allows navigating and exploring the whole system, like a file system. Parameters and Systems have a short text-based key (a name), which makes they easy to remember and intuitive to find and manage. Although sort named, every Parameter is unique in the hierarchical structure. Parameters can be flexibly grouped by a reference in different logical lists, for implementing interfaces, telemetry collection, event logging and more. The PS also provides serialization and deserialization (in several binary and text formats), storage in persistent memory, callbacks, range checking, a Command Line Interface, among other features.

And of course it's open source: https://gitlab.com/s3space/libs3pp :)

Poster Tea Time / **4**

Open-Source Multi-Domain CubeSat Architecture for Search and Rescue

Author: Ernest Adjei[1]

[1] *Erasmus Mundus Masters Student in IoT Cybersecurity*

CubeSats are increasingly used as low-cost communication relays, but their convergence with drones, trail-side environmental IoT sensors, and ground control stations creates new challenges in security, resilience, and interoperability. Search and Rescue (SAR) missions provide a compelling case where these systems must interoperate under constrained and adversarial conditions. Rapid intervention can mean the difference between life and death for victims. Yet, operations in mountainous regions or disaster-stricken zones face obstructed terrain, poor cellular coverage, and the limited reach of Visual Line of Sight (VLOS) drones.

This work proposes an open-source Beyond Visual Line of Sight (BVLOS) architecture. Trail-side IoT sensors detect motion, sound, and pressure, transmitting data via LoRa to guide drone waypoints. Drones execute autonomous SAR surveillance with AI-assisted human detection. Telemetry and commands are managed via lightweight MQTT-SN over SDR. CubeSats provide resilient LEO links between drones and ground control stations, which coordinate mission planning, telemetry aggregation, and victim rescue.

To evaluate the system's security posture, traditional frameworks such as MITRE ATT&CK, STRIDE, and SPARTA were considered. While effective for enterprise networks or isolated domains, they are limited in capturing complex interdependencies in modern space-enabled architectures. Applying them to this system would provide incomplete threat visibility and limited resilience analysis.

METEORSTORM™, an open-source framework developed by ethicallyHackingspace, was used for multi-domain threat modeling, offering comprehensive system decomposition and enabling exposure assessment, adversarial simulation, and resilience planning across the full CubeSat–Drone–IoT sensors–Ground Control Station chain.

Simulated attacks, including MQTT-SN injection, telemetry spoofing, and RF interference, revealed critical attack surfaces. Detection engineering, combining rule-based logic and machine learning, achieved strong anomaly detection despite resource constraints.

The system was implemented with open-source tools such as ArduPilot (SITL), Gazebo, MQTT-SN, GNU Radio, and Flask. It provides the CubeSat community a multi-domain architecture for resilient, interoperable systems, enabling life-saving missions in communication-limited regions.

Keywords: CubeSat, BVLOS, Trail-Side Environmental IoT, LoRa, MQTT-SN, SDR, Ground Control Stations, METEORSTORM, Multi-Domain Threat Modeling, Anomaly Detection, Open Source, SAR, Victim Detection, Secure Communications

2nd Session / **5**

Test the digital Space Systems by the tools engineering

Author: Djamel METMATI[1]

[1] *CSI*

The Space as a service provides the capacity to deliver products and an access easier to the orbits. Moreover, the way to produce a satellite out of the box by the size, by the functions expected, the potential data from system design, the programming and the format data evolution. These external conditions provide a digital support to test the operation concepts including the operation security on-line and off-line through the operation engineering with more tools to ensure the same goals of safety, performance applicable for Space. In this process, some steps shall be included to improve the security of Space systems and subsystems during the design and the verification phase. This step should be an digital environment to test the robustness of the systems and subsystems by development environment for software through the use of on board computer as a container with input and output for data.
The tools engineering as dockers micro-service architecture provide the capacities to test the digital Space systems by unique computer on board while considering the data expected for the other subsystem. It considers a information model applicable to the computer on board to test the functions and the data processing.
source : https://github.com/esa/nanosat-mo-framework
https://ingescape.com/fr/bibliotheque-open-source/

2nd Session / **6**

The Space cybersecurity Framework : The OPS SAT Red Team approach

Author: Djamel METMATI[None]

The commercial opening of Space through private actors supported by states or not able the possibility put the space networks face to the effects of robustness to the service. To ensure the full delivery of a service, the hardening need to be improve by the networks Team : blue, purpose, and above all the red team. The work is supported by the Defence security certified in Space for the Space networks assessment to put in place a programme to evaluate and to test Space networks and improve their resilience to manage the mass-market application in New Space. And the offensive security certified in Space exist to think about the scenatios potentially applicable to disturb the functionalities of assets in Space delivering services for the ground segment. Through a reverse engineering of OPS SAT from ESA test by malware and the add-on of CAN anomaly detection scenario, the capabilities of Space Red team able to warn the preliminary design and the upload of software on board computer show the need to apply cybersecurity semantic framework like Sparta, Shield, MITRE, EMB3D or specific one linked with the mission.
source :
https://github.com/esa/nanosat-mo-framework
https://ingescape.com/fr/bibliotheque-open-source/
https://github.com/mguentner/cannelloni

5th Session / **8**

Integrating Open-Source Digital Fabrication for Educational CubeSat Prototyping in Africa

Author: Matthew Koomson[1]

[1] *Ghana Fablab*

The global CubeSat ecosystem continues to evolve through open-source collaboration and localized innovation. This presentation explores how digital fabrication, open hardware, and STEM-based community engagement are being leveraged in Ghana to design and prototype educational CubeSat systems. Drawing from our work at Ghana FabLab, we showcase how tools such as 3D printing, CNC milling, and microcontroller platforms (e.g., Arduino, ESP32) are used to introduce students and young innovators to the foundational systems of satellite engineering.

This initiative demonstrates that low-cost, open-source prototyping can be an accessible and scalable entry point into space technology, especially in underserved regions. The session covers our current development of a ground-based CubeSat model, incorporating telemetry transmission, solar power simulation, and open-source satellite communication protocols. We also explore how collaborative platforms and shared documentation accelerate knowledge transfer across local and international maker communities.

The goal is to inspire cross-border partnerships, promote inclusivity in the global CubeSat movement, and highlight Africa's emerging role in open space innovation. We invite collaborators to join us in developing community-based, education-friendly CubeSat kits that can empower the next generation of satellite engineers.

This presentation will be of interest to educators, open-source hardware developers, CubeSat engineers, and space outreach programs looking to expand their global impact through grassroots innovation.

8th Session / **9**

A Framework for Blockchain-Verified Ground Infrastructure: Enabling Open Source CubeSat Communications Through Decentralized Networks

Author: Tristan Hundley[1]

[1] *Decen Space UG and Technische Universität Berlin*

CubeSat missions face critical ground station access bottlenecks that limit mission effectiveness. Traditional centralized ground networks are characterized by high deployment costs, significant downlink latencies exceeding 90 minutes [1], and long periods of idleness, with stations often unused for over 85% of potential satellite pass times [2]. Furthermore, geographic distribution imbalances, known as the Uneven Queuing Effect, can result in a 13–31% loss in potential throughput [3]. These combined factors create substantial barriers for academic institutions and open-source space projects seeking affordable and responsive ground station access.

We are developing a research framework to investigate the viability of Decentralized Physical Infrastructure Networks (DePIN) for ground stations through a methodology combining literature review, economic modeling, and experimental validation [4]. This framework examines the coordination of federated traditional, amateur and Ground-Station-as-a-Service (GSaaS) providers [5] using blockchain consensus mechanisms [6]. Our experimental work involves the implementation and testing of four novel cryptographic proof systems designed to verifiably report on physical infrastructure performance: Proof-of-Location (POL) [7], Proof-of-Accuracy (POA) [7], Proof-of-Backhaul (PoB) [8], and Proof-of-Flow (PoF) [9]. Current experiments focus on implementing a distributed hash-based verification system for ground station telemetry and evaluating consensus overhead in simulated satellite pass scenarios.

Literature analysis demonstrates that distributed ground networks could potentially reduce data downlink latency by up to 76% (from over 90 minutes to 21 minutes) [1] and improve throughput by 13–31% through intelligent, network-wide scheduling [3]. Our economic modeling suggests that a federated network could achieve break-even points with as few as 50 participating stations, offering potential cost reductions of 60–80% for university-scale operators [2, 5]. Preliminary digital experiments and implementations testing the cryptographic proof mechanisms show sub-second verification times, indicating their suitability for real-time ground station coordination [7, 8, 9]. Ongoing testing is focused on evaluating consensus latency and the scalability of proof validation under realistic LEO communication windows.

Our analysis indicates that blockchain-based coordination could enable trustless, dynamic collaboration between diverse ground station operators without requiring complex legal frameworks, significantly lowering barriers for educational and research-focused CubeSat missions [4]. The proposed framework supports the development of open-source ground station virtualization standards while

maintaining compatibility with existing infrastructure [10]. Key research challenges remain, including the optimization of consensus mechanisms for real-time satellite pass constraints [11] and ensuring regulatory compliance across international boundaries [12]. Future experimental work will seek to validate whether these cryptographic proof systems can operate effectively within CubeSat communication windows while delivering the security and decentralization benefits required by the global educational and open-source space community.

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Poster Tea Time / 10

Multi-Functional Optical Ground Station Testbed and Hardware-in-the-Loop Simulator

Author: Manfred Niehus[1]

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[3] *Mechanical Engineering Department CIMOSM, ISEL - Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa*

This contribution presents the development of an experimental testbed and hardware-in-the-loop simulator for a multi-functional optical ground station (OGS) being established in Portugal. The system is centered around a 43 cm Planewave CDK17 telescope mounted on an L500 Alt-Az platform, enhanced with a Planewave Series 5 focuser and a custom-designed optical breadboard integrated at the Cassegrain focus. This modular breadboard supports a range of advanced functionalities, including imaging, plate-solving, real-time beacon acquisition, closed-loop tip-tilt correction using one or two fast steering mirrors, and a quadrant photodiode, and turbulence analysis through a custom Shack-Hartmann sensor assembly.
The OGS further supports classical free-space optical communication at C-band, for both transmission and reception, leveraging FPGA-based systems within open-source development frameworks. Quantum communication capabilities are also integrated, with a dedicated broadband optical path for BB84 polarization-encoded signal detection and an alternative configuration for phase-encoded signals at telecom wavelengths. In the latter, quantum signals are coupled to single-mode fibers for delivery to remote detection nodes. Multiplexing and demultiplexing strategies combine dichroic elements with configurable wavelength division multiplexing, enabling reconfigurable operation across classical and quantum domains.
Lab integration is ongoing, with field tests planned to evaluate performance under diverse sky conditions ranging from urban high-Bortle environments to dark-sky locations. The testbed is conceived as a flexible, open architecture platform to support experimentation, training, and integration into international optical and quantum communication initiatives. We welcome collaborative opportunities to further develop and share this emerging capability.

7th Session / **13**

QEMUlate your CubeSat

Authors: Konstantinos Kanavouras[1]; Eleftheria Chatziargyriou[None]

[1] *University of Luxembourg*

CubeSat developers are usually encouraged to test their satellite software on actual hardware as early as possible. Development boards, engineering models, and hardware-in-the-loop setups are a very common occurrence across engineering labs. However, these devices are often limited by the constraints of physicality: Small numbers, complex logistics and high costs can make testing inefficient, especially when the members of a team are not co-located.

In this talk, we will present how **QEMU's System Emulator** can be used to reliably execute your onboard software without any hardware! More specifically, we will show how QEMU can be tailored to execute an arbitrary Cortex-M project, using AcubeSAT's OBC as an example. We will discuss the initial integration process, as well as different methods to mock both internal microcontroller peripherals, and external devices. Armed with a functioning emulator, we'll also show how testing can be automated and scaled.

This process could be then applied to virtually any ARM or RISC-V project, allowing you to run simple CI checks to complete Functional Test campaigns without spending a single Euro!

3rd Session / **14**

More-than-Planet: Opening Planetary Infrastructures

Author: Miha Turšič[1]

[1] *Waag Futurelab*

If you can't open it, you don't own it. This principle extends beyond hardware, software or data transparency. It strikes at the heart of planetary sovereignty and justice. Infrastructures—satellites, instruments, data platforms, and computational models—are the invisible physical architectures through which the planet is sensed, imagined, governed and shaped. Today, these systems remain largely controlled by state, military, and corporate actors. Yet what they observe and model affects everyone, humans and non-humans.

Opening planetary infrastructures is a democratic imperative. It means challenging the prevailing opacity of Earth observation systems and reclaiming environmental data as a public good. It calls for public computation—where technologies are designed not just for efficiency or profit, but for care, participation, and accountability. Initiatives like Libre Space Foundation, Open Weather or Solar Protocol exemplify how open-source, citizen or critical makers led efforts can produce alternative infrastructures rooted in local relevance, autonomy, and distributed stewardship.

To open planetary infrastructures is to redistribute power across the stack, from orbital architectures to interface layers. It means inviting plural imaginaries into the circuits of sensing, data modelling, and acting. In doing so, More-than-Planet provides for a truly public planetary condition, one that is not simply observed from above but composed, through collaboration, dissent, and collective care, from below.

3rd Session / **15**

FabSat: Prototyping Open Satellite Infrastructures Across the Global Fab Lab Network

Author: Henk Buursen[1]

[1] *Waag Futurelab*

In response to the growing need for accessible and distributed space technologies, Waag Futurelab has initiated the development of FabSat—a satellite that can be designed and built using the resources available in any Fab Lab worldwide. Leveraging the global infrastructure of the Fab Foundation, which connects labs through shared tools, skills, and digital fabrication environments, the project explores how space systems can be democratized through open-source and locally producible designs.

The first phase of the project focuses on aligning existing open-source satellite and ground station designs—particularly those under the Libre Space Foundation—with the foundational qualities of Fab Labs: public access to digital fabrication and repositories; adherence to the Fab Charter, a common set of tools and processes, and active participation in the global Fab Lab network.

This phase will test compatibility through collaborative prototyping with Fab Labs across at least one location per continent, mapping regional opportunities and constraints. The outcome will be a pilot FabSat programme designed for Fab Lab experts to implement and validate within their local contexts.

The second phase will scale this initiative across the wider Fab Lab ecosystem by inviting makers to engage with three challenges: constructing ground stations integrated into the SatNOGS network, refining and adapting FabSat designs through new fabrication techniques developed within the community, and prototyping satellite payloads that critically and creatively reimagine the use of Earth' s orbit.

By merging open hardware, distributed making, and planetary-scale experimentation, FabSat offers a blueprint for radically inclusive space infrastructure.

6th Session / **18**

The CENSUS Ground Station as a Node in NanosatGRID: Enabling an Open-Source Network for Two-Way Satellite Communications

Author: Chiara Pasquariello[1]

Co-authors: Aldric Parent [1]; Boris Segret [1]

[1] *CENSUS, Observatoire de Paris –PSL*

The CENSUS pole (CEntre for Nanosatellites in Sciences of the UniverSe) has integrated its ground station (GS) into the SatNOGS Network, enabling more than 10000 satellite observations. To facilitate deployment and maintenance of the station, the SatNOGS client has been containerized using Docker, and an automatic installer has been developed to allow full remote setup of the software stack, exploiting two custom Docker images.
The next development of the ground station involves enabling transmission capabilities, transitioning the station from receive-only mode to full duplex operation. This enhancement is essential to support two-way communication with satellites and future mission operations, and it will involve a dedicated and customized software chain, exploiting GPredict, GQRX and GNU Radio. The available laboratory radio hardware will be used to setup a full closed communication loop, allowing to test and validate the GS hardware and software setup.
These efforts serve as a foundation for the NanosatGRID project, which aims to interconnect multiple ground stations into an open-source network for coordinated satellite operations, in which assets will be shared for both reception and transmission. The proposed architecture introduces a scheduling and management orchestrator, alongside a centralized controller responsible for establishing data links between nodes of the network, and enabling remote telecommand transmission. The design takes inspiration from the open-source SatNOGS ecosystem and aims to remain compatible with it (for reception), allowing integration with existing infrastructure while extending its capabilities to full duplex communication.
The presentation will provide an overview of the current setup, the steps being taken to enable transmission, and the role of these developments in the broader context of open, scalable ground segment infrastructure.

Poster Tea Time / 19

On-Board Computer for a 1U CubeSat (AEGIS SAT-01) Towards Debris Free Missions

Authors: Braulio Silva[1]; Guilherme Costa[1]; Ana Marques[2]; André Silva[1]; Artur Encarnação[1]; Diogo Oliveira[1]; Gonçalo Silva[1]; Margarida Matos[1]; Martim Silva[1]; Nuno Cordeiro[1]; Paulo Nascimento[1]; Ricardo Fernandes[2]; Rodrigo Lourenço[1]; Manfred Niehus[1]; Mário Véstias[1]; Rui Duarte[1]

[1] *Polytechnic of Lisbon*

[2] *University of Lisbon*

This work describes the hardware and software design and implementation for a 1U CubeSat satellite on-board computer. The primary goal was to create an embedded system capable of coordinating tasks, collecting data from various sensors, and managing communication with ground station, all within the tight energy and memory constraints of a small and cheap low-power microcontroller in real-time.
The electronic circuit was breadboarded using commercial-off-the-shelf modules. The OBC software was organized into three layers. The first layer handles direct hardware control, providing drivers for sensor interfaces and communication modules. The second layer offers high-level functions that gather and format sensor readings—such as temperature, humidity, pressure, and inertial orientation—without using floating-point arithmetic which the provided microcontroller does not support. The third layer relies on a lightweight real-time operating system to schedule periodic tasks, coordinate event signals between modules, and switch between low-power and active modes.
Laboratory tests confirmed that the system correctly initializes all implemented sensors, retrieves measurements, and formats data for transmission. Communication links were verified for reliability,

and timer functions successfully triggered periodic task execution. Throughout development, available memory emerged as the main limitation.
In summary, the proposed system fulfills its requirements, including core functions—sensor management, data handling, and real-time task scheduling while demonstrating an architecture optimized for resource-constrained space applications. Future work will focus on further memory optimizations and methods for in-orbit 'over-the-air' updates.

1st Session / **20**

SatNOGS - State of the Union

Author: SatNOGS Community[1]

Co-author: Alfredos Panagiotis Damkalis [2]

[1] *SatNOGS project*

[2] *Libre Space Foundation*

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.

1st Session / **21**

SatNOGS SSA/SST Operations

Author: SatNOGS Community[1]

Co-author: Alfredos Panagiotis Damkalis [2]

[1] *SatNOGS project*

[2] *Libre Space Foundation*

SatNOGS has started as a project for automating tracking and communications with satellites though a network of ground stations. Early enough the need for accurate satellite orbital data, lead us, the SatNOGS Community, to develop and utilize processes and tools that help us to improve our observations.

This development get us involved in Space Situational Awareness(SSA) and Space Surveillance and Tracking(SST) fields. Our public processes, our opensource tools and our open data play today a significant role in open and public SSA/SST activities.

This is a proposal for a talk focusing on how SatNOGS Community organize and performs SSA/SST operations in all stages of a satellite's operations life.

Ephemerista Workshop / **23**

Ephemerista open-source Satellite Communications simulator tool

Authors: Clément Jonglez[None]; Nikoletta Triantafyllopoulou[1]

[1] *LSF Comms and Ephemerista PM*

As the space industry rapidly evolves, the need for accessible, collaborative, and powerful mission analysis tools has never been greater. Ephemerista is an open-source, satellite communications simulator tool funded by the European Space Agency (ESA) and developed by the Libre Space Foundation. Ephemerista provides a comprehensive suite of tools for satellite constellation design, orbit propagation, and telecommunications analysis. This workshop will provide an introduction to the Ephemerista ecosystem, highlighting its core functionalities and open-source philosophy. Attendees will learn how to leverage Ephemerista's Python API to perform key tasks, such as defining spacecraft orbits, modelling ground stations, and conducting link budget analyses. We will also demonstrate the intuitive web-based GUI, which allows for 3D visualisation of space assets and facilitates collaborative design efforts. The workshop will cover practical use cases, from single-satellite mission planning to large-scale constellation simulations. By the end of this session, participants will have a foundational understanding of how to use Ephemerista to streamline their space mission design and analysis workflows, fostering a more collaborative and innovative approach to space exploration.

6th Session / **24**

Mission Control Software the open source way

Author: Victoria Malyshkina[1]

Co-author: Nestoras Sdoukos [1]

[1] *Libre Space Foundation*

How can you develop a mission control center to support a mission involving 2 CubeSats? You don't develop it, you use YAMCS open source mission control software! At least that is what Libre Space Foundation did for its PHASMA mission and you should too.
In this talk i am gonna present how the LSF software team used YAMCS to create a working mission control center to send telecommands and receive telemetry from the PHASMA CubeSats. We are gonna dive in YAMCS XTCE loader to describe our CCSDS Space Packet and specific telecommands, in the creation of appropriate data links for TM&TC for CCSDS USLP packets, and we will even dabble in Java when we need to write our own command post processor. We will then send and receive our commands from the Web interface and examine the packets along with how erroneous ones are handled.

8th Session / **25**

Space Based Precipitation Measurement with a CubeSAT

Author: Varun Dwarakanath[1]

[1] *Assistant Professor*

Precipitation measurement is necessary to study the rainfall patterns and predict the rainfall and storms. There are multiple ground based radars that perform this functionality. CSU-CHILL is one such example where ground based radars are used precipitation measurement. Maintenance of these radars are difficult and expensive. The proposal is to now use CubeSAT and develop a doppler Radar as payload. These doppler radars are small and can be deployed on CubeSATs. The performance of these payload can be improved with cloud profiling too.
X-band is the most suited frequency for such applications and it has been found that the existing small architecture can be used for a sensitivity upto -45 dBz. This can be further improved with reduced NF, high gain antenna and pulse bandwidth. Also, beamsteering can be used with array thinning for estimating rain fall in a specific direction.

Poster Tea Time / **26**

DESIGN AND IMPLEMENTATION OF AN ESP32-BASED ON-BOARD-COMPUTER FOR A 1U CUBESAT EDUCATIONAL PROTOTYPE

Author: aristo davino[1]

Co-author: Agfianto Eko Putra [1]

[1] *Gadjah Mada University*

The growing need for hands-on space technology education demands affordable, easily accessible learning kits that let students build and test core satellite subsystems. Existing CubeSat kits such as HeptaSat, KitSat, and OpenOrbiter are costly, imported, and lack local support, limiting adoption in Indonesia. This research addresses that gap by designing and partially implementing a low-cost 1U CubeSat prototype focused on its On-Board Computer (OBC) subsystem, using the ESP32 microcontroller as the central controller.
The ESP32's dual-core processor, built-in Wi-Fi/Bluetooth, and multiple I^2C/UART interfaces enable real-time data acquisition and control of three flight-representative sensors (MPU6050 IMU, BMP280 pressure/temperature, NEO-6M GPS). Task scheduling is managed by FreeRTOS, sensor fusion uses Madgwick and Kalman filters, and data is logged to microSD and streamed via WebSocket to a browser dashboard. By leveraging off-the-shelf components, open-source firmware, and a modular architecture, this prototype offers a replicable, locally adaptable platform that immerses students in embedded satellite systems without prohibitive costs.

5th Session / **27**

PHASMA: Monitoring the Electromagnetic Spectrum from Above

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The PHASMA mission, developed by the Libre Space Foundation, is a two 3U CubeSat constellation designed for spectrum monitoring and space-based situational awareness. The mission's primary objectives include in-orbit spectrum analysis (UHF, GPS and S-band) to quantify global spectrum utilization, identify interference sources, and detect regulatory violations using on-board DSP and machine learning. Additionally, PHASMA will contribute to space situational awareness by monitoring satellite transmissions for improved orbit determination and rapid satellite identification. The

project also serves as a technology validation platform for several Libre Space Foundation open-source systems, including the SatNOGS-COMMS transceiver.

1st Session / **28**

Libre Licensing in the Final Frontier: Open-source licensing for Space Hardware, Software and Data

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The selection of open-source licenses is a foundational decision for CubeSat projects, with significant implications for collaboration, development, and mission viability. A cohesive licensing strategy is essential to manage the distinct requirements of hardware, software, and data. Such a licencing challenging must align with aerospace-specific regulatory frameworks, to ensure compliance and interoperability.
This presentation offers a practical and methodical approach to these challenges. Drawing upon the extensive experience of the Libre Space Foundation (SatNOGS, Qubik, SIDLOC) and insights from multinational collaborations like EU-RiSE, we will provide a clear analysis of effective licensing models for complex space projects.
Participants will gain practical guidance on:
* Choosing licenses for hardware, software, and data that align with mission goals.
* Avoiding common pitfalls when mixing different open licenses.
* Ensuring compliance with both open-source principles and legal restrictions.
* Building licensing strategies that encourage global collaboration and innovation.
The session will conclude by offering a clear framework to guide licensing decisions, enabling teams to build robust, collaborative, and successful CubeSat missions, while adopting and developing open-source solutions.

8th Session / **29**

An Open-Source Wrapper for Basilisk Simulations

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Simulating the trajectory at low altitudes is challenging. The complex dynamics include Earth atmospheric drag, Solar Radiation Pressure, and gravitational perturbations from the Sun, the Moon or other planets. Implementing these effects can be tedious for actors designing complex trajectories, reentry strategies, or autonomous decision-making solutions. This highlights the need for a comprehensive and easy-to-use framework.

Many existing software packages and libraries can model satellite motion and provide common perturbation models. Among these, the open-source Basilisk framework stands out for its modular architecture, ability to represent multiple interacting systems, and suitability for hardware-in-the-loop testing.

However, Basilisk's steep learning curve and developer-oriented design can be a barrier to newcomers and to rapid prototyping of mission-specific tools. To bridge this gap, we are developing

GECKO, a lightweight wrapper that streamlines Basilisk usage and simplifies the integration of external modules. It eases the use of Basilisk for applications such as testing autonomous decision-making algorithms, simulating deorbiting strategies, or experimenting with reinforcement learning (RL) for trajectory optimization. Our current focus, which led to the development of Basilisk, is on building a Conjunction Data Message (CDM) generator to emulate realistic collision-warning scenarios in Low Earth Orbit, enabling the testing and validation of autonomous decision-making algorithms.

By lowering the entry barrier to Basilisk, GECKO aims to foster collaboration and accelerate open-source innovation, with scalable simulations for RL training and hardware-in-the-loop capabilities for onboard validation.

6th Session / **30**

Communicating with AcubeSAT via a SatNOGS based platform

Authors: Georgios Vellios[1]; Giorgos Chatziathanasiou[2]; Ioanna Petkou[2]; Konstantinos Gkaripis[2]

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AcubeSAT is a 3U CubeSat, developed to conduct a biological experiment in Low Earth Orbit (LEO), designed and built by the interdisciplinary volunteering student team SpaceDot, at the Aristotle University of Thessaloniki. Aiming to investigate how gene expression in eukaryotic cells is dynamically regulated in space, this satellite is designed to record their growth and provide valuable experimental data, via its onboard imaging system, to the Ground Station. By demonstrating a novel payload design for high-throughput life sciences' studies in orbit, AcubeSAT presents demanding requirements in terms of communication resources.

After the successful environmental qualification campaign of the Communications (COMMS) Board based on the Libre Space Foundation (LSF) SatNOGS COMMS board design, conducted with the support of the Fly Your Satellite! 3 programme at ESA Academy's testing facilities, the communications team is now advancing towards the development of networking applications for AcubeSAT. A complete end-to-end network architecture is being implemented, spanning from the Ground Station to the application layer software running onboard, utilizing open source tools for the Mission Control Software, such as YAMCS. Although the mission poses significant technical challenges, progress in the development of the physical layer has been advancing steadily, by implementing the modulation and demodulation techniques, as well as the encoding and decoding methods on the flight software and hardware.

This presentation aims to highlight the current status of AcubeSAT's communications subsystem while also providing a deeper dive into its physical layer. A closer look at the in-house developed Offset Quadrature Phase-Shift Keying (OQPSK) modulator, used for high-speed transactions between the mission's terminals to transfer experiment results, will offer insight into both the GNU Radio tool developed for the Ground Station and the corresponding Field Programmable Gate Array (FPGA) Intellectual Property (IP) Core.

5th Session / **31**

AcubeSAT, the 3U platform for biological experiments in space: a status update

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Given the ever-growing demand to make science in space more approachable –and the value of experimental data in such conditions –the SpaceDot team has been driven by the ambition of sending a low-cost, high-throughput, modular science platform in Low Earth Orbit (LEO), in service of open science. This has led to the conception of AcubeSAT, a 3U CubeSat carrying a novel payload which combines fluidics, optics and electronics to probe the gene expression of yeast cells in space. AcubeSAT is being developed by students at the Aristotle University of Thessaloniki, with support from the European Space Agency's (ESA) Education Office under the Fly Your Satellite! 3 programme. Throughout the years, the team's efforts to design, manufacture and integrate AcubeSAT's various parts have led to the accumulation of useful knowledge and lessons learnt, which are all thoroughly documented in open-access fashion on its GitLab page.

Several key developments have occurred in the time that has passed since the last time the team was present in OSCW. Most notably, there has been a major redesign in key subsystems and the satellite' s payload. The mission is currently in the manufacturing and testing phase, having completed a full environmental qualification campaign of AcubeSAT's SatNOGS COMMS board, which is based on Libre Space Foundation's (LSF) design, while its payload assembly and OBC/ADCS board were qualified in vibration testing, with thermal and vacuum (TVAC) tests scheduled for both in September 2025.

With this presentation, the team plans to share its latest contributions to the open source space community, some of the technical lessons learned throughout the years focusing on the manufacturing and testing phase and the challenges that have been faced attempting to build a CubeSat in an academic environment by a student team.

7th Session / **32**

RACCOON OS - A Free, Open Source Operating System for Secure Space Applications

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RACCOON OS is an open source operating system based for secure space applications based on Linux, which is being developed at the Technical University of Berlin with support from the German Aerospace Agency (DLR) and partners like Quantum Galactics GmbH and the Helmholtz Center for Information Security (CISPA).

The goal of this project is to create a free, easy to use and secure platform for developing and operating space applications. The main use case for RACCOON OS is in the role of a Payload Data Handling system, i.e. applications requiring significant computing and storage resources, although it can also be used to perform the tasks of a basic On-board Computer (telemetry, parameter management, etc.)

A key aspect which is sometimes disregarded in NewSpace missions is computer/information security. Surveys and research into this has shown that the majority of missions lack any form of command authentication, and in many cases critical security vulnerabilities that would allow an attacker to take control of the satellite are present in self-made and commercial spacecraft platform software.

To this end we are working on a minimal, widely portable Linux distribution that builds in certain security features like Secure Boot, application sandboxing using syd-sandbox and, importantly, a bandwidth-minimizing differential update process using OSTree.

In addition to the Linux distribution, RACCOON OS consists of a set of standard userspace programs (rccn_usr_comm application, rccn_usr_cfdp server, rccn_usr_launch monitoring daemon, etc.) and a framework for writing space applications using the ECSS Packet Utilisation standard.

All of the frameworks and applications are written in Rust, although end user applications can be written in any programming language of choice. Communication between applications happens through the Zenoh middleware, which is also written in Rust and supports mutual authentication between peers and access control.

We are also investing in general improvements to the open source support for standards like CFDP (CCSDS File Delivery Protocol), PUS, and SDLS (Space Data Link Security) protocol. This year, together with our partners we were able to sponsor a basic implementation of SDLS in Yamcs.

In this presentation we would also like to talk about the upcoming missions running RACCOON OS that we have in the near-term pipeline, and our plans for making development of RACCOON OS sustainable. Finally, we would like to invite anyone to join our community and contribute in any way that they can - we certainly have a lot of work on our hands :)

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3rd Session / 39

Monitoring Light Pollution With Crowdsourced Data

Light pollution is an often-overlooked environmental challenge with profound effects on ecosystems, astronomy, and human health. While photometers for measuring sky brightness are widely available, most existing solutions are closed, fragmented, or limit access to the data they generate.

This talk introduces an integrated, fully Open Source approach to monitoring light pollution. By combining SC Robotics'Open Hardware Dark Sky Meter devices with the Libre Space Foundation's

experience in building community-driven data platforms, we are creating a collaborative ecosystem where anyone can measure, share, and explore night-sky brightness data.