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OVERVIEW OF ALAINSAT-1 MISSION: A REMOTE SENSING STUDENT NANOSATELLITE

Abdul-Halim Jallad[1,2], Adriano Camps[3,4,5], Prashanth Marpu[6], Mai AlMazrouei[2], Ahmed Ba-Layth[2], Shamma Aleissaee[2], Abdullah Alsalmani[2], Mohamed Okasha[7], Adrian Perez-Portero[3,4], Amadeu Gonga[3], Juan Ramos-Castro[3,4], Shindi Oktaviani[8], Edwar Edwar[1,8], Yasir Abbas[1], Mark Angelo Purio[9]*

[1]Department of Electrical Engineering, College of Engineering, United Arab Emirates University
[2]National Space Science and Technology Centre, United Arab Emirates University
[3]CommSensLab – UPC, Universitat Politècnica de Catalunya – BarcelonaTech, E-08034 Barcelona, Spain
[4]Institute of Space Studies of Catalonia (IEEC) – CTE-UPC, E-08034 Barcelona, Spain
[5]ASPIRE Visiting International Professor, Department of Electrical Engineering, College of Engineering, UAE University, PO Box 15551 Al-Ain, UAE
[6]Group 42, Abu Dhabi, UAE
[7]Department of Mechanical and Aerospace Engineering, College of Engineering, United Arab Emirates University
[8]Telkom University, Indonesia
[9]Kyushu Institute of Technology, Japan

*a.jallad@uaeu.ac.ae

ABSTRACT

AlainSat-1 is an educational and scientific nanosatellite project that was initiated in late 2019 by the IEEE Geoscience and Remote Sensing Society (GRSS) along with National Space Science and Technology Center (NSSTC) of UAE University in the frame of the 2nd Student Grand Challenge [1]. The project involves close collaboration between four international universities to design, build, test and launch a remote sensing CubeSat.

The spacecraft is a 3U CubeSat that has a mass of around 4 Kgs. The spacecraft has an active 3-axis control system capable of attitude determination and control to less than one degree. Two communications systems will be used on-board: a UHF System and an S-Band System. The project has passed the Critical Design Review (CDR) stage and is currently in the assembly and integration phase. The satellite is currently planned for launch to a sun-synchronous orbit on-board a Falcon 9 rocket in the second quarter of 2024.

Index Terms— CubeSat, Remote sensing, AlainSat-1

1. INTRODUCTION

In recent years, there has been a remarkable surge in the development and deployment of CubeSats, small and low-cost satellites that have revolutionized the field of space exploration and remote sensing. These miniature satellites, typically weighing in the order of a few kilograms, offer an exceptional opportunity for young professionals and students to actively engage in the realm of space technology and its applications. With their compact size, CubeSats are easier to design, build, and launch, making them accessible to educational institutions and research organizations. Their versatility and affordability have opened up new avenues for hands-on experience and practical involvement, fostering the curiosity and enthusiasm of aspiring scientists and engineers. CubeSats have emerged as a powerful tool for nurturing the next generation of space enthusiasts, providing invaluable learning experiences and empowering young minds to contribute to the ever-expanding frontiers of space exploration and remote sensing.

ALAINSAT-1 satellite project is the outcome of the second IEEE GRSS Grand student challenges that is intended to engage young professionals in solving complex engineering problem within the scope of GRSS. The second challenge is a collaboration between the National Space Science and Technology Center and the IEEE Geoscience and Remote Sensing Society (GRSS) with the aim of allowing student teams to develop Earth Observation payloads for a small satellite.

In 2019, a jury composed of scientists from NASA, ESA and UAE Space Agency has evaluated the proposals received to develop the Earth Observation Payloads for the 3U CubeSat mission to be developed at the National Space Science and

Technology Center (NSSTC), UAE. After the evaluation process two proposals were selected.

• A student team from Universitat Politècnica de Catalunya (UPC), Spain, proposed developing a combination of payloads in small form factor for CubeSats. These include an L-band radiometer for monitoring ice thickness and soil moisture, a multispectral camera for monitoring vegetation, and a software defined radio for monitoring Radio Frequency Interference.

• A student team from Telkom University, Indonesia proposed development of a multispectral camera and a miniature spectrometer for atmospheric sensing.

In addition, a student team from Kyushu Institute of Technology, Japan was also selected to develop smart cameras with onboard classification capability to automatically detect the best quality images for downlinking.

In this article we, we present a brief description of the final AlainSat-1 mission concept, and design, including an overview of the spacecraft bus.

2. MISSION OVERVIEW

This section provides an overview of the mission objectives, an overview of the payloads built by the student teams selected as explained in section 1. In addition, the section presents the subsystems of the satellite, the mission's orbital analysis, and the Concept of Operations (ConOps), providing a top-level view of the mission.

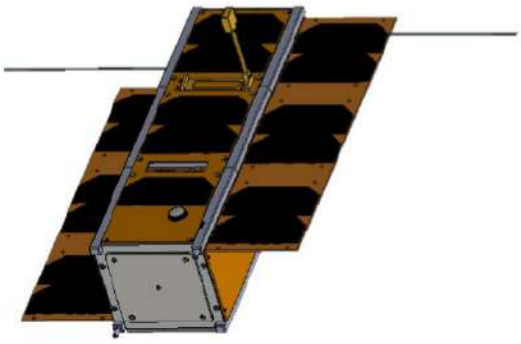

Fig. 1. Top-level view of AlainSat-1.

The mission objectives are as follows:

- Technology Demonstration: Test payloads developed by students from partner international universities.
- Perform Microwave Radiometry (MWR) measurements at L-band, vegetation analysis using a Normalized Difference Vegetation Index (NDVI) /Near-Infrared Regions (NIR) camera, and Radio-Frequency Interference (RFI) detection and classification.
- Take Images using a miniature Multispectral camera.
- Perform using image classification to autonomously detect the best quality images for downlinking.

To achieve the above objectives, the satellite will carry two different primary payloads built by three universities.

• RITA payload: Universitat Politècnica de Catalunya (UPC), Spain, is developing the Remote sensing and Interference detector with radiometry (RITA), as one of the mission payloads. RITA carries three experiments: An L-Band microwave radiometer (MWR), a Low-Power Wireless Area Network (LPWAN) transceiver, and a hyperspectral camera. The RITA payload will be used for various remote sensing applications such as monitoring soil moisture and vegetation, and monitoring Radio Frequency Interferences [2].

• Locana Payload: Telkom University, Indonesia, is developing an RGB-based camera payload. The team at Kyushu Institute of Technology, Japan, will use the images captured by the Locana payload to perform onboard classification using machine learning to automatically detect the best quality images (low cloud coverage) for downlinking [3].

In addition, the mission will also carry a secondary payload to demonstrate the NSSTC's novel modular CDHS architecture, that is highly adaptable and scalable to meet future data handling needs of small satellites.

The mission requirements includes a minimum of 3 years of in-orbit lifetime. The selected orbit is a sun-synchronous (SSO) orbit with an altitude of 575 km, providing an estimated of 4.5 years minimum in-orbit lifetime as shown in figure 2.

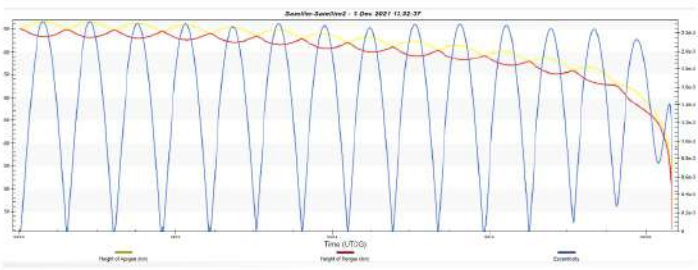

Fig. 2. Estimate Lifetime simulation of AlainSat-1 at an altitude of 550 Km.

The AlainSat-1 spacecraft bus design (fig. 2) consists of an attitude determination and control system (ADCS), a power management and distribution system, an on-board computer, a communications system and the structure. The ADCS uses three reaction wheels and three magnetic torquers for control, and sun sensors, a horizon sensor and a star tracker for attitude determination. This achieves a control accuracy of less than one degree.

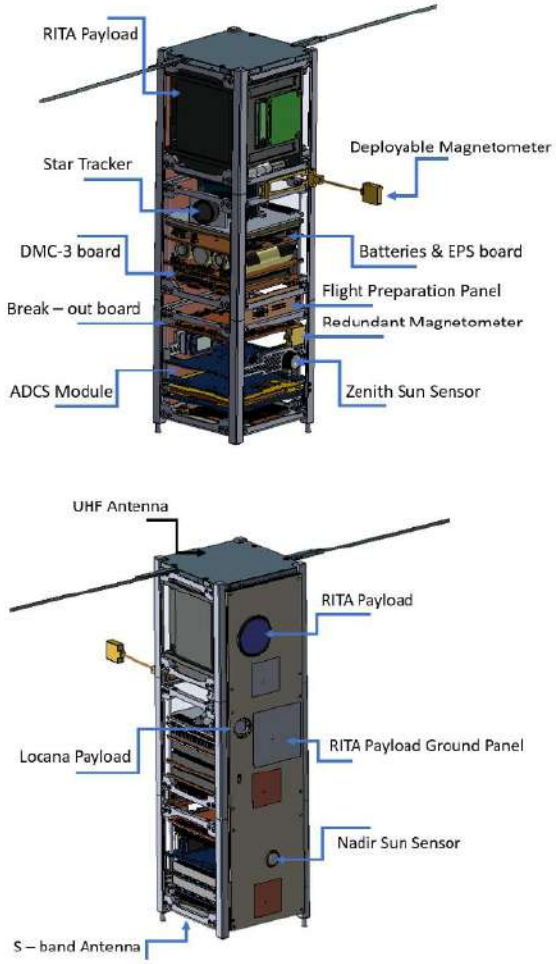

Fig. 2. Internal components of AlainSat-1.

The CDH consists mainly of an On-Board Computer board with an ARM Cortex M processor, 32 MB SDRAM, 128 MB flash. and an SD card for mass storage. A CAN bus is used as the primary on-board data bus, with an I2C bus used as a secondary bus. The satellite uses two deployable solar panels, causing the total number of solar cells to be equal to 17 cells, capable of an estimated average power 0f 5.8W.

The satellite's communications system consists of a UHF transceiver for two-way Telemetry and telecommand communications and an S-Band transceiver for downloading the data, implemented inside the RITA payload, and also to be used as a back-up communications link. The satellite uses a modular multi-layered service-based software architecture. This paper presents the overall mission objectives, design architecture, and concept of operations.

10. CURRENT STATUS

The project has passed the critical design review (CDR) phase, and have moved into the assembly and integration phase. The various subsystem has been individually verified to be working as per the requirements. The system is currently being integrated together. The mechanical fit check was successful, and currently moved into the software and hardware integration of the various subsystems.

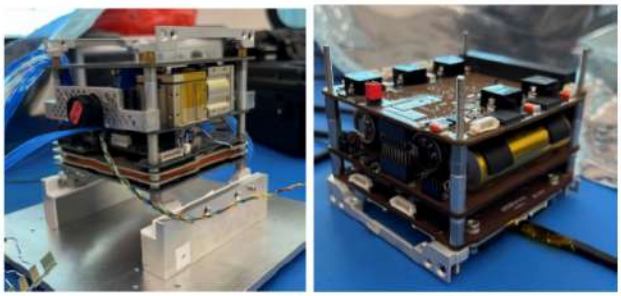

Fig. 3. The lower assembly of AlainSat-1 (left) and the middle assembly of AlainSat-1 (right)

3. CONCLUSIONS

AlainSat-1 is a 3U CubeSat that is a collaboration between four universities in four different countries. The project trained more than 20 students on various aspects of remote sensing and satellite development. The project requirements led to a satellite with a 3U form factor, driven mainly by the requirements of interference detector of the RITA payload. The selected orbit is a 575 km sun synchronous orbit, driven by the requirement of 3 years in-orbit lifetime. The satellite hardware integration is currently being assembled, and the software implementation is ongoing. The satellite is now scheduled for launch in the third quarter of 2024.

4. REFERENCES

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