ACCELERON AEROSPACE JOURNAL (AAJ)
E-ISSN: 2583-9942 (Online) | Accessible at www.acceleron.org.in
Volume 5, Issue 6, (pp.1618-1621)
Article ID: AAJ.11.2106-2566
Technical Paper
https://doi.org/10.61359/11.2106-2566

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SOLARAS S2: An Overview of India's Private Solar CubeSat Mission

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Abstract: The frequent development of small satellite technology has made access to space more reliable and flexible for scientific research for educational and technology testing mission purposes. SOLARAS S2 is 1U CubeSat satellite developed by Grahaa space as part of its early nanosatellite development works. The main goal of the mission is to test key spacecraft subsystems while carrying out experimental studies related to solar radiation and satellite communication performance. The satellite is scheduled for launch as a rideshare payload aboard South Korea's HANBIT-NANO, operated by Innospace, from the Alcântara Space Center by end of December 2025, and is intended to be placed into a low Earth orbit at an altitude of about 300 km. SOLARAS S2 operates an open and non-commercial technology illustration mission, by continually transmitting telemetry and beacon signals in the UHF and VHF bands around the world to receive and analyze the signals, supporting satellite health monitoring, signal behaviour studies, and leaning activities. The spacecraft follows standard 1U CubeSat design, featuring a small structure, limited power availability, and modular subsystems suited for early in-orbit testing. Although with technical and scientific goals, the mission emphasized regulatory compliance through formal registration with international telecommunication union, ensuring official use of radio-frequency spectrums for mission. Overall, SOLARAS S2 shows smaller size satellites can provide affordable and sustainable missions while supporting future nanosatellite and constellation development.

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1. Introduction

The significant development of small satellite technology in the space sector has made missions more cost-effective, quicker to develop, and easier to manage. Among these platforms, CubeSats are widely used for technology validation, educational objectives, and preliminary scientific research. Their standard size allows easier, lower-cost launches and rapid design iterations, making them ideal for testing novel subsystems and mission concepts in Low Earth Orbit (LEO) [1–3]. SOLARAS S2 is an advanced 1U CubeSat developed by Grahaa Space under its early nanosatellite and technology demonstration program. The mission focused on testing essential spacecraft subsystems while performing experimental investigations such as solar radiation measurements and satellite communication performance. With open telemetry broadcasting, SOLARAS S2 functions both as a precursor for future missions and as an educational satellite that promotes engagement with the global amateur radio community (Fig. 1) [4]. The satellite was scheduled for launch aboard the HANBIT-NANO launch vehicle operated by Innospace, with orbital insertion planned from the Alcântara Space Center, Brazil. The launch will take place by end of December 2025. SOLARAS S2 is designed to operate in Low Earth Orbit (LEO) at an altitude of approximately 300 km with a moderate orbital inclination. This orbital configuration provides frequent ground station passes, supporting effective telemetry reception, beacon monitoring, and communication performance analysis using multiple ground stations across different locations. From a design perspective, SOLARAS S2 is built as a compact 1U CubeSat with dimensions of approximately 10 × 10 × 11.3 cm and a total mass of around 700 grams. Despite its small form factor, the satellite supports several essential subsystems, including power generation, onboard data processing, RF communication, and payload interfaces. These subsystems enable solar radiation studies and reliable communication performance. In addition, the mission is designed to comply with applicable international space communication regulations to ensure proper spectrum usage and legally compliant operations [2–5]. Beyond its near-term engineering goals, SOLARAS S2 serves a strategic role within Grahaa

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Article History: Received: 16-Oct-2025 || Revised: 19-Nov-2025 || Accepted: 28-Dec-2025 || Published Online: 30-Dec-2025.

Space's long-term nanosatellite development strategy. The mission contributes to early in-orbit validation of spacecraft bus performance, communication reliability, and regulatory compliance readiness, which are critical operational requirements for future Earth observation missions and constellation-based satellite applications. As an open and non-commercial demonstration mission, SOLARAS S2 highlights the role of small satellites in supporting cooperative, responsible, and sustainable space ecosystems.

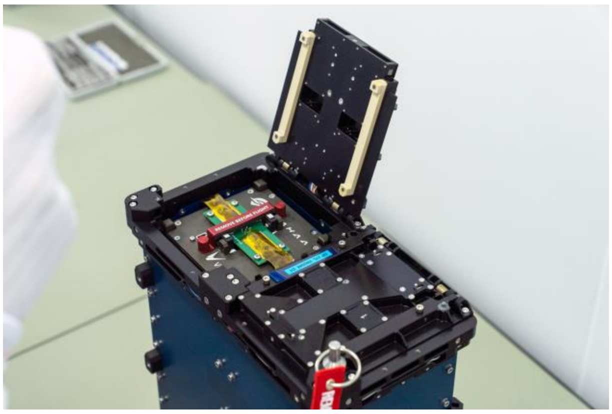

Figure-1 SOLARAS S2 Nanosatellite Developed by Grahaa Space for TD

2. Mission Overview and Objectives

The SOLARAS S2 satellite mission is formulated as a nanosatellite-based technology demonstration focused on spacecraft subsystems that enable experimental scientific measurements. SOLARAS S2 is scheduled for launch by the end of December 2025 aboard the HANBIT-NANO launch vehicle from the Alcântara Space Center, Brazil. The launch is planned to deploy the satellite into Low Earth Orbit (LEO) under a rideshare mission profile (Fig. 2). The central objective of the mission is to gain in-orbit experience with a compact, miniaturized CubeSat platform and to establish a dependable baseline for future nanosatellite constellation-oriented mission architectures.

Figure-2 Team Innospace with HANBIT-NANO Launch Vehicle along with Brazilian Air Force (FAB) [Image Courtesy: Innospace]

The SOLARAS S2 mission is structured for a nominal operational duration of approximately ~1.5 months. This timeframe is sufficient for monitoring spacecraft performance parameters, including communication link stability and payload functionality, under actual space environment conditions. The mission is configured for operation in Low Earth Orbit, which provides repeated visibility over multiple ground stations, enabling regular telemetry reception and continuous data collection throughout the mission duration. From a research perspective, the principal aim of SOLARAS S2 is to monitor solar radiation phenomena, generating data on solar activity over time. These observations support the understanding of space environmental conditions and their effects on small-scale satellites operating in Low Earth Orbit. Although the payload capability is constrained by the 1U volume and available power limitations, the mission facilitates the acquisition of preliminary experimental datasets that are valuable for future sensor optimization and mission design strategies. Beyond its scientific objectives, SOLARAS S2 incorporates significant engineering-driven goals related to spaceborne communication systems. The mission focuses on validating the performance of its onboard communication subsystem through continuous telemetry and beacon transmissions. These signals enable real-time monitoring of satellite health parameters and communication link quality over time, which is critical for assessing in-orbit reliability throughout the mission lifespan [4].

Acceleron Aerospace Journal || AAJ.11.2106-2566
Volume 5, Issue 5, pp (1618-1621)
E-ISSN- 2583-9942
https://dx.doi.org/10.61359/11.2106-2566

A distinctive characteristic of the mission is its commitment to an open-science philosophy that promotes engagement from the international amateur radio community. By utilizing amateur radio frequency allocations, SOLARAS S2 enables licensed operators worldwide to receive, decode, and analyze transmitted satellite signals. This cooperative approach supports studies related to signal behavior, orbital pass prediction, and independent assessment of spacecraft operational performance. In addition to its scientific and engineering outcomes, SOLARAS S2 fulfills an important instructional role by providing experimental data and operational experience for future missions. The mission offers hands-on exposure to spacecraft development processes, subsystem integration, standards compliance, and end-to-end mission operations. Operating as a non-commercial technology demonstrator, SOLARAS S2 contributes to the advancement of small satellite platforms by expanding access to space research and strengthening technical capabilities within the evolving private space sector [6].

3. Spacecraft Design and System Description

SOLARAS S2 is a 1U CubeSat platform that conforms to standard CubeSat size guidelines. This design makes it compatible with conventional deployers and rideshare launch systems. The spacecraft is compact, measuring approximately 10 × 10 × 11.3 cm, with a total launch mass of around 700 grams. This size enables low-cost launch opportunities while providing sufficient volume for essential subsystems and payload integration. The structure of SOLARAS S2 is designed to provide mechanical strength and stability during launch, while supporting subsystem integration within a limited space. The satellite structure incorporates internal modules for power management, onboard data handling, communication electronics, and payload interfaces. The design ensures proper alignment of internal components, effective load distribution, and protection against vibrations and shocks experienced during launch [7].

SOLARAS S2 employs a CubeSat bus architecture that enables modular subsystem integration. This bus-based approach simplifies system development and testing while supporting scalability for future missions. The onboard system is designed to ensure reliable operation of all subsystems, including command handling, telemetry generation, and payload data collection, within the constraints of a 1U form factor. Power capability is a critical aspect of spacecraft design. SOLARAS S2 operates with limited onboard power, primarily generated by compact solar panels and managed through an internal power management system. The power budget is designed to support continuous operation of essential functions such as telemetry transmission, broadcasting, and onboard data processing. Despite its small size, the spacecraft can deliver stable power to critical subsystems, ensuring reliable performance throughout the mission [8]. Moreover, the spacecraft parameter and configuration are outlined in table-1 below.

Table-1- SOLARAS S2 Parameters

Category	Parameter	Value
Spacecraft	Satellite Class	1U CubeSat
Spacecraft	Dimensions	10 × 10 × 11.3
Spacecraft	Launch Mass	~770 grams
Mission	Mission Type	Technology Demonstration
Mission	Mission Duration	~1.5
Orbit	Orbit Type	Low Earth Orbit (LEO)
Orbit	Nominal Altitude	~300
Power	Peak Power Capability	~24 watts
Communication	Frequency Bands	VHF / UHF
Launch	Launch Vehicle	HANBIT-NANO

4. Communication System Architecture

The communication system of SOLARAS S2 is crucial for both mission operations and its open-science objectives. Its primary function is to transmit telemetry and beacon signals, enabling continuous monitoring of satellite health, system status, and basic mission parameters. These signals provide essential feedback on spacecraft performance and help maintain situational awareness throughout the mission. SOLARAS S2 operates in the VHF and UHF frequency bands, which are commonly used for CubeSat and amateur radio satellite missions. The selection of these bands supports efficient signal propagation and ensures compatibility with a wide range of existing ground station configurations. Telemetry data packets and beacon signals are transmitted at regular intervals, allowing ground stations to receive satellite information without the need for complex tracking systems or high-gain antennas. Interaction with ground stations is a vital component of the mission. The communication system is designed to support reception by multiple ground stations distributed across different geographic locations, including those operated by the global amateur radio community. During each orbital pass, the satellite establishes short communication windows with ground stations, enabling data reception, signal quality assessment, and orbit tracking. This distributed ground station approach improves mission coverage and increases the probability of successful data reception. A distinctive feature of the SOLARAS S2 communication architecture is its global reception capability. By employing an open telemetry transmission model, the mission enables licensed amateur radio operators worldwide to receive, decode, and analyze satellite signals. This collaborative approach supports independent verification of satellite performance, studies of signal propagation, and real-time tracking. Overall, the communication system not only supports mission operations but also aligns closely with the mission's educational and open-science goals [9, 10].

5. Conclusion

The SOLARAS S2 mission represents a significant milestone in the advancement of nanosatellite development and early in-orbit capability validation. As a 1U CubeSat technology demonstration, SOLARAS S2 integrates scientific experimentation, engineering verification, and open participation within a compact and cost-effective satellite platform. The mission is designed to monitor solar radiation in the surrounding space environment, enabling the collection of radiation data over time and providing valuable insights into its effects on small satellites operating in Low Earth Orbit. In parallel, continuous beacon and telemetry transmissions support the evaluation of spacecraft subsystem behavior and communication performance under actual orbital conditions. SOLARAS S2 is scheduled to be deployed as a rideshare payload aboard the HANBIT-NANO launch vehicle operated by Innospace, placing the satellite into Low Earth Orbit with a suitable inclination to enable frequent contact with multiple ground stations. Operating in the VHF and UHF frequency bands, the communication system enables global signal reception and encourages active participation from the amateur radio community, reinforcing the mission's collaborative and educational objectives. Beyond its immediate mission goals, SOLARAS S2 contributes to the long-term strategic roadmap of Grahaa Space by establishing a strong technical foundation for future nanosatellite missions. The experience gained through spacecraft design, launch integration, and in-orbit operations supports the development of more advanced payloads and mission architectures, while demonstrating how small satellite platforms can enable accessible, sustainable, and responsible space missions.

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7. Conflict of Interest

The author declares no competing conflict of interest.

8. Funding

No funding was issued for this research.