JSST Journal of Space Science and Technology

P-ISSN: 2008-4560
E-ISSN: 2423-4516

Journal of Space Science and Technology

Vol. 19, No. 2, pp. 70-79, 2026
https://doi.org/10.22034/jsst.2026.1610
Journal Homepage: https://jsstpub.com

Original Research Paper

Design of Test Platform for Electrical Verifying of Satellite

Majid Moghaddam

Department of Electrical Engineering and Information Technology, Iranian Research Organization for Science and Technology (IROST), Tehran, Iran

ARTICLE INFO

Article History:

Received 24 December 2025
Revised 17 February 2026
Accepted 18 February 2026
Available Online 20 February 2026

Keywords:

Electrical test model
Electrical ground support equipment
Pre-seismic signals
Multi-level testing
Seismological satellite subsystems

ABSTRACT

Advanced technology has unlocked new opportunities for the rapidly growing satellite industry. The design of seismic satellite is a novel technology and has very challenges. The primary objective of a seismic satellite system is to monitor and quantify electromagnetic pre-seismic signals within Earth's atmospheric layers, with a particular focus on the ionosphere. These signals are detectable via specialized radiometric sensors and radiofrequency wave analysis. This paper presents a novel system and subsystem-level test model for a seismological satellite, including its electrical ground support equipment (EGSE). The EGSE serves as a critical test platform to ensure full compatibility before and after subsystem integration. It verifies satellite performance through multi-level testing by simulating electrical interfaces between onboard systems and communication modules. The qualification process is conducted at the subsystem and system levels using both engineering model and flight model. Following environmental testing, the satellite undergoes a comprehensive final functional test to confirm mission readiness. The proposed test model validates critical subsystems, including power, attitude control, communications, on-board data handling, and payload, as well as overall system integration. The test platform is designed in accordance with European cooperation for space standardization protocols to guarantee compliance with space-grade reliability standards.

*Corresponding Author's E-mail: moghaddam@irost.ir

How to Cite this Article:
M. Moghaddam, "Design of Test Platform for Electrical Verifying of Satellite," *Journal of Space Science and Technology*, Vol. 19, No. 2, pp. 70-79, 2026, https://doi.org/10.22034/jsst.2026.1610.

NOMENCLATURE

EGSE	electrical ground support equipment
MTIU	Master Test and Interface Unit
PCDU	Power Conditioning and Distribution Unit
AOCS	Attitude and Orbit Control System
OBDH	On-Board Data Handling
AIT	Assembly, Integration, and Test

1. INTRODUCTION

The small satellite paradigm, epitomized by CubeSat's and Nanosats, has catalyzed a profound transformation within the space industry, disrupting established economic and operational models. This shift is propelled by their distinct benefits over conventional large satellites, including dramatically lower production and launch costs, expedited development cycles, and enhanced launch flexibility [1]. Also, the significant potential of Artificial intelligence and novel technology enhance a variety of real-world space operations. Also, autonomous satellite control to on-board data handling and AI have proved to be a potent tool for improving the efficiency, dependability and safety of space missions [2].

Earthquakes constitute a dynamic geophysical phenomenon primarily caused by crustal movements along tectonic plate boundaries. The sudden release of accumulated strain energy during seismic events generates complex energy transfer mechanisms between the hypocenter and surrounding medium. The released energy can generate distinct physico-chemical perturbations across Earth's layered systems including the lithosphere, atmosphere, and ionosphere, which serve as detectable seismic precursors.

The fundamental mission of seismological satellites involves comprehensive investigation and probabilistic assessment of seismic events through systematic monitoring of these precursor phenomena within the ionospheric layer, complemented by ground-based observational studies. This multidisciplinary approach focuses on detecting and analyzing [3, 4]. This operation is carried out by the telecommunication subsystem, which transmits the information collected by the ionospheric sensing payloads to the central station located at the organization's space site, facilitates the exchange of Telemetry and Telecommand (TMTC) data with the central station, and transmits radio signals for satellite tracking by the ground station. This seismological satellite, utilizing several sensors and by measuring deviations and disturbances induced in radio signals during their passage through the ionosphere, is capable of identifying electromagnetic anomalies and disturbances in electron density, as well as acquiring data on changes in atmospheric layers. This capability leads to seismology and earthquake prediction [5-8]. Consequently, the communication payload in the seismological satellite will incorporate these specific sensors.

For satellite testing, in addition to general equipment, the design and fabrication of satellite-specific equipment is also required. EGSE comprises tools used by satellite manufacturers for testing and validating the electrical functionalities of the satellite on the ground prior to launch. EGSE consists of hardware and software elements that perform electrical functional tests of the satellite equipment by simulating the interfaces of existing subsystems to ensure full compatibility after the integration of all subsystems into the overall platform [5-11]. In essence, the designed EGSE must simulate potential faults of each subsystem on the ground, assuming space conditions.

The rest of this paper is organized as follows. section 2 reviews technical requirements in system and subsystem-level. Section 3 contains subsystem EGSE design for comprehensive validation. Section 4 describes the results and discussion and finally, Section 5 concludes the paper.

2. TECHNICAL REQUIREMENTS IN SYSTEM AND SUBSYSTEM-LEVEL

The Integrated Satellite EGSE is a system used to test a satellite and its subsystems during Assembly, Integration, and Test (AIT) phases. Its primary purpose is to simulate the satellite's operational environment (both in-space and launch), send commands, and monitor telemetry.

The test interface unit (TIU) is the heart of this system. It acts as the single, centralized interface point between the complex EGSE and the satellite itself. It provides electrical isolation, signal conditioning, and routing, ensuring the satellite is protected while allowing comprehensive testing [8].

The verification and validation of the satellite's functionality, in strict compliance with the space product assurance and testing standards defined in ECSS-E-ST-10-24C, are paramount to the mission's success. This necessitates a sophisticated and comprehensive EGSE system. The core of this ground segment is the master test and interface unit (MTIU), which is specifically designed to meet the technical requirements for testing the complete satellite system and its constituent subsystems. The primary subsystems under test include the power conditioning and distribution unit (PCDU), the TMTC subsystem, the attitude and orbit control system (AOCS), the On-Board Data Handling system (OBDH) EGSE encompassing both hardware and software, the dedicated seismological prediction payload, and the Ground Station interface.

The designed EGSE architecture must facilitate a multi-tiered testing strategy. This strategy encompasses both subsystem-level testing, where individual units are validated in isolation, and system-level testing, where the fully integrated satellite platform is evaluated for overall performance, functional compatibility, and operational readiness under simulated mission scenarios [12].

The EGSE shall enable closed-loop system testing, where all subsystems operate concurrently. For instance, it will simulate a mission scenario where the AOCS points the payload, the payload generates data, the OBDH processes and stores it, and the TMTC subsystem downlinks it to the simulated ground station, all while the power subsystem is monitored for load and stability. The design of the EGSE shall be optimized to achieve the maximum utilization of the same EGSE hardware and software for various levels of test from unit level up to system level. Also, the system shall be modular and scalable to support testing from unit level to system level and to allow for parallel testing of different subsystems.

3. SUBSYSTEM EGSE DESIGN FOR COMPREHENSIVE VALIDATION

The EGSE design must adopt a system-level integration approach to manage the interdependencies of all satellite subsystems. As key flight hardware (like attitude actuators and sun sensors) is not functional during ground tests, the EGSE must use high-fidelity simulators to emulate them. This integrated test model must emulate the satellite's complete operational cycle. The constituent components of each EGSE subsystem, must be meticulously designed and tested to ensure they accurately impose the required operational loads and provide the expected services, thereby fully validating the satellite's system-level functionality and performance before launch.

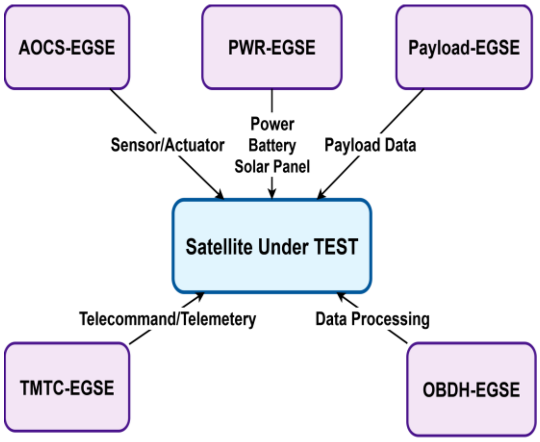

Fig.1. EGSE subsystems for the satellite under test.

The design of the EGSE follows a systematic, subsystem-oriented approach to create a high-fidelity Hardware-in-the-Loop (HIL) simulation environment. The primary objective is to validate the functionality and interoperability of all satellite subsystems under simulated orbital conditions, where physical hardware is either unavailable or non-operational on the ground. The overall architecture of test configuration, including the spatial model of the test setup, is depicted in Fig.1, with the Electronic-Box(E-BOX) serving as the central satellite dynamics and system model.

3.1 Attitude and Orbit Control Subsystem (AOCS) EGSE

The AOCS EGSE is architected to create a high-fidelity, closed-loop simulation environment for validating the satellite's attitude determination and control software. Since the actual space environment cannot be replicated on Earth, this unit replaces physical sensors and actuators with high-precision simulated counterparts. This unit is responsible for verifying the functionality and software of the satellite's AOCS. It forms a critical closed-loop control simulation to replicate the satellite's rotational dynamics in orbit [13, 14]. The Fig.2 illustrates the specifications of the AOCS EGSE.

1) Sensors & Actuators

The simulation includes two magnetometers and a sun sensor for attitude determination, and three magnetic torques as actuators for attitude control.

2) Closed-Loop Operation

The software calculates the satellite's theoretical state (attitude and angular rates) and generates corresponding analog output signals for the magnetometers via a Digital-to-Analog Converter (DAC). The satellite's AOCS unit receives these simulated sensor readings and computes the necessary commands for the magnetic torquers. The output currents from the torquers are then measured, digitized, and fed back into the AOCS software. By comparing the simulated true state with the AOCS-controlled state, the correctness and performance of the AOCS software are rigorously validated

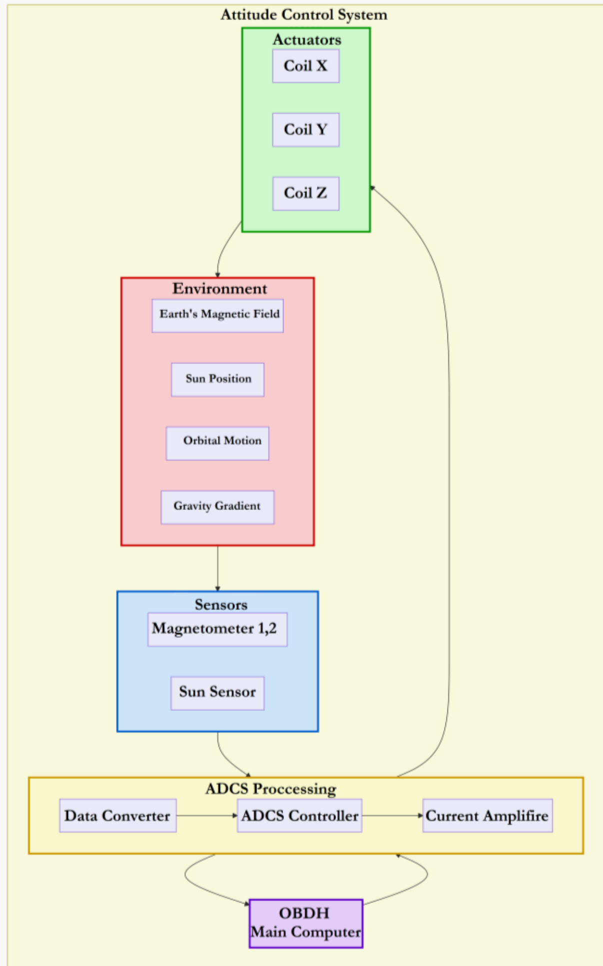

Fig. 2. The specification of AOCS EGSE.

3.2 Power Subsystem EGSE

The Power (PWR) EGSE is required to simulate the power generation profile of the solar arrays, including battery charging and the critical power budget management during eclipse periods. In really, the PWR EGSE must emulate the satellite's complete electrical power chain. Since the actual solar arrays and batteries cannot be tested under real space conditions on the ground, the PWR EGSE uses high-fidelity simulators. Fig.3 shows the PWR EGSE unit.

1) Power Source Simulation

A variable power supply is used to simulate the variable current-voltage (I-V) characteristics of solar arrays under different illumination conditions, including eclipse transitions. For higher accuracy, the organization's solar simulator chamber can be utilized to characterize and emulate the behavior of the photovoltaic cells.

2) Load and Interface Management

The PWR EGSE interfaces directly with the AOCS EGSE to simulate the power modulator's behavior, ensuring the power distribution system is correctly managed during high-load activities, such as actuator firing.

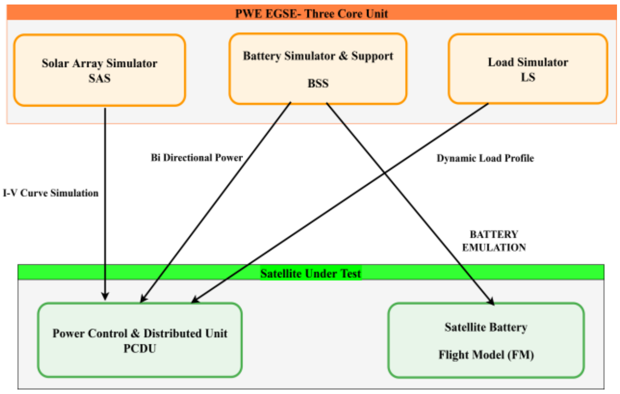

Fig. 3. The PWR EGSE unit.

3.3 Telemetry and Tele command Subsystem EGSE (TMTC EGSE)

The TMTC EGSE simulates the functions of the ground station, both with and without the Radio Frequency (RF) unit, to validate the satellite's command and data handling capabilities. It is architected in two main parts.

1) Base-band Unit

This unit acts as the interface with the OBDH system. It receives data and clock signals from the OBDH. Functioning as the critical bridge between the satellite's digital systems and the RF domain, it manages bidirectional data flow through two distinct paths. In transmit path, the baseband unit performs data coding, removes any DC offset, and generates the baseband-modulated signal. Conversely, in receive path, it demodulates incoming RF signals, extracts data and clock signals, and ensures protocol compliance with relevant ECSS standards. This integrated functionality ensures reliable and standardized communication across the satellite's architecture.

2) Radio Frequency Unit

This unit handles modulation/demodulation, power amplification, and frequency conversion, effectively creating a "virtual RF link" for end-to-end communication testing without requiring actual radio transmission. The comprehensive operation of the TMTC EGSE system, which serves as a ground station simulator for satellite communication testing is illustrated in Fig. 4. The system is architecturally divided into three core functional units that work in concert to validate the satellite's command reception and data transmission capabilities.

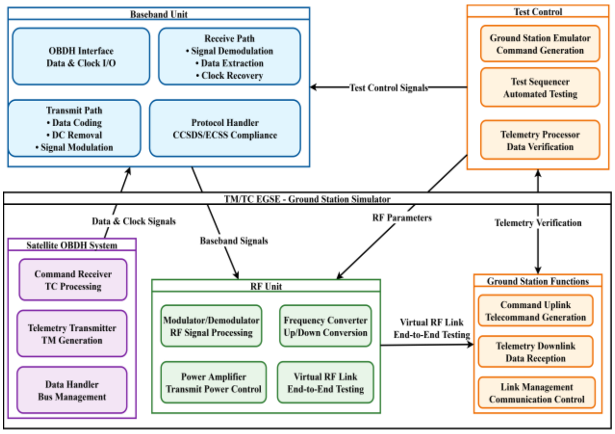

Fig. 4. The operation of the TMTC EGSE system.

The test control unit of the TMTC EGSE as an automated ground station emulator, manages the entire testing process by generating telecommands, checking the received telemetry, and running automated test sequences. This unit verifies both the satellite's response to commands and the accuracy of downlinked data, ensuring the communication system meets all operational requirements.

3.4 On-Board Data Handling (OBDH) EGSE

The OBDH EGSE provides a direct external interface to the satellite's onboard computers. Its primary functions are to facilitate the upload of flight software, provide a real-time debugging interface, and simulate data bus traffic to validate the OBDH's data management and scheduling capabilities under load.

3.5 Payload-EGSE

The Payload EGSE must generate synthetic data streams that mimic the ionosphere radio signal perturbations, facilitating an end-to-end validation of data acquisition, processing by the OBDH EGSE, and subsequent downlinking via the ground station EGSE. The Payload EGSE in the proposed design will verify the performance of a scientific communications payload suite, comprising a Tri-Band Beacon (TBB), a Store-and-Forward (S&F) unit, and a GNSS Radio Occultation (GNSS-RO) instrument, against stringent requirements.

The S&F unit onboard a Low Earth Orbit (LEO) satellite operates on a two-phase, non-real-time data relay principle, enabling global data collection from dispersed terrestrial platforms. During its orbital pass, the satellite establishes a communication link with individual ground terminals. These platforms, which include seismic and geodetic sensors, uplink their stored data packets to the satellite. The satellite's communication subsystem receives these packets, which are then processed by the OBDH system. The OBDH system retrieves the aggregated data from the mass memory, often applying data compression to optimize throughput. This consolidated data is then transmitted via a high-speed downlink, to the ground station. A UHF band antenna is utilized for S&F telecommunication.

The ionosphere, a significant component of the upper atmosphere, protects the Earth by filtering out harmful solar and cosmic radiation. Within this region, total electron content (TEC) stands as one of the most important measurable parameters. By reflecting changes and disturbances in the ionospheric plasma, TEC data provides a crucial foundation for research into how space weather influences communication and navigation systems and how these ionospheric changes are linked to underlying natural phenomena [15]. Two primary techniques for ionospheric sensing are described here. The first infers the TEC along the signal path and quantifies signal scintillation by analyzing alterations in the satellite signal, such as its doppler shift and the rotation of its polarization plane. The second technique, ionospheric tomography, uses satellite beacons to scan the ionosphere, creating a time-resolved profile of its electron density distribution [16].

The integration of a GNSS-RO instrument on a seismology satellite represents a powerful synergistic approach to Earth observation, enabling the detection of seismo-ionospheric perturbations associated with large earthquakes. The GNSS-RO technique operates by precisely measuring the phase delay, amplitude, and bending angle of signals from GNSS satellites as they are occulted by the Earth's atmosphere. These measurements are used to derive high-vertical-resolution profiles of atmospheric parameters, including electron density in the ionosphere, temperature, pressure and density in the stratosphere and troposphere. The telecommunications payload utilizes GNSS-RO to provide the reception and measurement of the refraction of radio signals from navigation satellites in LEO. For this section of the design, an L-Band antenna has been employed.

Also, the TBB telecommunications payload utilizes the L, VHF, and UHF bands. TBB function generates and sent three radio signals with one frequency consist of VHF, UHF and L as a beacon. These three beacons must be phase. When three beacons pass from ionosphere layer, the ground station achieve this signals and measures phase difference between each other. So, the ionosphere layer variation is extracted and 3D tomography is introduced.

However, all EGSE subsystems are introduced, so, the Flight model of the EGSE is demonstrated in Fig. 5. All EGSE subsystems are connected to the satellite engineering model as a E-BOX. This design illustrates the full functional test of the satellite model using dedicated test subsystems. The proposed integrated EGSE architecture offers a reliable, high-fidelity platform for subsystem and system-level validation. It uses closed-loop HIL simulations for critical subsystems and rigorous performance testing. This approach reduces mission risk by thoroughly verifying satellite functionality and subsystem interoperability on the ground, in full compliance with ECSS standards. Because of successful experience of MESBAH satellite implemented by IROST team, the structure of this satellite is chosen for EGSE design of seismic satellite

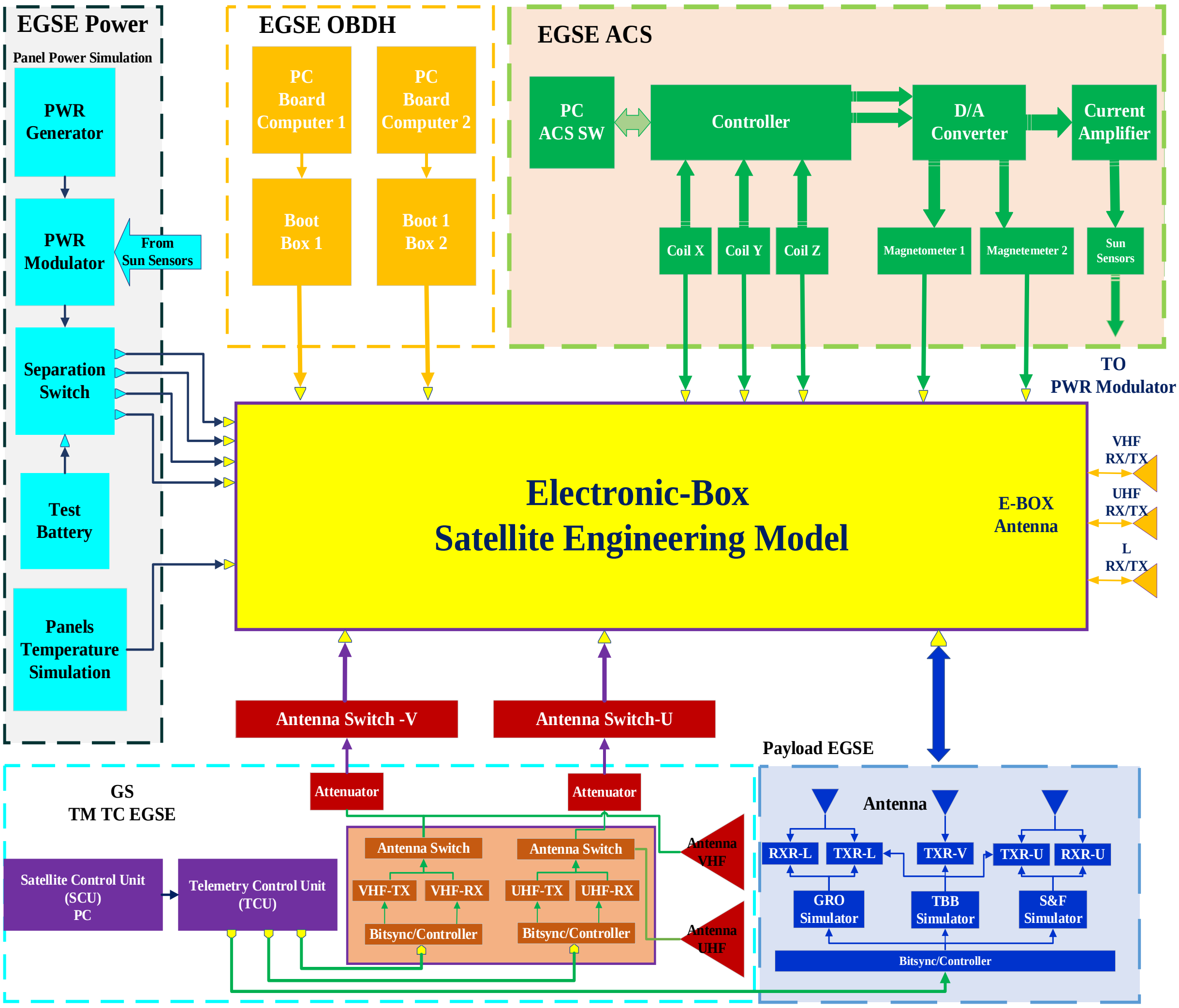

Fig. 5. The Flight model of the proposed EGSE.

4. RESULTS AND DISCUSSIONS

This EGSE design provides comprehensive testing capabilities for the complete payload suite, ensuring all units meet their performance requirements and work seamlessly together before launch. The hypothetical proposed design is to use a steerable antenna for the VHF and UHF bands, which through time division, would handle the tasks of the TBB telecommunications payload and the TMTC functions. However, the UHF band antenna is utilized for S&F function that receives data from ground terminals in various locations, and as a redundancy of TMTC telecommunication. Furthermore, a separate L-Band antenna has been considered in the design to perform part of the TBB payload tasks and the GNSS-RO payload duties, in order to achieve maximum antenna efficiency. The dedicated L-band antenna allows these tasks simultaneously and continuously without interruption. The antenna system of seismological satellite is shown in Fig. 6. It minimizes the number of physical antennas, saving weight, cost, and complexity.

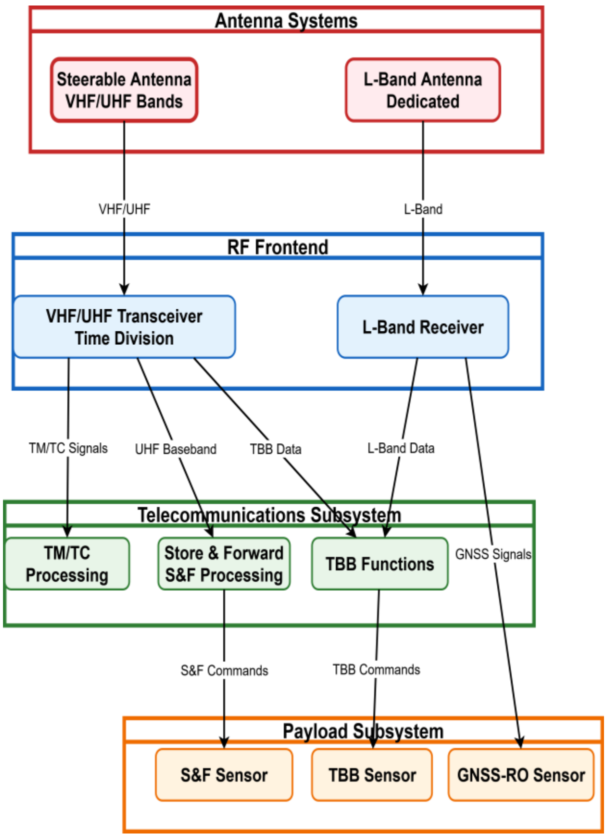

Fig. 6. The proposed antenna system of seismological satellite.

China's Seismo-Electromagnetic Satellite (CSES) represents the nation's first dedicated space-based platform for monitoring geophysical fields and ionospheric disturbances associated with seismic activity [17,18]. However, the proposed design reduces system complexity and mass by characterizing electromagnetic fields with three key sensors, rather than using data from the eight distinct scientific payloads of the CSES satellite.

The short functional test shall be performed during the environmental test and as final check of satellite before launch. This test has to be carried out spending not much time (in the order of minutes) with minimum EGSE. To perform short functional test, the following test equipment shall be necessary, TMTC EGSE with RF section, sensors and actuators EGSE, power supply, link with the board computer, harness and connectors saver. With the same test equipment, it is possible to charge the battery even when the satellite is already attached to the launch platform. The short functional test shall be a standard verification to repeat more times.

Test shall be performed to reproduce in real time the behavior of the satellite in acquisition, nominal operational and contingency phase. To perform short functional test, the following test equipment shall be necessary, TMTC EGSE with RF section, sensors and actuators EGSE, power supply, link with the board computer, harness and connectors saver. With the same test equipment, it is possible to charge the battery even when the satellite is already attached to the launch platform. The short functional test shall be a standard verification to repeat more times.

The verification of the main satellite requirement, in particular the hardware functionality shall be executed. To accept the functionality of the entire satellite, a full functional test shall be conducted as a standard verification at least twice, before and after the environmental test campaign with the flight model. Accordingly, a corresponding test procedure shall be developed. While, the functions verified in the short and full functional tests are quite similar, they differ in the depth of verification. The main functionality to be tested during the full functional test includes the following such as, starting operations after separation from launcher, bus system level test, payload integration and verification, power supply to each satellite device, simulated battery and panels, OBDH functionality (data management), TMTC link with simulated ground station, AOCS hardware functionality, redundancy management and redundant device functionality.

Table 1. Flight model test phase.

Step	Subsystem verification step	Repeat
1	OBDH and PWR integration & verification	1
2	TMTC subsystem integration & verification	1
3	ACS Software integration & verification	1
4	ACS hardware integration & verification	1
5	Bus system level test	1
6	Payload integration & verification	1
7	Solar panels integration	1
8	Full functional test	>1
9	Short functional test	>1
10	Environmental test at system level	1
11	System Verification Test	1
12	Verification of the interface between satellite & launch platform	1

Critical failures shall be simulated to analyze the consequence on the satellite. The test schedule shall be nominally performed with the designed EGSE model step by step. Table 1 defines the order to carry out the verifications and flight model test phase. The system level test shall be a standard verification to repeat at least two times (before and after the environmental test environmental test campaign with flight model) to accept the functionality of the whole satellite. According to Table 1, short and full functional test should be repeated more than one time (> 1). There is estimated time spend for each step according to test equipments. For thermal and EMC verification the test configuration shall be equal to the short functional test configuration. Suitable test harness must be used to avoid problems with high temperatures and to fulfill the test facility interface. The present description of the flight model test phase start from the assumption that all the satellite subsystems are already successfully tested. During this phase shall be performed all the necessary test step to have the complete acceptance of satellite.

Table 2. The required EGSE to properly test the satellite at subsystem and system level.

Subsystem	Functional Parameters
Payload EGSE	Data-exchange functions by the Board Computer. GNSS-RO, TBB sensitivity and accuracy.
AOCS EGSE	Attitude simulator based on closed loop verifications. Simulating space environment, satellite orbit & dynamics. Drive the AOCS hardware. Verify the functionality of sensors & actuators.
Power EGSE	Simulated battery and solar panels Power monitor. Power loads simulator.
TMTC EGSE	Simulation of the base-band ground station without RF unit. Simulation of the RF section of the ground station (Tx, Rx and antenna).
OBDH EGSE	Board Computer link to boot software from external. Monitor and control of the software under test. Give visibility of the data exchange by Bus probe. Simulation of data acquired by OBDH. Provide a simulation of missing equipment.
Integrated System	Emergency power system functionality. System-level error management functionality. Telemetry data correlation from multiple sources. Common grounding quality between subsystems.

Besides the commercial off-the-shelf electrical equipment normally available in each laboratory, the required EGSE to properly test the satellite at subsystem and system level are listed in Table 2. This Table presents some key parameters that must be validated as part of the test platform infrastructure. As demonstrated in the table, the functional parameters defined for the subsystems serve to reduce failure probability and improve overall system reliability. Furthermore, the parameters highlighted in the last row are introduced for the purpose of robustness design in the integrated system.

5. CONCLUSION

This paper presented the preliminary novel test model of the system and subsystem-level for a seismological satellite, along with its EGSE. The designed EGSE employed high-fidelity simulators to replicate space conditions on the ground. The basic structure of EGSE was designed according to MESBAH satellite platform. The EGSE architecture of all subsystems including AOCS, Power, TMTC, Payload and OBDH were thoroughly designed. Furthermore, the seismic satellite was modeled as an electronics box, and each EGSE subsystem was connected independently to test the functionality of the overall system comprehensively.

The full functional test configuration and flight model test phase was presented to have the complete acceptance of satellite. Also, the functional parameters of the subsystems and required EGSE to properly test the satellite were demonstrated to reduce failure probability and improve overall system reliability.

To reduce system complexity and mass, the proposed EGSE payload characterized electromagnetic fields using only three key sensors, which were sourced from the TBB, S&F, and GNSS-RO of payload units. Also, the proposed design used a steerable antenna for payload functions and TMTC telecommunications to maximizing overall antenna efficiency.

The designed test model is essential for properly validating the performance of the seismographic satellite, from its individual components to its integrated system performance in a simulated space environment.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest

REFERENCES

[1] R. Karim and P. Malcovati, "On-Chip-Antennas: Next milestone in the big world of small satellites—A survey of potentials, challenges, and future directions," *IEEE Aerospace and Electronic Systems Magazine*, vol. 36, no. 1, pp. 46–60, 2021, https://doi.org/10.1109/MAES.2020.3016751.

[2] K. Thangavel *et al.*, "Artificial intelligence for trusted autonomous satellite operations," *Progress in Aerospace Sciences*, vol. 144, pp. 1-36, 2024, Art. no. 100960, https://doi.org/10.1016/j.paerosci.2023.100960.

[3] Zh. Zeren, *et al.*, "The representative scientific results of the China Seismo-Electromagnetic Satellite," *Earthquake Research Advances*, vol. 5, no. 1, 2025, Art. no. 100314, https://doi.org/10.1016/j.eqrea.2024.100314.

[4] P. Shi, D. Angus, A. Nowacki, S. Yuan, and Y.Wang, "Microseismic full waveform modeling in anisotropic media with moment tensor implementation," *Surveys in Geophysics*, vol. 39, pp. 567–611, 2018, https://doi.org/10.1007/s10712-018-9466-2.

[5] M. Moghaddam, "Design of electrical ground support equipment for testing and measuring the performance of seismological satellites," in *23rd International Conference of the Iranian Aerospace Society (AERO)*, Tehran, Iran, 2025, Art. no. AEROSPACE23_233, (in Persian), https://civilica.com/doc/2403852.

[6] European Cooperation for Space Standardization (ECSS), "Space engineering - Interface management," ECSS-E-ST-10-24C, 2015, https://ecss.nl/standard/ecss-e-st-10-24c-interface-management-1-june-2015/.

[7] European Cooperation for Space Standardization (ECSS), "Space engineering - Technical requirements specification," ECSS-E-ST-10-06C, 2009, https://ecss.nl/standard/ecss-e-st-10-06c-technical-requirements-specification/.

[8] European Cooperation for Space Standardization (ECSS). "Space engineering - System engineering general requirements," ECSS-E-ST-10C, 2017, https://ecss.nl/standard/ecss-e-st-10c-rev-1-system-engineering-general-requirements-15-february-2017/.

[9] R. Killough, J. Hanley, A. Henry, R. Klar, and S. Miller. "Simulators, software and small satellites: Testing in tight spaces," in *Aerospace Conference*, Big Sky, MT, USA, 2016, pp. 1-7, https://doi.org/10.1109/AERO.2016.7500702.

[10] Zh. You, "Ground tests of micro/nano satellites", in *Space Microsystems and Micro/nano Satellites*, Micro and Nano Technologies, Oxford, UK: Elsevier, 2018, pp. 147–166, https://doi.org/10.1016/B978-0-12-812672-1.00005-9.

[11] V. Centonze, A. Lovascio, and A. D'Orazio, "An innovative EGSE approach for satellite RF system characterization based on real-time monitoring and space environment-oriented analysis", in *International Workshop on Metrology for AeroSpace (MetroAeroSpace)*, Padua, Italy, 2017, pp. 68–73, https://doi.org/10.1109/MetroAeroSpace.2017.7999540.

[12] J. Oh. Park *et al.*, "Electrical ground support equipment (EGSE) design for small satellite," *Journal of Astronomy and Space Sciences*, vol. 19, no. 3, pp. 215-224, 2002, https://doi.org/10.5140/JASS.2002.19.3.215.

[13] M. Zarourati, M. Mirshams, and M. Tayefi, "A review on underactuated attitude control of reaction wheel actuated satellites," *Journal of Space Science*

and Technology, vol. 18, no. 2, pp. 83-119, 2025, (in Persian), https://doi.org/10.22034/jsst.2025.1528.

[14] M. Rivandi, M. Mirshams, and M. Zarourati, "Design and implementation of a balance system for the CubeSat attitude determination and control tabletop simulator," *Journal of Space Science and Technology*, vol. 16, no. 1, pp. 75-88, 2023, (in Persian), https://doi.org/10.30699/jsst.2023.1426.

[15] Y. Tong *et al.*, "Analysis and elimination of tri-band beacon interference with the fluxgate sensors onboard CSES," *Science China Technological Sciences*, vol. 64, pp. 2328–2336, 2021, https://doi.org/10.1007/s11431-020-1799-y.

[16] Ch. Y. Zhang *et al.*, "A tri-band terrestrial beacon digital receiver system for band terrestrial beacon digital receiver system for TEC measurements," *Frontiers in Astronomy and Space Sciences*, vol. 10, 2023, Art. no. 1167331, https://doi.org/10.3389/fspas.2023.1167331.

[17] X. H. Shen *et al.*, "The state-of-the-art of the China Seismo-Electromagnetic Satellite mission," *Science China Technological Sciences*, vol. 61, pp. 634–642, 2018, https://doi.org/10.1007/s11431-018-9242-0.

[18] L. Wang *et al.*, "Data processing methods and procedures of CSES satellite," *Journal Remote Sensing*, vol. 22, no. S1, pp. 39-55, 2018, (in Chinese), https://doi.org/10.11834/jrs.20187360.