Development and On-Orbit Operation of a Reliable CubeSat Platform for Testing Korean-Manufactured EEE Parts: EEETester

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***Abstract*— The Republic of Korea has been actively promoting the development of domestically manufactured electronic components through national R&D initiatives. Despite this progress, adoption in space missions remains limited due to insufficient flight heritage. To bridge this gap, the Korea Aerospace Research Institute (KARI) developed the EEETester, a 12U CubeSat platform dedicated to in-orbit validation of domestic Electrical, Electronics, and Electromechanical (EEE) parts. This paper describes the platform's modular 4U bus, 8U payload capacity, and the successful on-orbit operation of the first mission. Future missions scheduled for 2026 and 2027 will continue to build space heritage for the national space ecosystem.**

Keywords—EEETester, CubeSat, KARI, EEE Components, In-Orbit Testing

I. INTRODUCTION

The growth of Korea's R&D policy has fostered the development of advanced memory and active EEE components. However, a significant challenge persists: a lack of flight heritage that prevents these components from being integrated into high-stakes missions. While Commercial Off-The-Shelf (COTS) subsystems are gaining global credibility, domestic components require dedicated qualification. The EEETester project was established to accelerate this qualification to TRL6+ by providing a reliable 12U CubeSat platform for in-orbit demonstration or verification.

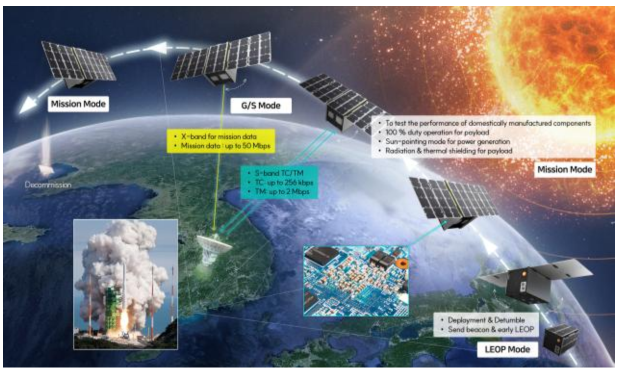


Fig. 1. Illustration of the EEETester's concept of operations

The adoption of domestically produced electronic components is frequently hindered by a lack of flight heritage. To address this, global space agencies utilize small satellite platforms—such as CubeSats and microsatellites—to provide low-cost, high-reliability in-orbit validation.

Several international missions serve as precedents for the EEETester's mission architecture:

- **OPS-SAT (ESA)**: A 3U CubeSat dedicated to testing powerful on-board computers and mission control software [1].
- **IOD-1, 2 (ESA/GMV, Thales Alenia Space)**: Validates next-generation satellite navigation systems and derisks core technologies [2].

In Korea, the push for independent space development has utilized similar strategies:

- **NextSat-1 (KAIST)**: A 100 kg microsatellite designed to verify core space technologies, including advanced transponders and data storage modules [3].

This paper introduces the EEETester project and its system architecture. In addition, unveiling the in-orbit operation results of the 1st satellite, lessons learned are addressed for 2nd and 3rd satellites.

II. SYSTEM ARCHITECTURE

The EEETester is a versatile, high-reliability 12U CubeSat platform featuring a 4U bus that accommodates payloads up to 8U. Figure 1 illustrates the platform in its stowed and deployed configurations. As summarized in Table I, the system supports multiple payloads through flexible mechanical and electrical interfaces, with specific data and power architectures detailed in Figures 2 and 3. The dual deployable solar panels feature integrated latch-up protection for all power outputs. To ensure mission longevity, the electronics were designed to mitigate radiation effects, and the S-band communication link utilizes a redundant architecture. Furthermore, the bus offers high-precision attitude control across multiple modes, complemented by high-speed S-band capabilities for reliable mission data downlink.

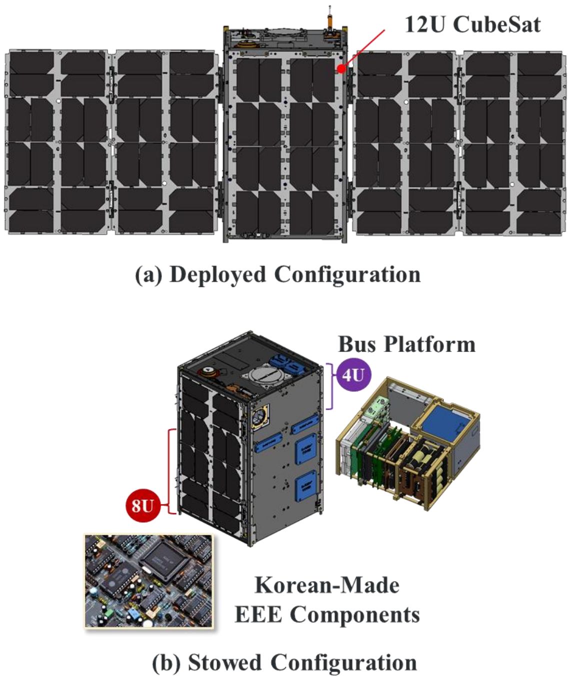


Fig. 2. Configurations of the EEETester's platform

TABLE I. EEETESTER PLATFORM SPECIFICATION

Contents			Performance
Mission	Objectives		In-orbit testing Korean-made EEE components
	Operation Orbit		500-600 km, Sun-Synchronous
	Design Lifetime		1 year
Payload	Mass & Volume		Up to 12 kg & 8U
	Power Provision		20 W (duty 100%)
			(4×)3.3 V, (3×)5 V, (2×)12 V, (1×)VBAT (<2 A)
	Data Communication		(1×)CAN, (1×)RS-232, (4×)RS-422, (1×)SPI, (4×)GPIOs
Bus Platform	Mass		11.50 kg
	Attitude Control	Mode	Sun-pointing, Nadir-pointing, G/S (or Target) tracking (3-RW, 3-MTQ, 1-S/T, 6-DOF IMU, 3-CSS/MAG)
		Accuracy	0.031° (G/S tracking)
		Stability	0.004°/s
	Power Generation		Up to 86 W
	RF Comm.	S-band TC	200 kbps
		S-band TM	1.5 Mbps
		X-band Download	35 Mbps

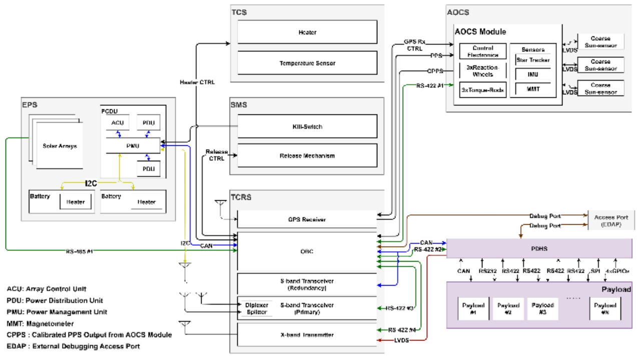


Fig. 3. EEETester platform's electrical interface – data communication

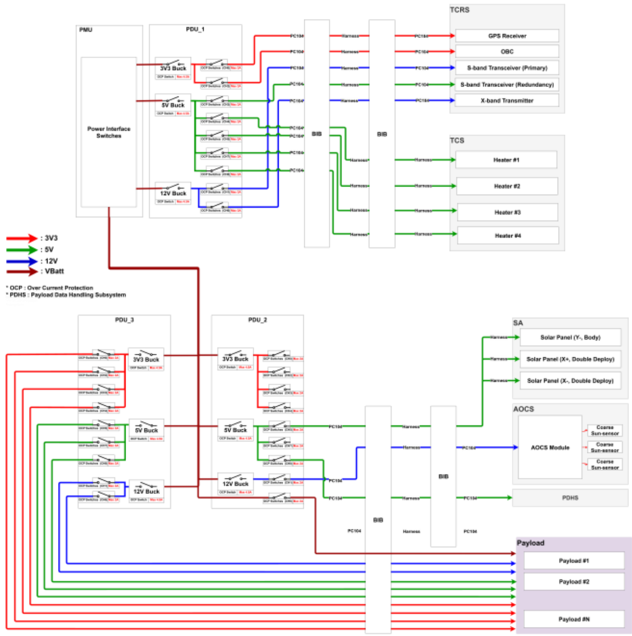


Fig. 4. EEETester platform's electrical interface – power distribution

III. ENGINEERING AND QUALTIFICATION

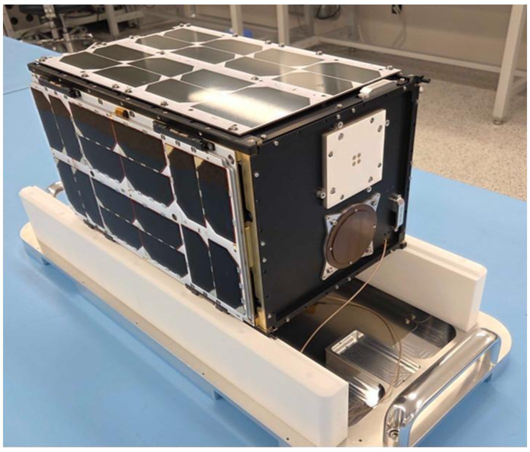
To enhance a reliability given project timeframe and reducing the cost, the model philosophy follows Engineering-Qualification Model (EQM) and Flight Model (FM) in either unit and system level.

TABLE II. EEETESTER UNIT ENVIRONMENT TEST SPECIFICATIONS

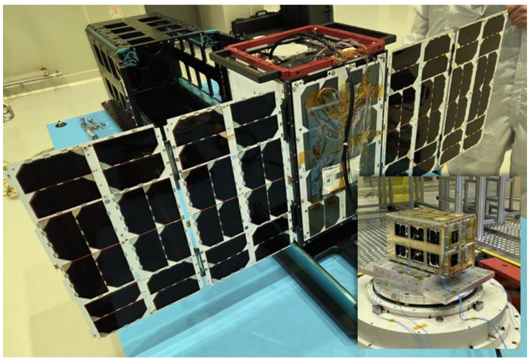
Contents		Values
Vibration	Sine Burst	10G & 10 cycles
	Random Vibration	16.75 Grms
Thermal-Vacuum	Cycles	8 cycles (non-operating 1 cycle, operating 7 cycles)
	Temperature	(Non-operating) Hot: 81℃ / Cold: -36℃ (Operating) Hot: 60℃ / Cold: -30℃
Radiation	Total ionize dose	20 krad (500 rad/hr)
	Single event	60 MeV heavy ion

A. *Unit Qualification*

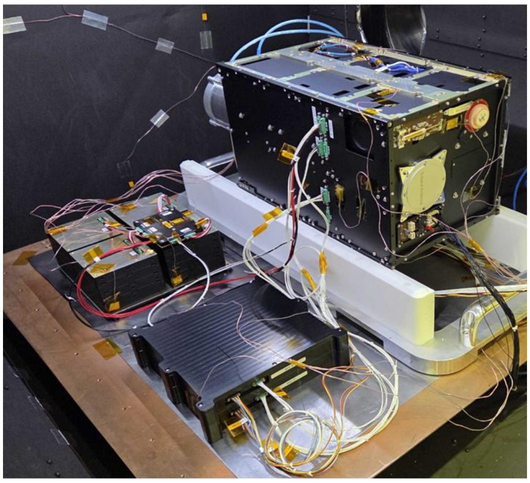
The reliability of the EEETester platform boards—specifically the On-Board Computer (OBC), Bus Interface Board (BIB), and Payload Interface Board (PIB)—was evaluated through comprehensive vibration, thermal vacuum, and radiation test campaigns. As summarized in Table II, test levels were tailored to verify structural and functional integrity while maintaining cost-efficiency. The campaign was successful; all processors, memory modules, and active components remained operational, validating a three-year design life in Low Earth Orbit (LEO).



(a) EEETester EQM Configuration



(b) EEETester EQM Deployment Test & Vibration Setting



(c) EEETester EQM TVAC Setting

Fig. 5. EEETester's EQM configuration and environmental test settings

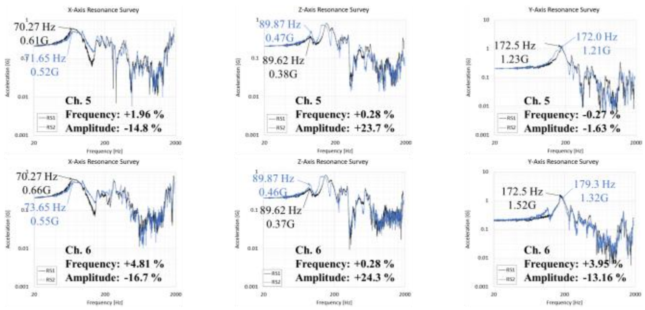
B. *Satellite Assembly, Integration and Testing*

The EQM and FM were integrated at the system level to verify mechanical and electrical interfaces and overall functionality. Satellite-to-ground RF communication was validated using RF Electrical Ground Support Equipment (EGSE). Following integration, the deployment mechanisms for the dual deployable solar panels and S-band antenna system were successfully tested.

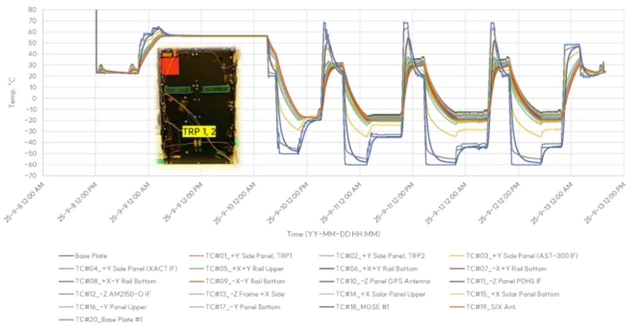
As summarized in Table III, environmental test campaigns were conducted to simulate launch vibrations and the on-orbit thermal vacuum environment. Deployment functionality was further verified post-vibration and during the TVAC cold soak phase to ensure mission readiness..

TABLE III. EEETESTER SYSTEM ENVIRONMENT TEST SPECIFICATIONS

Contents		Values	
		Acceptance	**Qualification**
Vibration	Random Vibration	6.90 Grms	9.71 Grms
Thermal-Vacuum	Cycles	4 cycles (non-operating 1 cycle, operating 3 cycles)	8 cycles (non-operating 1 cycle, operating 7 cycles)
	Temperature	(Non-operating) Hot: 60℃ / Cold: -30℃ (Operating) Hot: 56℃ / Cold: -16℃	



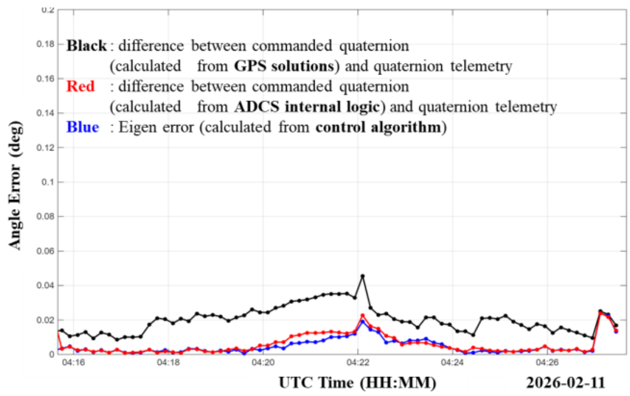
(a) FM Vibration Test – Random Vibration



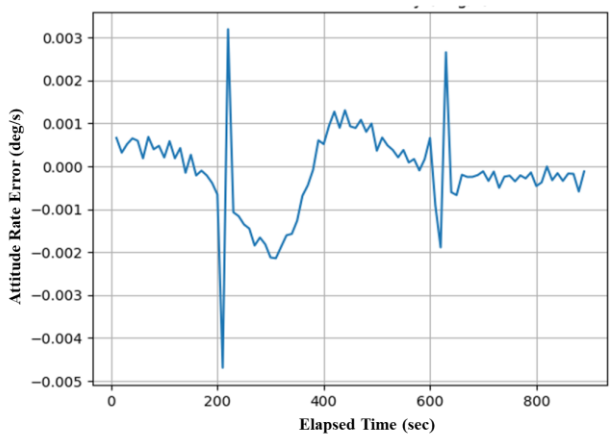
(b) FM Thermal Vacuum Test

Fig. 6. Results of the EEETester's FM environment test

As shown in Figure 6(a), the frequency shifts and amplitude variations observed during the random vibration test remained within 10% and 30%, respectively. All system functionalities—including deployment mechanisms and heater operations—were fully verified throughout the thermal vacuum test campaign. The corresponding temperature profiles are illustrated in Figure 6(b).



(a) GS pointing error analysis



(b) GS pointing attitude rate error analysis

Fig. 7. Results of the first EEETester's attitude control performance in orbit

IV. Launch and In-Orbit Operations

A. *In-Orbit Operation Results*

Following its successful deployment by the KSLV-II on November 27, 2025, the first EEETester has maintained a 600 km Sun-Synchronous Orbit with a 12:30 local time on ascending node.

Figure 7 illustrates the platform's on-orbit attitude control performance during ground station pointing, specifically showing (a) pointing error and (b) rate error. The stability of the platform is exceptional, with pointing and rate errors maintained at less than 0.02 degrees and 0.001 degree per second, respectively.

Currently, the platform executes payload testing according to preprogrammed mission scenarios and delivers the resulting data to the payload hosts via S-band and X-band high-speed communication links.

B. *Lessons Learned*

Although the platform was developed with a more rigorous philosophy and stricter test specifications than standard CubeSats to enhance reliability, several areas have been identified for improvement in future iterations. Key lessons learned from the development and in-orbit operational phases are addressed below:

- **Redundancy Standardization**: The current S-band system employs two disparate transceivers: a high-speed primary unit and a low-speed redundant unit. To ensure more seamless and reliable telemetry and telecommand links, future architectures should utilize identical hardware and software configurations for both primary and redundant strings.
- **FDIR Robustness under Stress**: During the mission, the flight software struggled to execute the Fault Detection, Isolation, and Recovery (FDIR) logic as defined when multiple fault events occurred consecutively within a few hours. This highlights the need for more rigorous, long-duration operational testing that simulates the full mission profile, specifically focusing on complex, multi-point fault management scenarios.

V. Conclusion

The EEETester project successfully established a high-reliability 12U CubeSat platform specifically designed to build flight heritage for Korean-manufactured EEE components. The inaugural mission, launched in November 2025 via the KSLV-II, has validated the platform's performance in a 600 km Sun-Synchronous Orbit.

On-orbit data confirms exceptional stability, with pointing errors maintained at less than 0.02 degrees, ensuring a precise environment for payload operations. The mission has provided critical lessons for the upcoming 2026 and 2027 launches, specifically regarding the need for standardized redundant S-band architectures and more robust FDIR logic to handle consecutive fault events. By providing a flight-proven 8U payload capacity and high-speed X-band communication, the EEETester serves as a vital bridge to TRL6+ for the national space ecosystem.

Future missions will continue to expand this heritage, integrating a diverse array of domestic technologies ranging from advanced semiconductors to intelligent rover modules as summarized in Table IV.

Acknowledgment

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References

[1] European Space Agency, "OPS-SAT: The world's first open, in-orbit testbed," ESA, 2019.

[2] GMV & Thales Alenia Space, "In-Orbit Demonstration missions (IOD-1, 2): Validating next-generation satellite navigation systems," 2021.

[3] KAIST Satellite Technology Research Center, "NextSat-1: Verification of core space technologies and scientific missions," KAIST, 2018.

TABLE IV. EEETESTER PROGRAM OVERVIEW

<table>
<tr><th colspan="2">Parameter</th><th>EEETester #1</th><th>EEETester #2</th><th>EEETester #3</th></tr>
<tr><td rowspan="3">Orbit</td><td>Altitude</td><td>600 km</td><td>530 km</td><td>500 km</td></tr>
<tr><td>Inclination</td><td>97.79°</td><td>97.41°</td><td>97.41°</td></tr>
<tr><td>LTAN/LTDN</td><td>12:30</td><td>10:30</td><td>13:30</td></tr>
<tr><td colspan="2">Mission life</td><td colspan="3">12 Months</td></tr>
<tr><td colspan="2">Launcher</td><td colspan="3">KSLV-II</td></tr>
<tr><td colspan="2">Launch date</td><td>2025.11.27</td><td>2026 3Q</td><td>2027 3Q</td></tr>
<tr><td colspan="2" rowspan="18">Payloads</td><td rowspan="6">Samsung Electronics’
DRAM/NAND</td><td rowspan="3">SK Hynix’s memory</td><td rowspan="2">SK Hynix’s
Radiation-hardened storage devices</td></tr>
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<tr><td rowspan="2">LG Electronics’s materials & components
for LEO satellites</td></tr>
<tr><td rowspan="3">Electrical propulsion anode</td></tr>
<tr><td rowspan="2">DC/DC converter based on domestic components/parts &
up-screened COTS power semiconductors</td></tr>
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<tr><td rowspan="6">SRAM, Diode, Connector, Capacitor, Resistor, Heater Magnetics</td><td rowspan="3">Fast steering mirror</td><td rowspan="2">Semiconductors from the Global TOP Aerospace Semiconductor Strategic Research Group.</td></tr>
<tr></tr>
<tr><td rowspan="2">CMOS image sensor</td></tr>
<tr><td rowspan="3">OTV Navigation Avionics</td></tr>
<tr><td rowspan="2">Polyimide (PI) fasteners for satellite Multi-Layer Insulation (MLI) mounting</td></tr>
<tr></tr>
<tr><td rowspan="6">ASIC (ADC & DAC)</td><td rowspan="3">Reaction Wheel Assembly</td><td rowspan="2">Intelligent processor module test equipment for small-scale space exploration rovers</td></tr>
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<tr><td rowspan="2">Special electrolyte batteries featuring non-flammable &
fire-resistant properties</td></tr>
<tr><td rowspan="3">Integrated ADCS</td></tr>
<tr><td rowspan="2">AI-based micro-Hall effect thruster control &
atomic oxygen theoretical current measurement module</td></tr>
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