OSS-1 (Orbital Small Station – 1)

- OSS-1 (Orbital Small Station – 1) is a mini space station capable of fully autonomous operation in Low Earth Orbit (LEO). The project integrates power generation, AI-controlled mission planning, attitude determination, and communication systems in a compact platform. Its goal is to minimize human intervention in space operations while providing a reliable, continuous station infrastructure. OSS-1’s design complies with NASA CubeSat standards and orbital safety protocols.

Purpose & Vision

- The main objective of OSS-1 is to develop a low-cost yet highly functional autonomous mini-station. This system independently performs data collection, analysis, power optimization, and environmental awareness tasks. Experience gained from the SpaceButLive project in energy management, communication, and attitude control has been directly transferred to OSS-1. This structure enhances scalability in space missions and pioneers the next generation of small orbital stations.

System Architecture

- Current ISS-class systems suffer from high cost, human dependency, and energy inefficiency. OSS-1 addresses these issues with its compact size, autonomous structure, and optimized power management. The system measures 1 m^3, weighs 95 kg, and is powered by a 300 W solar array and a 150 Wh $LiFePO_4$ battery pack. The AI-based control software dynamically manages power distribution and data prioritization. The result: reduced maintenance requirements, extended mission duration, and high reliability.

Autonomy & Artificial Intelligence

- OSS-1 consists of four main modules: front, central, rear, and side. The front module houses sensors, high-resolution cameras, and communication antennas. The central module includes the AI-Core processor and mission control unit. The rear module contains the energy storage, power regulation, and micro-thrust system. The side modules are deployable solar panels. The carbon-composite body features anti-UV coating for radiation and thermal protection. Power circuits are redundant, and data transmission is carried out through the X-Band at 256 Kbps. Orbit: 525 km SSO, Period: 90 min, Daily revolutions: ~15.

Security, Resilience & Energy

- At the heart of OSS-1 lies the AI-Core system, which analyzes sensor data to make real-time decisions. Inputs from the IMU, thermal sensors, star trackers, and photometric sensors are fused for attitude, power, and mission planning. The system has been optimized through Reinforcement Learning–based simulations. Upon anomaly detection, OSS-1 adjusts power or orientation and can trigger a reset-on-fault recovery mechanism. The AI also optimizes communication timing, data prioritization, and power consumption. This enables OSS-1 to operate stably for weeks without human intervention.

Security and Resilience

- OSS-1’s safety framework is based on multi-layer protection and fault tolerance. Average power generation is maintained at 22 W and consumption at 13 W. A dual-line power system and AI-assisted balancing circuits ensure electrical stability. The 3-axis ADCS (gyroscope, magnetometer, reaction wheel) manages attitude control. A Whipple Shield provides dual-layer protection against micrometeoroids, while a lead-composite radiation shield mitigates SEU/SEL effects. Thermal control is maintained within ±5°C via multi-layer insulation (MLI) and active fan systems. A TLE-based collision avoidance algorithm autonomously directs the micro-thrust system during potential conjunctions. System components have been validated through virtual analyses compliant with NASA GSFC protocols. At end-of-life, a Drag-Sail is deployed to increase atmospheric drag, ensuring controlled deorbiting.

Results & References

- OSS-1 represents the next generation of small-scale, highly functional space stations. Its AI-driven control, energy balancing, and multi-sensor architecture enable fully autonomous mission execution. The design conforms to NASA CubeSat and MIL-STD standards. Despite its compact structure, it offers long mission duration and high data integrity.

- References:

- - NASA-STD-4003, NASA-STD-8739.8, MIL-STD-1540
- - NASA MEM, ORDEM, NRLMSISE-00, JB2008 models
- - NASA Small Spacecraft Technology State of the Art (2023)
- - CubeSat Design Specification
- - SpaceButLive engineering outputs (power, attitude, communication)

- All NASA data were used from open-source technical reports and public engineering standards.