



Small Sat/Cube Sat Relevant Experience

Flight Hardware - Metis staff develops flight hardware and ground support equipment for NASA's Synchronized Position Hold Engage and Reorient Experimental Satellite (SPHERES) program. Metis staff have capabilities and experience in the fields of systems engineering, structural engineering, electrical engineering, materials science, manufacturing, and machinist skills, in addition to other specific aerospace disciplines. In addition Metis has experience with electro static discharge (ESD) control, hazardous materials storage and use, polymeric application certifications, solder certification, and cryogenics. Metis also handles all flight hardware level safety, shipping, and logistics, with respect to high value flight quality products.

Continual science development for the SPHERES program results in a diverse portfolio of custom test hardware, software, and test engineering products. Products developed by Metis include a 3 DoF microgravity simulation platform air carriage, a motion controlled infrared activated sensor characterization platform used in Houston with the development of new Solid State Lighting Assemblies to be implemented inside of the international space station, and custom CO₂ tank manufacturing development hardware for integration of next generation CO₂ tanks for the SPHERES program inside the ISS.

Recently, one of the SPHERES satellites identified as "Blue" was having performance issues during science operations inside the ISS. Due to the long operational lifespan of the SPHERES program, the satellite showed symptoms including divergence in localization where the computer compensated and directed the thrusters to a target but could not achieve its destination. It was decided to return the satellite to Earth, for inspection and repair at NASA's Ames Research Center in California's Silicon Valley. Metis and other members of the NASA SPHERES engineering team collaborated with the Massachusetts Institute of Technology (MIT) to bring "Blue" back to a functional state. The joint team started the process of inspection and performance evaluation where it was soon discovered the CO₂ cold gas propulsion subsystem was not operating nominally. The behavior allowed for small thrust maneuvers but would soon limit the gas flow and pressure available to the thrusters. This made the performance intermittent and unpredictable, adding further challenge to finding an on-orbit diagnosis.

In the SPHERES lab at Ames, engineers spent three weeks working to make the satellite fully operational and meet the required standards. The team replaced the faulty gas regulator, which caused a limited amount of flow resulting in a majority of the behavior seen on orbit. They also upgraded the same firmware shared by the more mature SPHERES satellites on station. Once all the upgrades were completed, they verified the repairs and upgrades met program requirements, the SPHERES engineering team performed functional tests to ensure SPHERES' readiness and continue further science on station.

Metis is also developing the battery pack design for NASA's BioSentinel mission. This involves generating a validation build, procedure development, complying with requirements for safety as well as mission assurance, document generation, assembly and integration, cell testing, battery verification testing, and cradle to grave involvement of this subsystem component.

Systems Engineering - SPHERES requires a diverse level of systems engineering in which Metis satisfies by developing documentation and procedures with the approval and consultation with quality assurance agents as well as program management. The documentation generated is relevant to NASA JSC, NASA Ames, MIT, and other participant of the SPHERES community including academia, guest scientist, and other government agencies. Metis has produced root cause analysis of failures and anomalies, test engineer reports, ISS science procedures, general engineering

documentation and record keeping. In addition, Metis often consults and assist with design review processes for a variety of small satellite programs within NASA Ames as well as NASA JSC.

Flight Software – Metis has developed software on a space-based cubesat to debug and complete health checks of the vehicle. Custom software was also generated for ground support hardware in conjunction with MIT based hardware.

Integration – Metis engineers have worked with NASA JSC's payload safety review panel, Payload integration managers, Research integration managers, Technology integration managers, and science schedulers for ISS operations. Recently, Metis played a significant role in the NASA Inspire-2 payload integration. Metis submits information and test confirmation results to the verification and tracking log database. This process is mandatory before the completion of any and all space hardware and science destined for the ISS.

Operations - Metis staff support science on the International Space Station (ISS) with roles and responsibilities which include operating access controlled command and data handling across a secure network link directly to the international space station science dedicated laptop terminal. In addition Metis staff guides the astronaut through the scientific activities with supervision, data logging, and only the fly problem consultation and resolution.

Facilities - Metis staff develops, maintains, and supports several laboratories located at NASA Ames. This includes certified flight labs used in the integration and development of flight hardware destined for space applications. In addition test laboratories for SPHERES operational checks and new science development, as well as engineering test experiment labs. Metis staff is also responsible for all safety compliance for facility and staff including up to date certifications and annual training requirements.

Recently, the Metis team actively revived a decades old free flying simulator by evaluating and overhauling the entire system to meet new requirements. This room-sized electro mechanical laboratory which allows robotic vehicles to float around a room allows for simulated physics much needed for robotic development at Ames. This platform now has attracted customers from other programs to further benefit the advancement of NASA and space flight experiments in general. The implementation of this new system involved a through decomposition of the past system and implementation of new safety measures as well as satisfying the financial constraints imposed.

Certifications - The Metis team currently holds the following certifications:

- IPC J-STD-001ES Space Applications Electronic Hardware Addendum to J-STD-001D Requirements for Soldered Electrical and Electronic Assemblies Designed& Manufactured
- NASA-STD-8739.1, Workmanship Standard for Polymeric Applications on Electronic Assemblies
- NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring
- NASA Ames ESD Program/ANSI/ESD S20.20
- Respirator Certified
- Safety, Environmental and Mission Assurance (**SEMA**) Agreement for Safety Restricted Items
- Multi Mission Operation Center (MMOC) approved user