Modal Propellant Gauging – International Space Station (MPG-ISS)

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Abstract

During summer 2020, I worked as a NASA Intern in the NE-L6 division with my mentor, Dr. Edwin Cortés. The goal for this summer was to develop a payload design for the International Space Station that implements the Modal Propellant Gauging (MPG) fuel gauging technology. Current fuel gauging systems exceed preferred weight limits, have large gauging errors in microgravity and many are at relatively low Technology Readiness Levels (TRLs). In the MPG approach, surface acoustic waves are excited on the outside of the tank and resonant frequencies are measured. The resonant mode frequencies are sensitive to the presence of adhered liquid and so serve as an indicator of the total contained liquid. Modal measurements and tank excitations are performed by adhering sensors to the outer tank walls and using a small data acquisition (DAQ) system to record and process the modal data. MPG provides an accurate, lightweight and fuel agnostic alternative to current systems. It is being considered for use on the Orion Spacecraft, the Gateway Power and Propulsion Element (PPE), and the ascent modules from the lunar surface to Gateway.

I was tasked with designing the payload mechanical structure that contains the MPG-ISS experiment. MPG-ISS is distributed across two standard modular lockers. The lockers used are part of the Expedite the Processing of Experiments to Space Station (EXPRESS) racks containing 8 lockers per rack. Since each locker has space and weight limitations, this experiment will be distributed across two lockers. First, I designed the layout of the front panel interface on both lockers. This consisted of the electrical and fluid connections between the two lockers, multiple LED indicators, and power connections to the ISS EXPRESS Rack.

Next, I worked on designing a Propellant Management Device (PMD) for the tanks to be used in this experiment. A PMD is a standard attribute in all tanks to keep contained liquids in certain places in zero gravity. Once this design was finished, I moved onto creating a mounting system for both tanks. Since this project will take flight on a Falcon-9 rocket, it will undergo intense vibration during flight. The challenge was to hold the tanks in place during this vibration, as well as not change the mass-loading on the outer tank walls, which can complicate the modal data. Once this mount was completed, I began work on the enclosure for all the electronics. The electronics enclosure had limited space and had to be designed with attention to thermal load limits. The next challenge was to complete the flow loop components and connections. Lastly, I compiled a full 3D model of both lockers and began assembling a prototype.

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