National Aeronautics and Space Administration

NASAfacts

Space Technology

Game Changing Development

Slosh Experiment Aboard the International Space Station

Antares launch vehicle.

In order to build the next generation of spacecraft and rockets, NASA must improve its understanding of how fluids move in the microgravity environment of space. Because liquid propellants make up a majority of the mass of these space vehicles, their motion within the propellant tanks can cause perturbations or shifts in the vehicle's trajectory. Predicting the magnitude of these perturbations will allow the control system designers to properly tune their autopilot systems and prevent losing control of the vehicle.

Additionally, it is important to accurately know the location of the propellants within the tanks at all times of the mission for thermodynamic reasons. As the liquid propellants boil off, they cause a pressure rise in the tank. If left unvented, the pressure can rise to a point of rupture and cause a catastrophic loss of mission. For this reason most vehicle propellant tanks have a thermodynamic vent system that relieves the pressure at various points during the mission. When these vents are opened it is very important to only vent gasses and not vent liquids. Venting liquid will not only reduce the propellant level, it may also cause the vent to get blocked (from frozen liquid). Venting liquid propellants can also cause asymmetric venting that will impart an unexpected thrust to the vehicle altering its trajectory. All of these detrimental effects can be mitigated by knowing the location of the propellants within the tank at all times.

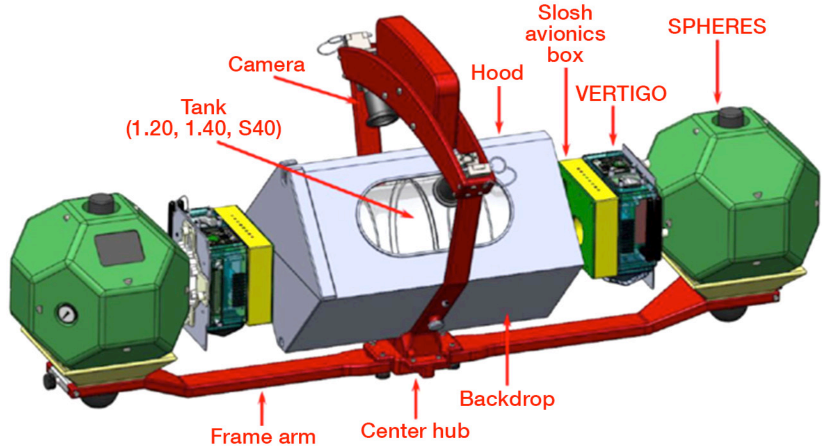
In order to predict the location of the liquid propellant during all times of the mission, NASA engineers use Computational Fluid Dynamics (CFD) software. These state-of-the-art computer programs numerically solve the fluid flow equations to produce a prediction for the location of the fluid at any point in time. These programs are very complex and require extensive validation before the results can be trusted. For liquid propellants, these CFD programs have been validated by experiments on the ground and found to be quite accurate. However, in the absence of gravity, the physics change drastically and liquids behave differently. These programs have not been validated for the microgravity environment of space.

The Slosh experiment aboard the International Space Station is designed to acquire data on behavior of liquids in the microgravity environment. The data will be used by engineers on Earth to validate these CFD programs making them ready for use in designing the next generation of space vehicles.

The experiment will use two soccer ball-sized robots that use small gas thrusters to maneuver as they free-float inside the space station. These small robots are called Synchronized Position Hold, Engage, Reorient Experimental Satellites (SPHERES). They will be attached to a metal frame at opposite ends. In the center of the frame is a clear plastic pill-shaped tank that is partially filled with green colored water. A pair of high resolution cameras will record the movement of the liquid inside the tank as the experiment is pushed around by the SPHERES robots. Additionally, several inertial measurement units will accurately record the position of the experiment as it moves within the space station.

The Game Changing Development (GCD) Program investigates ideas and approaches that could solve significant technological problems and revolutionize future space endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA's Space Technology Mission Directorate.

For more information about GCD, please visit http://gameon.nasa.gov/



Slosh experiment.


Slosh experiment launch package.

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