Airship Simulation Models for Planetary Exploration Using Darts/Dshell

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Robotically controlled airships and balloons are being considered for a wide range of planetary missions. In light of recent discoveries about Titan, the possibility of an airship mission to Titan is promising and exciting. Using an airship for planetary exploration presents unique challenges because its motion is very dependent on its environment. With landed rover missions, complete understanding of the interaction of a rover exploration vehicle and its environment is not as critical as with an airship. If problems arise with a rover, the system can go into a "safe" mode and do nothing until ground controllers can analyze the problem and decide how to deal with it. High-quality physical simulations of airships are important to develop a good understanding of how airships will interact with the environment in order to design airship configurations, develop control strategies, and create and test flight software.

At NASA's Jet Propulsion Laboratory (JPL), we have developed an airship simulation based on the *Darts/Dshell* high-fidelity dynamics simulation framework. This airship simulation model implements all of the key physical and aerodynamic features of airships including virtual mass effects, aerodynamic lift and drag forces of the main airship envelope and all attached fins, controllable thrusters, buoyancy effects, and more. The simulation includes a full model of the "ruddervator" tail fins including fixed and controlled surfaces.

Darts/Dshell Airship Simulation

In the airship simulation, the motion of the bodies involved is computed using the *Darts* high-fidelity multi-body dynamics simulation code. The "*Dshell*" part is used to model components that generate forces corresponding to aerodynamics, buoyancy, and thrusters. These forces are then applied to the bodies in the *Darts* multi-body simulation. The simulation also includes models of the environment of user-selectable fidelity developed for *DSENDS* (the entry and descent simulation for the MSL 2009 mission). In order to represent the terrain surface under the airship simulation uses the *SimScape* terrain modeling software library developed for Roams (rover simulation). *SimScape* allows the airship simulation to emulate instruments such as range finders that are needed by the onboard control software.

The simulation also includes a graphical visualization toolkit called "*Dspace*". The figure above shows the three dimensional view of the airship simulation. *Dspace* enables the simulation of views from cameras attached to the airship to simulate capturing images for science and control purposes.

The airship simulation can be run in several different modes. In one mode, the user can pilot the simulated airship as if it was an RC aircraft with controls to vary thrust, tilt the thrusters, and turn the movable control surfaces. The airship simulation can also be controlled from a non-human external source, such as receiving commands from emulated flight software or from scripts.

In the paper we will describe the features above in detail and describe how the airship simulation is being used at JPL to develop concepts for exploration of Titan using airships.