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Author: Mr. Timothy Cole
The Johns Hopkins University Applied Physics Laboratory, United States

THE CHALLENGES OF DESIGNING A LIGHTWEIGHT SPACECRAFT STRUCTURE FOR LANDING ON THE LUNAR SURFACE

Abstract

The Johns Hopkins University / Applied Physics Laboratory has been working with NASA's Marshall Space Flight Center on a design for lunar landers that would study many scientific features of the lunar environment. The requirements imposed on the design of the structure are: 1) Provide a stable platform for all of the various scientific instruments, 2) Provide a lightweight structure to minimize the launch costs and maximize the payload carrying capability, 3) Minimize the launch envelope to allow for the launching of multiple landers on one launch vehicle, 4) Provide a geometrically scaled structure that will allow for a controlled landing on the lunar surface while maximizing the chances of landing in an upright orientation. The stability requirement is dictated by the nature of the instrument suite. Many of the measurements to be taken on the lunar surface are so sensitive that any mechanical disturbances could potentially corrupt the measured data. Mechanical disturbances such as operating mechanisms, thermal expansion/contraction, deployable booms or other devices must be minimized. The lightweight requirement originates from the desire to minimize the launch costs and possibly package more than one lander on a single launch vehicle. The use of lightweight composite materials and manufacturing techniques are employed throughout the structure in order to minimize mass and maximize structural stiffness. Minimizing the launch envelope enables the potential packaging of several spacecraft into one launch vehicle shroud. This greatly reduces the launch cost per spacecraft. Multiple spacecraft on the lunar surface provides independent confirmation of science measurements taken and also highlights any variance in the science data taken at differing lunar latitudes. The lunar lander vehicle must arrive at the lunar surface at an upright orientation. In order to do this, the structure geometry must be designed to accommodate attitude errors in roll, pitch and yaw. In addition, the structure must be able to withstand various landing scenarios, which include a wide range of landing velocities and attitude rates. It is imperative that all of the structural requirements are met for this mission. Failure to meet any of the numerous challenging requirements could cause the loss of all the scientific objectives.