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MORPHEUS: ADVANCING TECHNOLOGIES FOR HUMAN EXPLORATION

Abstract

NASA's Morpheus Project has developed and tested a prototype planetary lander capable of vertical takeoff and landing designed to serve as a testbed for advanced spacecraft technologies. The vehicle provides a platform for bringing technologies from the laboratory into an integrated flight system at relatively low cost. This allows individual technologies to mature into capabilities that can be more readily incorporated into future human missions. Initial testing will demonstrate technologies used to perform autonomous precision landing on a lunar or other planetary surface.

The Morpheus vehicle is a planetary lander prototype propelled by a LOX/Methane engine and sized consistent with a reference mission carrying a 500kg payload to the lunar surface. The Project's major elements also include ground support systems and an operations facility. Morpheus testing includes three major types of integrated tests. A hot-fire is a static vehicle test of the LOX/Methane propulsion system. Tether tests are conducted with the vehicle suspended above the ground using a crane, which allows testing of the propulsion and integrated Guidance, Navigation, and Control (GNC) subsystems without the risk of vehicle departure or crash. Morpheus "free-flights" test the complete Morpheus system without the additional safeguards provided during tether. A variety of free-flight trajectories are planned to incrementally build up to a fully functional Morpheus lander capable of flying planetary landing trajectories. In FY12, these tests will culminate with autonomous flights simulating a 1km lunar approach trajectory, hazard avoidance maneuvers and precision landing.

Designed, developed, manufactured and operated in-house by engineers at the Johnson Space Center, the Morpheus Project represents an unprecedented departure from NASA's large-scale human spaceflight programs and projects. While these ventures traditionally require longer development lifecycles and testing at remote, dedicated testing facilities, Morpheus' research status allows the project to experiment with lean development and recurrent test practices that could also be beneficial to the execution of future spaceflight projects.

This paper expands on the project perspective that technologies offer promise, but capabilities offer solutions. It documents the integrated testing campaign, the infrastructure and JSC testing facilities, and the payloads being incorporated on the vehicle. The paper describes the fast pace of the project, rapid prototyping, frequent testing, and lessons learned from this unconventional engineering development process at NASA's Johnson Space Center.