Moon Base Transportation – Deliveries to the Lunar Surface

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Abstract

Development of the Moon Base will enable a home away from home for astronauts who will live and work at humanity's first lunar outpost. In this effort, NASA's Moon Transportation Office is responsible for enabling the transformational missions required to deliver habitats, supplies, science payloads, and all other elements needed to cultivate a permanent presence on the Lunar Surface. The Mission Concept (MC) is characterized through evaluation of an end-to-end architecture that can successfully deliver a generalized heavy large-volume payload, in excess of 4000 kg, to a precision landing and touchdown on the lunar surface.

The mission architecture utilizes a single launch configuration of a Lunar Lander (LL) with a unique propellant system. The LL has an integral orbital transfer capability and features jettisonable elements. The design circumvents the need for prop transfer on orbit and multiple launch configurations. The launch vehicle (LV) for this work will assume the capability to deliver a payload in excess of 40,000 kg to orbit, affording multiple LV solutions. Considerations for the LL and payload deployment from the fairing are assumed to be handled through compliance with a launch providers' Interface Requirements Document (IRD). The MC will span from launch at Kennedy Space Center (KSC) to terminal descent and touchdown on the lunar surface, requiring a total ΔV on the order of 6 km/s beyond what is required to get the vehicle stack to a 200 km circular Low Earth Orbit (LEO). Major mission phases include: launch and launch vehicle separation, transfer operations, pre-landing navigation, and lunar descent and touchdown.

A Concept of Operations (ConOps) is used as the primary design driver for defining architecture of the vehicles necessary to achieve final payload delivery. Numerous ground rules and assumptions will be provided for each phase of the mission. Concept designs for the LL is presented. An emphasis of the design maximizes a feasible path for maturation, manufacturing, and operation. A self-imposed practical consideration for this effort is the incorporation of legacy designed hardware to minimize expensive, time-intensive, and high-risk hardware development cycles. The propulsion system of the LL adopts a conventional storable bipropellant configuration of monomethyl hydrazine (MMH) and mixed oxides of nitrogen (MON3). This effort will

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showcase a unique propellant delivery system to minimize the reliance on propellant management devices (PMDs) during descent.

Numerous key constraints have been considered, across the multiple segments of the mission. These include the unique aspects of center of gravity (CG) management, thruster plume effects including self-impingement, propulsion system hardware limitations, navigation during multiple mission phases, and landing gear geometry for uneven terrain. These constraints shape the trades necessary for precision landing of heavy cargo and ensure compatibility with broader Moon Base Transportation concepts.

The resulting insights inform future transportation strategies for the Moon and beyond; directly contributing to the development of cargo-delivery standards that will support the long-term buildup of a sustainable, continuously inhabited Moon Base.