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A CONCEPTUAL DESIGN STUDY FOR AN UNMANNED, REUSABLE CARGO LUNAR LANDER

Abstract

Purpose: The objective of the conceptual design study was to design a reusable unmanned lunar lander capable of serving as a workhorse cargo delivery vehicle, operating between a station in Near-Rectilinear Orbit (NRO) and the lunar surface, subject to the following: (1) the lander utilizes Blue Origin's New Glenn three stage launch vehicle (LV) and thus is not to exceed a 20 mt TLI payload capacity, (2) the lander is responsible for all propulsive maneuvers beyond TLI, including ascent and descent to/from the lunar surface, (3) the lander proceeds directly from Earth to the lunar surface, dropping off an initial payload, then travels to a station in NRO where it is refueled, and returns to the lunar surface to deliver a (reuse) payload, (4) surface stays are 12 days, and (5) the lander must demonstrate a payload capability between 500 kg – 3,500 kg.

Methodology: A lunar lander modeling and simulation environment, also known as Lunar Lander Architecture Concept Exploration (LACE), was created in order to perform the required design study and trade analyses. Inputs to the modeling environment include vehicle information (e.g., propulsion system type, payload capacity, etc.) and a delta-V budget, where lunar descent and ascent are functions of vehicle thrust-to-weight. The modeling environment performs a multi-disciplinary design optimization to maximize payload and outputs a closed lunar lander design.

Results: The LACE environment was validated using the Descent Module of the Altair lunar lander (LDAC-3); the validation case increased confidence in the lander modeling capability. LOX/LH2, LOX/LCH4, and LOX/RP-1 propellant combinations and Cryogenic Fluid Management (CFM) approach (active or passive) were traded in order to examine the benefits of implementing cryogenic fluids and the corresponding disadvantages of a heavy thermal sub-system. Degrees of freedom included the number of engines and the max thrust per engine. The goal of the environment is to maximize both the initial and reuse payloads, while minimizing the total gross weight of the lander.

The LOX/LH2 propellant combination by far displayed the highest performance (Isp), but provided the smallest initial and reuse payload capabilities for the lander. LOX/LCH4 and LOX/RP-1 provided approximately the same initial payload mass capability, while LOX/RP-1 provided the largest reuse payload capability.