SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 3 (2C)

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LARGE CHEMICAL TRANSFER STAGES FOR LUNAR EXPLORATION

Abstract

In the past years, several agencies have expressed their increasing interest in lunar exploration, as recently reflected in the "Global Exploration Roadmap" by the International Space Exploration Coordination Group, ISECG. These exploration strategies consider long lasting human presence on the Moon which in turn necessitates large infrastructural elements like power plants, mobility vehicles and scientific equipment. To deliver these elements from an Earth bound orbit to a low lunar orbit, large transfer stages are required. This paper deals with chemical transfer stages to accomplish this task.

The optimum technical design can be deduced following a top level requirements matrix. The two main driving parameter of the matrix are: payload mass which ranges from 5 t to 20 t and propellant options. A technical architecture will be presented for each parameter combination. Three propellant types have been identified as viable options; two of cryogenic nature (LOX/LH2 and LOX/LCH4) and one storable (NTO/MMH-derivative). Special focus has been devoted to three subsystems that are characteristic for a chemical transfer stage: the propulsion subsystem, the structural layout and the thermal control system. Furthermore, a mission analysis based on the patched conic method has been performed for reliable (ideal) velocity demands. In addition gravity losses due to finite thrust manoeuvres have been computed by means of an orbit propagator. The selection of the optimum propellant combination as a function of the payload mass depends on the above mentioned points which have to be treated in a holistic way in order to achieve a consistent design. To give justice to this ansatz, launcher performances in terms of payload capability, volume constraints and injection orbit of existing and upcoming launchers are considered as well.

Contrary to the greater performance of LOX/LH2 in terms of specific impulse over NTO/MMH, the paper will prove that for lower payload masses storable propellant combinations are in fact superior to high energetic cryogenic propellant indicating a break-even point around 10 t. Programmatic aspects, like the availability of engines, potential international collaboration and the cost of enabling technology is also subject of the paper.

The presented results shall support near term decisions on a sensible choice of the optimum system architecture of future chemical transfer stages.