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CISLUNAR SPACE TRANSPORT EMPLOYING REUSABLE PROPULSION SYSTEMS (CLUSTER-PS), A PHASED EVOLUTIONARY APPROACH TO FULLY REUSABLE DEEP SPACE FUELING OF CREW AND CARGO MISSIONS

Abstract

The potential of fueling spacecraft in orbit is set to revolutionize spacecraft operations. Novel logistic approaches can significantly accelerate humanity's journey towards deep-space exploration, on top of the game-changing role it can play in the Moon exploration renaissance this coming decade. Orbital fueling in Low Earth Orbit (LEO) and lunar orbit can offer key advantages to spacecraft operating in the cislunar environment. The CLUSTER-PS concept focuses on near-term orbital fueling strategies that leverage existing assets for expedient completion and support of the Artemis missions while adhering to a fully reusable, environmentally conscious cislunar transport philosophy. The fueling concept proposed consists of a phased incremental and sustainable approach to an orbital fueling platform that starts with lofting existing assets like the Space Launch System Interim Cryogenic Propulsion Stage (SLS ICPS). Phase 1 revolves around clustering existing upper stages, like the SLS ICPS and later the SLS Exploration Upper-Stage (EUS) in LEO. These are integrated modularly into a thrust pallet that can accommodate several lunar payloads, like Orion, Dragon, lunar landers, or habitats. This phase is envisioned to be able to support the Artemis III mission, in 2026. A configuration of three stacked ICPS with RL10 engines is attached to the thrust pallet that can inject the crew capsule with a nearly fully loaded lander. Two stages are fully spent on the trans-lunar injection burn and the remainder is employed for return to Earth. The stack and capsule can also be brought to Earth with this configuration. The used upper stages are returned to Earth or LEO using decelerators for aerobraking. This phase does not include cryogenic fluid transfers in orbit. The payload and propulsion system stack is housed in a thermal blanket with solar photovoltaic panels on the sides to additionally provide a thermal shade that counteracts thermal cycling and associated boiloff during the orbital integration period which can span several weeks. During Phase 2 (2026-2028), water tanks are shipped to LEO so that the proposed orbital fuel-producing plant starts fabricating LOX and LH2 by electrolysis. A similar facility is built in Lunar orbit. This concept does not require the manufacture of fuel on the Moon, as water can be shipped from Earth to both locations. Lastly, in Phase 3 (2029-2031), contingent on water extraction and beneficiation followed by lunar surface-based electrolysis for the sustainable production and storage of propellant and oxidizer being found feasible, lunar fuel shipments can be commissioned.