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Author: Mr. Michael Elsperman
The Boeing Company, United States

Mr. Benjamin Donahue
The Boeing Company, United States
Dr. James Green
Space Science Endeavors, United States

KEEPING IT SIMPLE: A SINGLE LAUNCH MARS SAMPLE RETURN MISSION CONCEPT

Abstract

Here, a simplified implementation of a Mars Sample Return (MSR) mission is presented. Its key feature is an "all-in-one" mission that is flown from a single launch vehicle; this single MSR spacecraft will return directly to Earth after sample collection and does not require a separate Earth Return Stage (ERS). After injection to Trans-Mars injection (TMI) and a coast to Mars, the MSR spacecraft conducts an aeroentry at Mars and descends to the surface. After the collection of a variety of samples, the lander's Mars Ascent Vehicle (MAV) element ascends beyond Mars escape velocity and injects itself into a Hyperbolic departure trajectory. After a coast for 8 months, at Earth arrival the MAV's Earth Return Capsule (ERC) element separates and reenters. For this implementation of MSR, a launch vehicle must be utilized that can inject a significant mass to TMI. The NASA Space Launch System (SLS) has such a robust capability and can launch the required "all-in-one" lander. With this simplified approach, 3 separate MSR spacecraft, and 3 launch vehicles are not necessary, and the complex 'sample canister transfer' maneuver (between two spacecraft in Mars orbit) can eliminated; the consequence is that total program risk can be reduced significantly. Major elements of the 'all-in-one' spacecraft include the Descent Stage Element (DSE), Aeroshell, MAV, and ERC. In this study, a trade study is presented for the MSR spacecraft's propulsive stages, and will show how MAV, DSE and total Lander mass varies as a function of propellant selection and engine specific impulse.

The SLS's significant mass injection capability to TMI will allow (compared to the present '3 launch' MSE approach) more mass margin for reserves, weight growth and redundancy, providing additional reduction in risk. A feasible time period for the SLS launched MSR mission is 2033 and 2035; (opportunities occur about every two years) in these years the required Earth-Mars heliocentric delta-velocities are at a minimum (over the Earth-Mars 14-year synodic cycle). The SLS has had a successful first flight and is in production. The 'all-in-one' MSR spacecraft could be designed, built, tested and ready to fly by 2030 giving a robust 3 to 5 years of schedule margin. Also, description is given of the uprated SLS Block 1B, which will utilize the new Exploration Upper Stage (EUS). This work is done by the Boeing Exploration Launch Systems division in Huntsville Alabama, and the Boeing Advanced Systems group in Houston, Texas