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THE MULTI-MISSION EARTH ENTRY VEHICLE - PAST, PRESENT, AND FUTURE

Abstract

The Multi-Mission Earth Entry Vehicle (MMEEV) is an enabling technology developed at NASA's Langley Research Center (LaRC) over the last two decades for returning samples to Earth across a wide array of space science missions. Currently, the MMEEV is being considered for NASA's Mars Sample Return (MSR) mission. The original vehicle concept, the Earth Entry Vehicle (EEV), was innovated at LaRC in 1998 as a robust solution to return Mars soil samples to Earth under stringent backward contamination requirements. These backward contamination requirements drove the EEV to have higher reliability than any capsule previously designed for a return-to-Earth sample return mission. The EEV achieved this high reliability by employing a passive (no active systems) vehicle architecture optimized for fault tolerance in a compact, low-mass configuration that is extensible to virtually any sample return mission.

The original EEV concept utilized a carbon-carbon primary structure with high-density carbon phenolic thermal protection system. The capsule had a 60-degree sphere-cone forebody and a backshell geometry uniquely tailored to produce aerodynamics that would passively re-orient the vehicle if it entered the atmosphere with an off-nominal attitude. Contrary to every other sample return capsule conceived at the time, the EEV was designed to land without a parachute. The vehicle incorporated an integral energy-absorbing crushable structure that protected the Mars sample for landings on surfaces ranging from soft soil to solid concrete.

This paper describes 20 years of technological advancements LaRC has incorporated into the EEV architecture to evolve it from the original, MSR-enabling vehicle, to a true multi-mission capability relevant to any sample return mission. The vehicle's unique Integrated Composite Stiffener Structure (ICoSS) has been optimized for specific strength - supporting high-g atmospheric entries with steep entry angles that produce precise landing footprints on the ground. The vehicle geometry has been refined through wind tunnel testing and computational fluid dynamics simulations to improve the vehicle's aerodynamic stability and robustness to off-nominal conditions from hypersonic to subsonic flight. The resulting configuration of the current MMEEV architecture is described, with details provided on its sample carrying capacity and atmospheric entry trajectory capabilities. The upgraded vehicle performance is mapped into current space science objectives, showing how the MMEEV supports future sample return missions and continues to be an enabling technology for NASA's vision to return samples from Mars.