MARS SAMPLE RETURN EARTH ENTRY VEHICLE PROGRESS AND DEVELOPMENT

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Brief Presenter Biography: Jeremy C. Vander Kam is an Aerospace Engineer at NASA Ames Research Center where he serves as the deputy manager of the Mars Sample Return (MSR) Earth Entry Vehicle (EEV). He concurrently serves as the deputy system manager for the Orion Thermal Protection System (TPS). Jeremy has B.S. degrees in Aeronautical and Mechanical Engineering and a M.S. Engineering degree from U.C. Davis.

Introduction: The most recent Planetary Science Decadal Survey indicated that the Mars Astrobiology Explorer-Cache element of a potential robotic Mars Sample Return (MSR) architecture should be considered as the highest-priority large mission [1]. The MSR campaign is nearing the end of the formulation phase and several mission elements are being defined for Phase A work beginning in 2021. The last step of the overall MSR mission is performed by the Earth Entry Vehicle (EEV), which delivers Martian soil samples to a U.S. landing site where they would then be transferred to the Sample Receiving and Curation Facility.

Earth Entry Vehicle Design: The EEV design centers around delivering Martian soil samples to Earth while maintaining 1) Martian sample integrity for science objectives and 2) Martian sample containment in the interest of planetary protection. The EEV features a composite structure with several layers of energy absorbers and containment barriers, all protected by a robust Thermal Protection System. The EEV is passive, with no mechanisms or electronics in the interest of high reliability. This passive, ballistic entry results in a high-speed landing on Earth on the order of 40 m/s.

EEV design over the past year has focused on a classical cold structure/ablative TPS system designed for Earth entries around 12 km/s, resulting in heat fluxes in the range of 2,000 W/cm^2. To withstand these environments, the Heatshield for Extreme Entry Environment Technology (HEEET) TPS material, in a single piece, insulation layer (S/IL) configuration has been selected for the forebody heat shield and the Phenolic Impregnated Carbon Ablator (PICA) material for the back shell.

A further EEV design challenge is the necessity of withstanding a free-flight in-space segment of up to 6 days prior to Earth entry. This drives Micro-Meteoroid and Orbital Debris (MM/OD) robustness demands that exceed prior entry probe designs. In particular, TPS selection for MM/OD motivated the selection of S/IL HEEET for the forebody due to the robustness of that material system and the low threshold for damaged-state performance in such demanding aerothermal environments. On the back shell, where the aerothermal environments are considerably less, a less MM/OD-robust system can be employed to save mass.

The passive EEV design means that the vehicle must remain aerodynamically stable throughout atmospheric flight in order to properly engage the energy absorbing elements of the structure upon landing. EEV sphere cone shapes of 45- and 60- degrees have been evaluated and tested in order to satisfy this constraint.

This presentation will provide an overview of the current MSR/EEV design, some of the trades being currently explored, and summarize the high-level differences in both design and performance. In particular, the evaluation of 60- and 45- deg sphere cone shapes will be discussed.

The information presented about potential MSR is pre-decisional and is provided for planning and discussion purposes only.

References:: [1] Squyres, et al., “Visions and Voyages for Planetary Science in the Decade 2013-2022,” National Academies Press (2011).

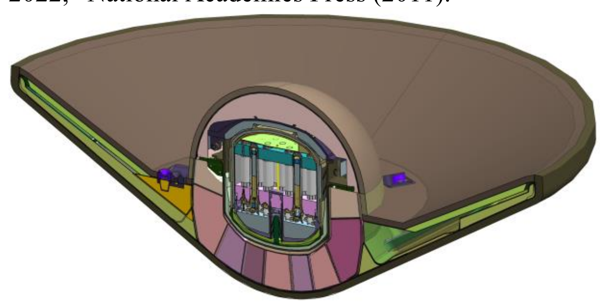

Fig. 1: Example EEV design