IMPACT OF NASA'S ENTRY SYSTEMS MODELING PROJECT ON PLANETARY MISSION DESIGN: VEXAG

A. Brandis[1], M. Barnhardt[2], M. Hughes[3], T. West[3] and M. Wright[2]. [1]AMA, Inc. at NASA Ames Research Center, Moffett Field, 94035, CA, USA: aaron.m.brandis@nasa.gov. [2]NASA Ames Research Center, Moffett Field, 94035, CA, USA. [3]NASA Langley Research Center, Hampton, 23666, VA, USA.

Brief Presenter Biography: Dr. Brandis is a senior research scientist employed by AMA Inc. in the Aerothermodynamics branch at NASA Ames Research Center. He is the principal investigator (PI) for NASA's Entry Systems Modeling Project, Dragonfly aerothermal lead, and Dragonfly Entry Aerosciences Measurements (DrEAM) PI. His research focuses on shock layer radiation with the NEQAIR code and EAST shock tube.

Abstract: Planetary missions continue to grow larger and more complex. Furthermore, the current focus on human exploration of the Moon and Mars, as well as Mars Sample Return (MSR), place increasingly stringent requirements on the reliability of the entry, descent, and landing (EDL) system that ensures the safe delivery of payload or crew to their destination. Planetary EDL is an area in which mission designers are critically reliant on modeling and simulation to demonstrate the reliability of the system, as there are no ground facilities that are able to fully test these systems in a flight-relevant environment. NASA's state-of-the-art modeling and simulation capability must continually evolve to meet the needs of the next generation of planetary EDL. To accomplish this aim, NASA's Entry Systems Modeling (ESM) Project was formed in 2013 and is funded by the Space Technology Mission Directorate (STMD) and Science Mission Directorate (SMD). ESM is the Agency's only cross-cutting effort for advancing entry systems modeling and simulation capabilities across a range of technical disciplines and Solar System destinations. ESM is a portfolio project covering a variety of mid-TRL research efforts within four core EDL-related areas of investment: (1) Thermal protection material modeling, (2) Shock layer kinetics and radiation, (3) Aerosciences, and (4) Guidance, navigation, and control. The material modeling group creates detailed material response models of thermal protection systems (TPS) from the micro- to macroscale, and at the fundamental and engineering levels. Shock layer kinetics and radiation focuses on radiative heating of spacecraft, quantum chemistry and benchmark experiments for validation. Aerosciences is a broad research area that impacts many aspects of entry systems, including parachutes, aerodynamics, and turbulent heating augmentation due to TPS roughness. The guidance, navigation, and control effort under ESM is expanding the capabilities of NASA's main flight mechanics tool, POST2, for use on high-performance computing architectures and to generalize interoperability with external applications for more detailed end-to-end simulation. In addition, several focused research topics have been approved to augment ESM's core portfolio. These include efforts for deep post-flight analysis of Mars 2020/MEDLI2 flight data; development of TPS failure models; improvement of hypersonic wake flow models; and a recently concluded effort to provide material response models for NuSil-coated PICA heatshield material. This presentation will discuss each of these investment areas and demonstrate via real mission examples how advances to the state-of-the-art enabled by ESM are directly impacting missions, including Mars Sample Return and Dragonfly as well as how ESM could potentially collaborate with the recently announced Discovery missions to Venus, DaVinci and Veritas.

Areas of research within ESM that could be applicable to an upcoming Venus mission might include:

- Radiative heating: Shock layer radiation can dominate heating during Venus entry. ESM has obtained initial experimental data for model development and uncertainty quantification and will look to expand upon our benchmark radiative heating data for Venus.
- Entry Dynamics: Free-flight dynamic CFD can augment ground tests to better understand aeroshell stability and provides traceability to flight. Advanced guidance and control algorithms could further enable and/or reduce risk for aerocapture maneuvers.
- Roughness Heating Augmentation: Risk and margin reduction via tailored roughness heating models for woven and tiled heatshield designs.
- Advancing Woven TPS & Thermostructural Models: ESM is developing woven TPS material models that could aid designs to close for Venus conditions and improve understanding of woven TPS material thermostructural performance.