Eric Nielsen

Session 2

Title: Closed-Loop Flight Simulations of Human-Scale Mars Entry Using Geographically-Distributed Exascale Computing

Abstract: Human-scale Mars missions will require lander concepts roughly the size of a two-story house with at least an order of magnitude more mass than those previously delivered to the Martian surface in support of robotic missions. A conventional deceleration approach based on the use of parachutes in the Martian atmosphere is not feasible. Instead, human-scale vehicle concepts will require the use of retropropulsion technology. Due to many factors including scaling limitations, vehicle complexity, and the need to test in conditions representative of the CO2 atmosphere on Mars, ground-based and flight testing on Earth will likely be very limited. New control laws must also be proven sufficient to reliably guide such a radically different concept during entry. For these reasons, HPC supporting high-fidelity simulations based on first principles will be used heavily to help develop the requisite technologies and ultimately the confidence to consider crewed missions.

This long-term R&D activity brought together an international team of diverse researchers across government, industry, and academia to perform novel closed-loop, fully autonomous flight trajectory simulations of a human-scale Mars lander. Scale-resolving computational fluid dynamics with finite-rate chemistry accounting for interactions between the high-energy liquid oxygen/methane rocket exhaust and the Martian CO2 atmosphere were computed on the Frontier exascale platform, while communicating in real-time with a state-of-the-art flight mechanics package executing on a NASA system located 500 miles away. This activity has demonstrated a feasible approach to eventually help establish the high level of confidence needed to field a crewed mission to Mars.

Bio: Eric Nielsen is a Senior Research Scientist in the Computational AeroSciences Branch at NASA Langley Research Center in Hampton, Virginia. He received his PhD in Aerospace Engineering from Virginia Tech and has worked at Langley for the past 30 years. Dr. Nielsen leads a development team specializing in computational aerodynamics software for the world's most powerful computer systems. The software has been distributed to thousands of organizations around the country and supports major national research and engineering efforts at NASA, in industry, academia, the Department of Defense, and other government agencies. He has served as the Principal Investigator on Agency-level projects at NASA as well as leadership-class computational efforts sponsored by the Department of Energy. Dr. Nielsen is a recipient of NASA's Silver Achievement, Exceptional Achievement, and Exceptional Engineering Achievement Medals as well as NASA Langley's HJE Reid Award for best research publication.