HIGH-ENTHALPY TESTING TO VALIDATE SIMULATION OF AN AEROSOL CAPTURE PROBE.

C. Naughton[2], C. Espinoza[1], J. Meurisse[2], A. Borner[2], D. Gentry[1]. [1]NASA Ames Research Center, Moffett Field, CA 94035 (christopher.w.naughton@nasa.gov, christian.espinoza@nasa.gov, diana.gentry@nasa.gov). [2]AMA, Inc., NASA Ames Research Center, Moffett Field, CA 94035 (jeremie.b.meurisse@nasa.gov, arnaud.p.borner@nasa.gov).

Author Biography: Christopher Naughton is an engineer working in the Aerothermodynamics branch of NASA Ames Research Center (ARC) where he supports projects such as Dragonfly, the Commercial Crew Program, and AERACEPT.

Introduction: AERACEPT (Aerosol Rapid Analysis Combined Entry Probe/sonde Technology) is a developing technology enabling in-situ aerosol particle sampling and analysis in a small spacecraft mission envelope. It integrates a passive aerosol sample collection system into a probe's thermal protection system (TPS) to remove the need for heat shield separation and active descent control (parachutes, gliders, etc.) [1]. AERACEPT is being validated against the requirements of the Nephele mission concept, which targets the middle and lower Venus cloud layers.

The proposed technology employs 3D Carbon-Carbon (3D-CC) at the probe's nose to withstand the extreme environments encountered in a Venus entry without producing pyrolysis gases that would contaminate the mission sample collection. Any shape change of this 3D-CC sample inlet will affect airflow through the sampling system, thereby impacting aerosol sample collection bias and efficiency. Accurate prediction of the nose's material response during entry is therefore of fundamental importance to the development and practical use of this technology. As a result, the AERACEPT project is planning a test campaign in the newly built PlasmatronX facility with a novel "Open Iso-Q" test article to validate state-of-the-art material response tools for a simulated Venus entry.

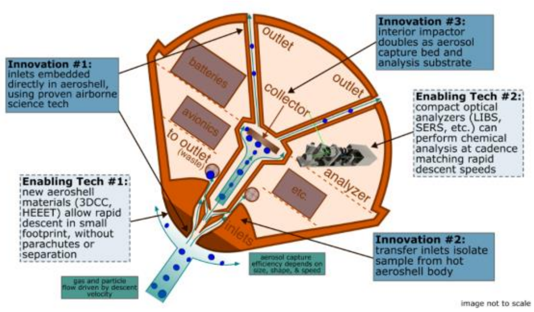

Fig. 1: *AERACEPT Combined Entry Vehicle / Atmospheric Sonde Concept.*

Test Facility: The PlasmatronX is a 350 kW inductively-coupled plasma facility developed and run by the Center for Hypersonics and Entry Systems Studies at the University of Illinois at Urbana-Champaign [2]. The facility can support ground testing for a variety of planetary destinations by simulating entry conditions in Nitrogen, Air, and Carbon Dioxide. To best simulate the Venus atmosphere and match flight-like recession, the planned AERACEPT test campaign will use Carbon Dioxide as its test gas.

Test Articles: AERACEPT has designed two test articles for this campaign: 1) a standard test article whose curved surface approximates a constant applied heat flux ("Closed Iso-Q" model) and 2) a novel inlet test article with a through-hole at the stagnation point ("Open Iso-Q" model). Both article types consist of a 3D-CC sample bonded to a graphite fixture. All articles will be laser scanned before and after testing to estimate shape change and recession, and the "Closed Iso-Q" articles will be instrumented with thermocouples to provide temperature histories. The test article temperatures and inlet shape change will be compared against simulations run with the Porous material Analysis Toolbox based on OpenFOAM (PATO) to validate the AERACEPT 3D-CC material response model.

Due to the high thermal conductivity of 3D-CC, multidimensional effects have a large influence on the test article temperature and the standard 1-D material response tools are not sufficient for test planning. The test campaign features (e.g. article design, run duration, heat fluxes) are therefore informed by a series of 3-D simulations using state-of-the-art material response tools such as PATO.

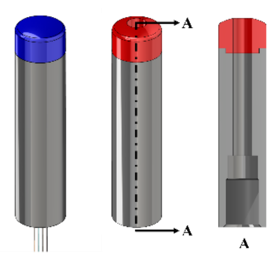

Fig. 2: *(Left to right) Closed Iso-Q article, Open Iso-Q Article, Cutaway view of Open Iso-Q model.*

Scope: The test campaign is scheduled for spring of 2024. Expected results include 1) Key drivers of selected test conditions (e.g. matching mission flight atmosphere & recession), 2) Simulation results that informed test article design, 3) Acquired test data such as recession measurements, temperature histories, and photos, and 4) Comparisons between test results and simulation predictions.

References:

[1] D. Gentry et al. (2023). *AERACEPT (Aerosol Rapid-Analysis Combined Entry Probe/sonde Technology): Enabling Technology for Missions to Venus Clouds*. [Abstract] AGU, San Francisco, CA, 2023.

[2] T. Oldham et al. (2023). *Aerothermal Characterization of the PlasmatronX Wind Tunnel: Optical Emissions Spectroscopy and Jet Temperature Reconstruction*. AIAA Scitech, National Harbor, MD, 2023.