Aerothermodynamic Testing of Aerocapture and Planetary Probe Geometries in Hypersonic Ballistic-Range Environments

by

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ABSTRACT

Planetary atmospheric-entry and aerocapture spacecraft require thermal protection systems (TPS) to enable their missions. Travel through any atmosphere at hypersonic speeds creates severe aerothermal environments that must be accurately predicted to generate successful and optimized TPS designs. Computer simulations used for this purpose must be validated against physical measurements obtained under controlled test conditions.

The NASA-Ames ballistic range provides a unique capability for aerothermodynamic testing of configurations in hypersonic, real-gas, free-flight environments. The facility can simulate conditions at any point along any trajectory of interest by independently varying the test-section pressure (effective altitude), the launch velocity of the model (flight Mach number), and the test-section working gas (planetary atmosphere). Proper initial surface-roughness conditions are created by pre-ablating the TPS materials in laminar-flow arc-jet environments prior to flight in the ballistic range. In ballistic range tests, the model travels at hypersonic speeds through a quiescent test gas, instantaneously creating real-gas effects (chemical non-equilibrium states) that closely match conditions achieved during actual atmospheric entry. Ballistic range experiments are generally orders of magnitude less expensive than flight tests in the Earth's atmosphere.

The challenge with ballistic range experiments is to obtain quantitative data from a model traveling at hypersonic speeds. Optical measurement techniques are the most practical means, since surface-mounted sensors require telemetry and will be lost, along with the model, at the terminal wall of the range. Thermal imaging has been employed in the Ames ballistic range to measure global surface temperature distributions on the forward regions of hypersonic blunt bodies. Both visible wavelength (intensified CCD) and infrared high-speed cameras are in use.

The proposed paper and oral presentation will review methodologies for conducting aerothermodynamic experiments in the Ames hypersonic ballistic range. Results concerning roughness-induced transition to turbulence and measured surface heat transfer rates will be given.