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Thermophysics

Engineers in the Entry Systems and Technology Division at NASA Ames developed a fully instrumented small atmospheric entry probe called SPRITE (small probe reentry investigation for TPS engineering). Conceived as a flight testbed for thermal protection materials, SPRITE was tested at full scale in an arcjet facility so that the aerothermal environments the probe experiences over portions of its flight trajectory and in the arcjet are similar. This ground-to-flight traceability enhances the ability of mission designers to evaluate the margins needed in the design of thermal protection systems (TPS) for larger scale atmospheric entry vehicles.

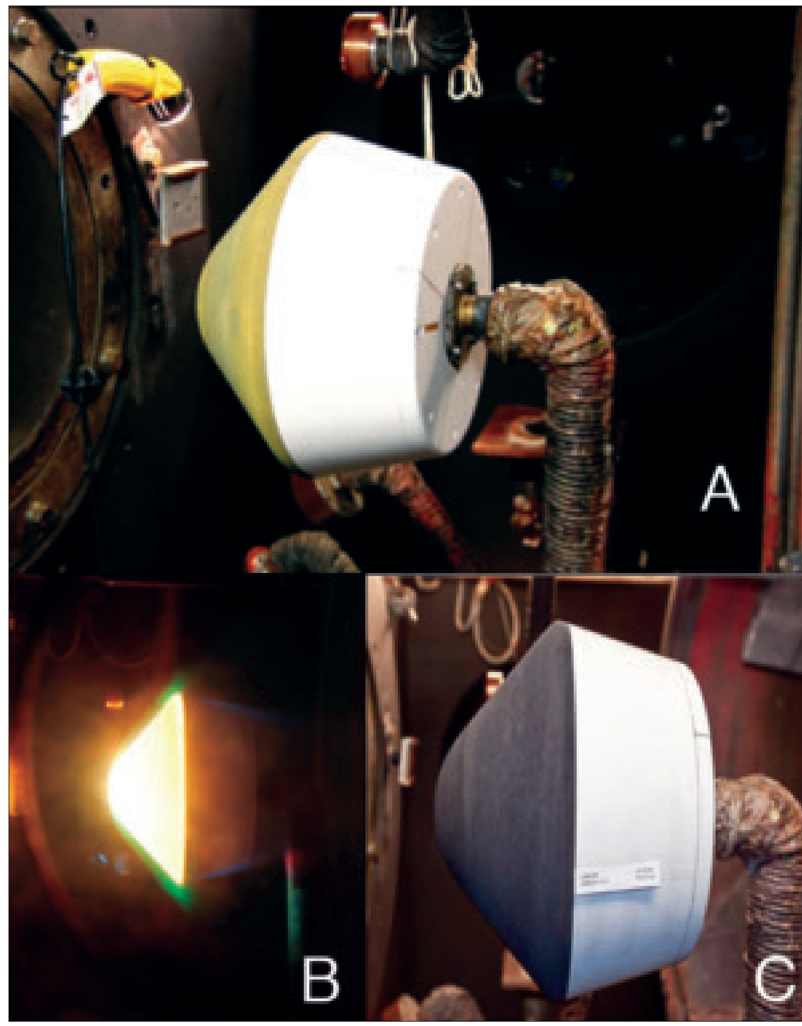
SPRITE is a 14-in.-diam., 45-deg sphere-cone with a conical aftbody and is designed for testing in the NASA Ames Aerodynamic Heating Facility. The probe is a two-part aluminum shell with PICA (phenolic impregnated carbon ablator) bonded on the forebody and LI-2200 (space shuttle tile material) bonded to the aftbody. Plugs with embedded thermocouples similar to those installed in the heat shield of the Mars Science Laboratory are integrated into the design, as are a number of distributed sensors. The data from these sensors are fed to an innovative, custom-designed data acquisition system that is also integrated with the test article.

Two identical SPRITE models were built and successfully tested in late 2010 and early 2011, and the concept is currently being modified to enable testing of conformable and/or flexible materials.

The NASA entry, descent, and landing technology development project is developing flexible ablative thermal protection materials to enable inflatable or deployable low ballistic coefficient entry systems for exploration at Mars. Use of these systems might also be extended to payload delivery at Venus, Saturn, and Earth.

The original flexible concepts were based on rigid ablator chemistry utilizing silica and carbon *flexible* substrates. More innovative approaches were developed concurrently and use polymeric and polymeric/organic flexible substrates.

Screening tests were performed on these materials with excellent results. The silica- and polymer-based materials easily survived aerothermal environments of 120 W/cm^2, and the carbon-based materials were effective in environments up to 530 W/cm^2. A second year of innovation has led to the generation of 15 different variants and improvements on these NASA-developed materials, together with five vendor-developed materials.



A sequence of photos shows the SPRITE model before testing in a plasma flow (A), in the plasma flow (B), and after exposure to the flow (C).

Given the performance of the carbon-based materials at high heat fluxes, it is envisioned that they may also substantially increase reliability and reduce life cycle cost of *rigid* aeroshell-based entry systems for multiple missions. The GCDP (game changing development program), an effort by Office of the Chief Technologist at NASA, has identified a need for the development of flexible ablative TPS capable of supporting exploration class missions. Based on the success of the work done in 2010 and this year under the project, this program will be funding further development in 2012.

by **Dinesh K. Prabhu** and **Robin A. Beck**