



## **NASA SBIR 2017 Phase I Solicitation**

### **27.01 Supersonic Parachute Inflation Materials Testing, And Instrumentation**

**Lead Center:** JPL

**Participating Center(s):** LaRC

**Technology Area:** TA9 Entry, Descent and Landing Systems

Mars landed missions have traditionally relied on large (nominal diameter between 11.5 and 21.5 m) disk-gap-band (DGB) parachutes that must be inflated between Mach 1.2 and 2.2 at dynamic pressures between 300 and 850 Pa to ensure that the terminal landing phase occurs before hitting the ground. For robotic payloads larger than the Curiosity rover, larger parachutes will be required. These parachutes need to be tested under the low-density supersonic conditions that match Mars conditions. However understanding the shape history, dynamics, and induced stresses in the parachute structure and broadcloth during the inflation event is needed to ensure that minimum strength margin requirements are met. Further understanding the strength capability of materials under bi-axial and shear stress is essential. The measured material capabilities and stress conditions during inflation will be matched with computer models that will eventually be used as predictive tools in the parachute design process. This SBIR asks for help inventing and utilizing techniques for measuring parachute materials strength capabilities under flight-like loading conditions, and measuring, or inferring, parachute material stress and shape histories found during the inflation process during supersonic parachute inflation testing planned for the 2018 timeframe.

#### **Parachute Materials Testing**

Low mass, high strength parachute fabrics typically are constructed using various woven low mass Dacron or nylon broadcloth (e.g., 1.2 oz./yd<sup>2</sup>) that are sewn as gores onto Kevlar (or other high strength) webbing that forms a circumferential and radial skeleton primary structure. These materials as well as associated seams and joints are typically strength tested uni-axially. In some cases bi-axial testing has occurred however test fixtures and test facilities that attempt to reproduce the bi-axial and shear-induced stresses and strain associated with the dynamic inflation event do not appear to exist.

Proposers to this subtopic should suggest ideas and provide the capability for determining the strength of these classes of materials including joints and seams under various bi-axial stress and shear conditions (materials, sample joints and seams will be provided) that are representative of the manner in which the materials are loading during and after inflation.

Phase I will be expected to deliver: Measurement detailed design (and design review), Details of material test requirements (to be worked with the lead center in this phase), Implementation and cost plan, and Test facility and calibration plan

Phase II will be expected to deliver: Tested and calibrated material test instrumentation and/or facility, Material testing (using samples provided by parachute manufacturers), Test data analysis and results.

#### **In-situ Instrumentation**

---

Ultimately, to prove that sufficient strength margin exists in the parachute design we need to determine the stresses or strains of the materials, seams and joints during the supersonic inflation event(s). Computer models that attempt to predict these stresses have not been validated due to an absence of data to ground the simulation results. NASA may execute supersonic, high-altitude inflation testing using various sized DGB parachutes in the 2018 timeframe. Plans include the use of high-speed stereo machine vision cameras that will allow shape history reconstruction of the very fast (< 1 sec) inflation event. Load cells on the riser(s) will provide estimates of the integrated tension during the event. After the test, the parachute and its instrumentation will be recovered and data extracted to gain understanding of the event. Some strain might be observable. What is missing are means to more directly measure or infer the peak stresses in the skeleton and broadcloth during the inflation event. Creative solutions have been proposed in the past, to instrument the parachute directly but these suffer from immaturity, use unproven integration techniques, and/or have questionable accuracies. These past solutions include: stress paint, strain threads that act as peak strain telltales, ultra-low-mass miniature self-contained strain gauges, and passive peak stress detection sewn into the circumferential and radial skeleton webbing (ball-strain yielding). These and other ideas are encouraged.

Proposers should suggest and have the ability to deliver various types of in-situ or remote instrumentation. Care should be taken to ensure that the incorporation of these devices do not excessively interfere with the operation of the parachute during the mortar-launched parachute inflation.

Phase I will be expected to deliver: Detailed design concepts, Implementation and cost plan, Details of accommodation (to be worked with the lead NASA center), and Instrument test and calibration plan.

Phase II will be expected to deliver: Tested and calibrated instrumentation, System test support (use of instrument in a ground or flight test), and Instrument data analysis.