ABSTRACT

Wireless communication with a parachute canopy potentially represents an advancement to the state of the tools available for parachute design, development, and testing. Embedded instrumentation of the parachute canopy will provide the capability to directly measure data such as reefing line tension, skirt position data, parachute health monitoring, and other telemetry, further validating computer models and giving engineering insight into parachute dynamics for both Earth and Mars entry that is currently unavailable. This will allow for more robust designs which are more optimally designed in terms of structural loading, less susceptible to adverse dynamics, and may eventually pave the way to currently unattainable advanced concepts of operations. The development of this technology has dual use potential for a variety of other applications including inflatable habitats, aerodynamic decelerators, heat shields, and other high stress environments.

ANTICIPATED BENEFITS

To NASA funded missions:
- Development of this technology has implications for future use on the Orion parachute recovery system
- May provide a direct benefit to the Capsule Parachute Assembly System (CPAS) and the Orion re-entry system

To NASA unfunded & planned missions:
- Optimal parachute performance and reduced mass in the EDL design for both Earth and Mars
- Inflatable decelerators
- Inflatable habitats
- Increased robustness in staging mechanisms for phased drag deployment
- Enhanced safety and probability of mission success

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To NASA unfunded & planned missions: (cont.)

- Instrumentation of the parachute canopy, providing reefing line tension, skirt position data, and other
- Telemetry, will provide insight to parachute dynamics currently unavailable, allowing for designs more robust to pendulum motion and other parachute failure modes

To other government agencies:
Application of this technology may be extended to military parachute use as well as Department of Defense uses under harsh operational conditions.

To the commercial space industry:
Commercial skydivers and equipment providers, commercial space companies (SpaceX, Boeing, Orbital Sciences, Bigelow Aerospace, etc.).

To the nation:
May be applied to:
- Inflatable Buildings: sports arenas, indoor fields, temporary buildings, etc
- Ship industry: sails
- Cars industry: airbags, tires

DETAILED DESCRIPTION

Entry, descent, and landing capabilities, including parachutes, lie on the critical path to human and robotic exploration of Mars. To date, the capability to actively communicate with a parachute canopy does not exist and in turn, data regarding the dynamics and health of the parachute system is unavailable. Since wired instrumentation capabilities are limited in the operational environment, wireless communication with a parachute canopy will be an advancement to the state of the art of parachute design, development, and testing. Embedded instrumentation of the parachute canopy will provide flight data within the

Technology Areas (cont.)

- Deployable Hypersonic Decelerators (TA 9.1.4)
- Instrumentation and Health Monitoring (TA 9.1.5)
- Descent and Targeting (TA 9.2)
- Materials (TA 12.1)
- Lightweight Structural Materials (TA 12.1.1)
- Lightweight Concepts (TA 12.2.1)
- Reliability and Sustainment (TA 12.2.3)
- Innovative, Multifunctional Concepts (TA 12.2.5)
- Mechanical Systems (TA 12.3)
- Deployables, Docking, and Interfaces (TA 12.3.1)
- Reliability, Life Assessment, and Health Monitoring (TA 12.3.5)
- Cross-Cutting (no content) (TA 12.5)
operational environment; in turn offering engineering insight into parachute dynamics for both Earth and Mars entry that is currently unavailable. This will allow for more robust designs which are optimally designed in terms of structural loading, less susceptible to adverse dynamics such as pendulum motion and gliding, and will eventually open the door to advanced concepts of operations (CONOPS).

The Parachute Canopy Instrumentation Platform (PCIP) is a technology, currently in development, that will allow for two-way wireless communication with the parachute canopy as well as the various structural components (risers, suspension lines, etc.). This system will need to be structurally reliable in order to withstand the harsh operational environment of parachute life cycle (large packing pressures, snatch loading, electromagnetic discharge) as well as ensure a clear and safe communication link between the parachute canopy and the vehicle which will not negatively affect other onboard systems.

The PCIP system is a platform that would enable implementation of a wide range of parachute canopy sensors and actuators. Establishing a "plug and play" platform with a reliable wireless communication link would allow for a consistent method of obtaining various measurements almost anywhere on the parachute system structure. Due to the variation in timescales of dynamics of parachute operation (very quick deployments to very slow steady state descent), the PCIP system must be capable of responding quickly and be highly sensitive to measurement changes, yet maintaining an operational state throughout the flight of the parachute. The hardware itself must be designed small and light enough as to not introduce a point mass which will impart unacceptable forces on the parachute canopy.

DETAILS FOR TECHNOLOGY 1

**Technology Title**
Flexible Structure Instrumentation Platform

**Technology Description**
This technology is categorized as a hardware system for manned spaceflight

The Flexible Structure Instrumentation Platform (FSIP) is a device enabling two way wireless communication between two points within a specified spatial area in order to telemeter data from sensors (such as strain gauges, GPS units) and/or transmit health statuses and/or send commands (such as actuation of other hardware). Harsh operating environments are withstood by FSIP, including large accelerations/inertial loads, electromagnetic interference, long term storage in high pressure and other stressing environments, and thermal cycling while minimizing negative impact.
to other radio frequency devices in the immediate area. An example application of FSIP is the instrumentation of a mortar deployed parachute on a space vehicle to wirelessly telemeter the strain in the canopy components along with health statuses to the vehicle during deployment, and wirelessly sending reefing cutter actuation commands from the vehicle to the canopy. The ability to collect this data will also allow validation of computer models of the behavior of complex flexible structures in harsh operating environments. The development of this invention may also require the development of other inventions (lightweight and durable sensors, electronics, and RF communications).

Capabilities Provided

- General Capabilities:
  - "Plug and play" platform
  - Two-wireless communication
  - Build to withstand a harsh operational environment - reliability
- Parachute Specific Capabilities:
  - Two-way wireless communication between a parachute canopy and payload, allowing for measurement of the canopy and transmission of commands
  - Real time reefing cutter actuation, collection of data to enable development and validation of parachute systems and related computer modeling

Potential Applications

This technology can be implemented in the design of flexible systems. Engineering development of systems can be enhanced by collecting previous unavailable data throughout the development process to inform the design. Implementation in existing systems (military payloads, commercial skydiving, drag racing parachutes) will allow for more advanced concepts of operations and allow for real time command transmission. Implementation on deployable inflatable structures (habitats, aeroshells, etc) will enable health monitoring as well as better informed designing.

Potential users of this new technology include NASA and related contractors, Department of Defense, commercial skydivers and equipment providers, commercial space companies (SpaceX, Boeing, Orbital Sciences, Bigelow Aerospace, etc.).