CHARACTERIZING AN EXPERIMENTAL DECELERATOR FOR DELIVERING NANO-SAT PAYLOADS TO PLANETRY SURFACES

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Abstract: NASA Ames Research Center is developing the Small Payload Quick Return (SPQR) system, designed to quickly deliver a small payload from the International Space Station (ISS). The SPQR system uses a unique atmospheric drag device which makes it compatible with crew operations. A crew member would release the system from the ISS. The atmospheric drag device would deploy, and de-orbit the system in roughly 40 orbits. A tube deployed re-entry vehicle would then allow the payload to enter the atmosphere. At an altitude near 30,000 meters (95,000 feet), a parafoil system would deliver the payload to the surface of Earth. In order to improve the accuracy of the targeting system over the gradual de-orbit process, it was necessary to develop an on-orbit position determination system. A Short Burst Data (SBD) modem offered by satellite phone vendors is to be tested to determine the viability of the uplink/downlink capability. This modem will include a GPS receiver and will transmit its location multiple times per minute, throughout the entire de-orbit period. The position resolution will help accurately characterize the aerodynamics of the atmospheric drag device throughout entry and descent.

The University of Idaho's Near Space Engineering program has worked with NASA Ames to test various subsystems for the SPQR system. To support the test of the Ames SPQR system, a telecomm system for telemetry comprising of an SBD modem and sensors was successfully flown on a weather balloon to an altitude above 27,000 meters (90,000 feet) in October 2011. The next balloon test of the telemetry system will include position determination, and is scheduled for spring 2012. These tests will culminate with a trip to space aboard the Antares' maiden launch, scheduled for August 2012 from NASA Wallops Flight Facility, as well as a similar experiment to be jettisoned from the ISS in September 2012. Further testing of the SBD modem is required, and then an Earth entry and descent test can be conducted. Once the atmospheric drag device is properly characterized and tested, the SPQR system could be used to deliver Nano-sat scale payloads to the surface of Mars.

SPQR Status and Logistics

ISS Payload Deployment Logistics

- **Problem:** Added complexity with certifying a payload to be brought aboard the ISS
- **Solution:** San Jose State University's TechSat Payload will allow familiarization with these requirements
- **Status:** TechSat is to be launched in September 2012

Exo-Brake Verification

- **Problem:** Method needed to determine the payload position multiple times per orbit.
- **Solution:** Short Burst Data (SBD) Modem will allow for reliable position transmission
- **Status:** Developing software and integrating with various hardware systems, such as GPS. Various test flight opportunities on TechSat, Orbital's Antares Launch, and Idaho's high altitude balloon flights.

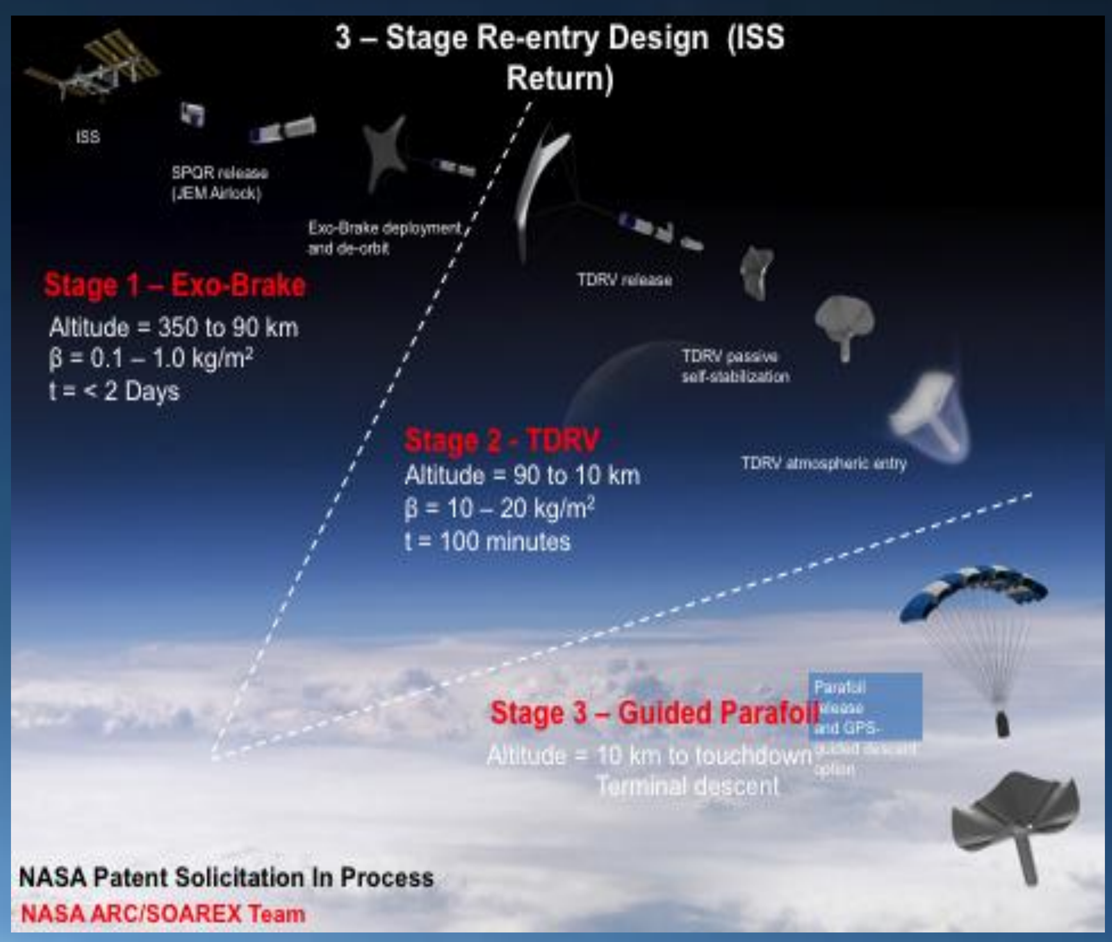
Accurate Payload Delivery to Earth's Surface

- **Problem:** Method needed to deliver ISS payload to a particular location on Earth's surface
- **Solution:** Snowflake, the GPS guided parafoil, will deliver the payload to a particular location.
- **Status:** Developed system has been deployed at altitudes up to 50,000 feet via balloons and UAV's.

Small Payload Quick Return (SPQR)

Concept to deliver a payload from the International Space Station (ISS) to the surface of Earth in an accurate and reliable manner.

1. ISS Deployment
2. Exo-Brake de-orbits SPQR in ~40 orbits
3. Tube Deployed Reentry Vehicle (TDRV) release
4. TDRV Stabilization and atmospheric entry
5. Snowflake system deploys ~100,000 feet
6. GPS Guided Snowflake delivers payload to desired location



Short Burst Data (SBD) Modem

Specifications

- 340 byte downlink, 270 byte uplink
- Satellite Network provides 100% coverage of Earth's surface
- Orbital Flights
  - Expect 2 hours of coverage at 400km
    - 2 MB / day data transfer rate

Flight Opportunities

Idaho High Altitude Balloon Flights

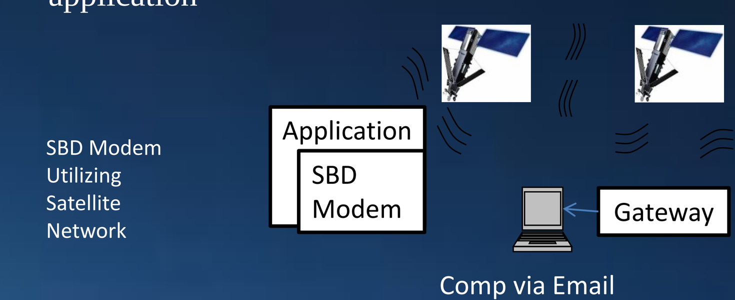
- Flown Fall 2011 and Spring 2012
  - Altitudes up to 90,000 feet
  - Successfully demonstrated uplink/downlink capability

Orbital Science's Antares Launch

- Wallops Flight Facility Launch in August 2012
- Verify modem operation in space

San Jose State University TechSat Payload

- ISS Deployment in September 2012
- Aim to demonstrate modem in an orbital application



Snowflake GPS Guided Parafoil

About Snowflake:

- Adapted by Joshua Benton and Marc Murbach of NASA Ames for use in the SPQR system
- GPS guided parafoil system, capable of delivering a payload to a particular location.

How it works:

- GPS system determines its location and heading with help from an IMU
- On board algorithm decides which direction Snowflake should head in
- Two servo motors can pull each side of the parafoil to steer the system.

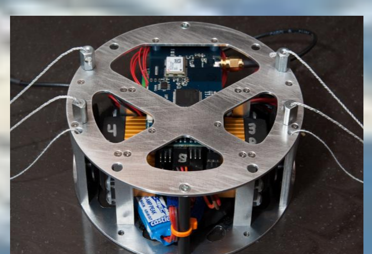
Flight Opportunities

UAV Drops

- Many drops from 5,000 feet and below
- Used to verify steering algorithms before high altitude drops

Idaho High Altitude Balloon Flights

- Flown five times from Fall 2010 to Spring 2012
  - Dropped from altitudes of 25,000 feet to 50,000 feet
  - Parafoil deployment and thermal issues have skewed promising results
  - Another attempt takes place Fall 2012



Snowflake Steering and Control System
Image Courtesy of Joshua Benton

Snowflake Upon Balloon Launch Recovery
Image Courtesy of Joshua Benton

Idaho RISE Spring 2012 Balloon Flight

SBD Modem

- Flown on Idaho high altitude balloon to a height of 80,000 feet
- Received 70% of packets transmitted
- 100% commands uplinked during flight (20 / 20)
  - Demonstrated ability to command a cut down of Snowflake
  - Demonstrated ability to change modem transmission rates and turn off system
- Exposed to -10 deg C, 0.08 atm

Snowflake:

- Cut away from balloon at 50,000 feet
- Parafoil maintained stability at high altitudes
  - Had been issue in the past
- Lack of thermal insulation caused electronic and servo motor failure
  - Steering algorithm and system maneuverability at high altitudes could not be analyzed
  - Mounted cameras did not detect audible noise coming from the servo motors, incomplete data log was recorded
  - At 2,500 feet, Snowflake warmed up enough to begin steering towards the desired landing target

Balloon & Snowflake Flight Path

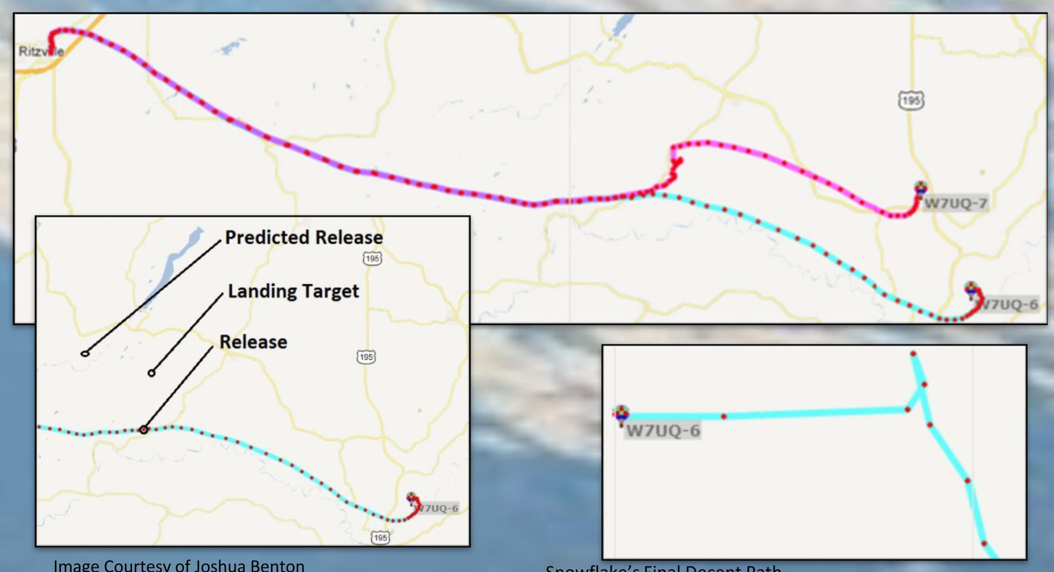
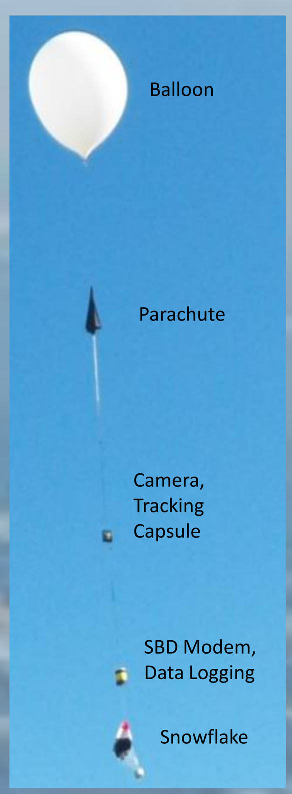


Image Courtesy of Joshua Benton

Snowflake's Final Decent Path

Video Camera mounted on Snowflake showing Parafoil inflated immediately after cut away from the balloon train
Image Courtesy of Joshua Benton



Goals

Current: Continue Component Development

- Prove Snowflake accuracy and viability
- Determine reliance of SBD modem
- Develop and test Exo-brake

Future: ISS Deployment

- Deploy complete SPQR payload from the ISS

Long-Term: Planetary Deployment

- Obtain space for a SPQR payload on a mission passing near planetary bodies
- Deliver a Nano-Sat payload to the surface of a planet, with special emphasis on Mars

Mars
Image Courtesy of NASA

SPQR Attributes

SPQR System

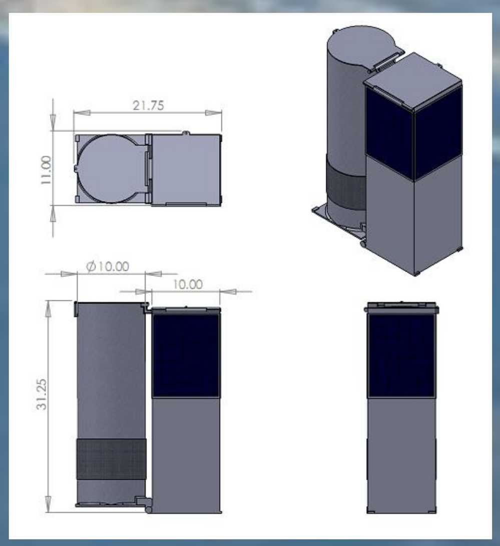
- 25.4 cm x 50.8 cm x 76.2 cm

Payload Delivery System

- Deliver 4.6L (3U cube) payloads
- Temperature control to -4 deg C

Payload Examples

- Scientific Experiments, such as Biological
- Items requiring a timely delivery
- NanoSats to planetary surfaces



Units in inches; Image Courtesy of Marcus Murbach

Summary

The SPQR concept has many components in development, most of which have given students a hands on learning opportunity, and even the chance to deal with flight hardware. SPQR aims to one day deliver 3U payloads from the ISS, and ultimately deliver a NanoSat payload to the surface of Mars

Interested?

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