ADEPT Sounding Rocket One (SR-1)

Flight Experiment Overview

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2017 IEEE Aerospace Conference

Big Sky, MT

Track 2: Space Missions, Systems, and Architectures

Session 2.03 Systems and Technologies for Landing on Planets, the Moon, Earth and Small Bodies

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What is this talk about?

My goal is for you to walk away with an understanding of the ADEPT technology, overview of the SR-1 flight experiment, SR-1 system description and capabilities, development test summary, and longer term mission infusion.

Presentation Outline

- ADEPT Technology overview
- SR-1 Flight Experiment Con-Ops
- Flight Experiment Success Criteria
- SR-1 Subsystem Description
- Risk-based Development Testing Approach
- ADEPT technology infusion options
ADEPT is a novel Entry, Descent, and Landing (EDL) architecture enabled with multi-layer, flexible woven carbon fabric

- Stowed at launch and deploys prior to atmosphere entry
- Serves as both heat shield and primary structure

Venus Mission Concept
6m ADEPT delivery of 1mT Payload

1. Approach
2. Deploy days prior to entry
3. Separation from spacecraft
4. Atmosphere entry
5. Peak heating (250 W/cm²)
6. Pilot chute
7. Subsonic chute deploy
Deployment reliability

Ejection from primary spacecraft

Fabric System Stowage

Pre-Entry orientation

Supersonic Aerostability

Exo-atmospheric Deploy

Mission end-to-end Demo

Fabric System

Component Structural Loads

Tension maintenance under load

Fabric edge buzz/flutter (Dynamic FSI)

Thermo-structural loads

Peak heat rate

Shear pressure

FSI

Tech Maturation for Mission Infusion

Shape Knowledge

Gore Deflection (Static FSI)

System-Level Arc Jet (SPRITE.C)

Aeroloads test (FY15)

7x10 Wind-tunnel test (FY15)

SR-1 Sounding Rocket Flight Test (FY17-18)

SR-1 Sounding Rocket Flight Experiment

- Demonstrating exo-atmospheric deployment and supersonic stability
- Aggressive schedule -> 1 year between PDR and Launch!
- Launch in late CY 2017

GCD approved (Aug 2016) SR-1 Sounding Rocket Flight Experiment

National Aeronautics and Space Administration
SR-1 Flight Experiment Overview

Launch
UP Aerospace SR
T = 0.0min

Spaceport America
Truth or Consequences, NM

Ascent
High spin rate

Stowed ADEPT Separates from Rocket

Booster Separation

Yo-Yo De-spin Lower spin rate

ADEPT Deployment Altitude ~ 100 km
T = 1.6 min

Peak Mach Number
Mach 3 (~70 km)
(No significant heating)

Ground Impact
Impact speed: 25 m/s
No parachute
T = 15 min
On-board data stored on SD card

White Sands Missile Range, NM

ADEPT Subsonic
Mach 0.8
T = 6 min

ADEPT stored in rocket fairing
SR-1 Animation movie
ADEPT SR-1 Flight Experiment

Key Performance Parameters and Success Criteria

**KPP-SR1-1: Exo-atmospheric deployment to an entry configuration**

**Project Goal:** Full, locked deployment before reaching 80 km altitude on descent, to 70° forebody cone angle

**KPP-SR1-2: Aerodynamic stability without active control**

**Project Goal:** Does not tumble before ground impact;

**SR-1 Flight Test Success Criteria**

A. ADEPT separates from the sounding rocket prior to apogee
B. ADEPT does not re-contact any part of the launch vehicle after separation
C. ADEPT reaches an apogee greater than 100 km.
D. ADEPT achieves fully deployed and locked configuration prior to reaching 80 km altitude on descent
E. Obtain video of deployed ADEPT to observe fabric response and flight dynamics during entry
F. Obtain data necessary to reconstruct ADEPT 6 DOF descent trajectory

- Data Sources to Verify Success Criteria
  - On-board data (Avionics data and GoPro camera) stored for post-launch recovery
  - White Sands Missile Range (WSMR) ground tracking data
SR-1 Layout and Subsystems

Deployment mechanism

Ribs

Struts

Carbon fabric “skirt”

Sliding Electronics Carriage:
- Avionics
- C-band Transponder
- Battery Pack
- GoPro Camera

Spot Trace

GPS patch antenna

Late access connectors

ADEPT SR-1: Flight Experiment Overview
SR-1 Electronics Carriage

GoPro Camera
- Hero 3
- Data (µSD)

Affordable Vehicle Avionics (AVA)
- IMU
- Accelometers
- GPS
- Data (µSD)

EPS Board
- Power regulation and distribution
- Simple events timing
- LED event indicator

Battery Pack (Behind Transponder)
- Panasonic Li-Ion Cells
- Size 18650
- Qty 6

C-Band Transponder
- TTC 520-XPDR
- 25W Unit

Electronics Carriage
- Supports on-board data collection and storage
- Supports Ground Tracking facilities
How SR-1 Data Sources will be Used

- **Primary IMU**
- **Backup IMU**
- **Magnetometer**
- **GPS Receiver**
- **GoPro® Camera on ADEPT**
- **C-Band Transponder**
- **Atmospheric Pressure and Temperature Measurement with Weather Balloon**
- **SPOT Trace® C-Band Transponder**
- **Ground Tracking Radar**
- **GoPro® Camera on Launch Vehicle Deployment Confirmation LED**
- **C-Band Transponder WSMR Ground Tracking Stations**

**Use: Trajectory reconstruction for dynamic stability assessment and FF-CFD simulation validation**

**Use: Confirm full and locked deployment**

**Use: Locate SR-1 after ground impact**

**Electronics Carriage**
- SD cards must survive ~ 25 m/s (54 mph) impact velocity!
Shock Testing of SD Cards (Drop Testing to Assess Impact Survival)

- Drop test location allows matching of flight article impact velocity
- Drop test configuration allows controlled impact testing of impact attenuator and SR-1 electronics carriage
Shock Testing of SD Cards
(Drop Testing to Assess Impact Survival)
Summary

• **ADEPT SR-1**
  - “First step” Flight experiment demonstrating ADEPT

• **Looking beyond SR-1**...
  - Small spacecraft by using an ADEPT EDL system to overcome volume limits
  - Secondary payloads to Venus, Mars, and LEO entry are feasible near-term applications
  - Nano-ADEPT provides technology development extensible to large ADEPT applications