ADEPT Sounding Rocket One (SR-1)

Flight Experiment Overview

Paul Wercinski
NASA Ames Research Center
Moffett Field, CA


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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
Adaptable Deployable Entry and Placement Technology (ADEPT)

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
Technology Maturation Strategy

- GCD approved (Aug 2016) 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
SR-1 Flight Experiment Overview

Launch
UP Aerospace SR
T = 0.0min

Spaceport America
Truth or Consequences, NM

Ascent
High spin rate

Yo-Yo De-spin
Lower spin rate

Booster Separation

Stowed ADEPT Separates from Rocket

ADEPT stored in rocket fairing

ADEPT Deployment
Altitude ~ 100 km
T = 1.6 min

White Sands Missile Range, NM

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

ADEPT Subsonic
Mach 0.8
T = 6 min

National Aeronautics and Space Administration
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

National Aeronautics and Space Administration

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

GoPro Camera
- Hero 3
- Data (µSD)

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

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

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

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

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

- **SPOT Trace® Ground Tracking Radar**: Use: Locate SR-1 after ground impact
- **Backup IMU**
- **Primary IMU**
- **Magnetometer**
- **GoPro® Camera on Launch Vehicle**: Deployment Confirmation LED
- **C-Band Transponder**
- **Atmospheric Pressure and Temperature Measurement with Weather Balloon**
- **GPS Receiver**
- **GoPro® Camera on ADEPT**
- **C-Band Transponder**
- **Ground Tracking Radar**
- **WSMR Ground Tracking Stations**

**Use Case**
- **C-Band Transponder**: USE: Confirm full and locked deployment
- **GoPro® Camera on ADEPT**: USE: Trajectory reconstruction for dynamic stability assessment and FF-CFD simulation validation
- **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

25 m/s

DROP PLATFORM
NFAC 80 x 120 INTAKE
LANDING ZONE

Electronics Carriage Simulator

~137 FEET (~25 m/sec)
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

1m ADEPT Mars Lander
Malin SSS Concept (2014)

1.5m Lifting ADEPT LEO Flight Test Concept
NASA Ames & JHU-APL Study (2016)

16m Lifting ADEPT Human Exploration