ADEPT SR-1
Development and Testing

International Planetary Probe Workshop 2018
Boulder, CO, June 2018
ADEPT SR-1 Flight Test: September 12th, 2018

Launch
UP Aero SR
T = 0.0min

Spaceport America
Truth or Consequences, NM

Ascent
High spin rate

Yo-Yo De-spin
Lowers spin rate

Stowed ADEPT Separates from Rocket

ADEPT Deployment
Altitude ~ 100 km
T = 1.6 min

Peak Mach Number
Mach 3 (~70 km)

Subsonic
Mach 0.8
T = 6 min

White Sands Missile Range, NM

Ground Impact
Impact speed: 25 m/s
No parachute
T = 15 min
Data stored on board

Key Performance Parameter 1: Exo-atmospheric deployment to an entry configuration

Key Performance Parameter 2: Demonstrate aerodynamic stability without active control
A Fast-Paced, Moderate-Risk Development Approach

- **Original approved timeline was 12 months from project approval (Aug 2016) to launch (Aug 2017):**
  - Original approved life cycle cost: $3.15M (all in)
  - There have since been three launch slips due to launch vehicle technical problems
  - Current launch date is September 12th, 2018 (~1 year delay)

- **Two nearly identical Nano-ADEPT SR-1 units have been assembled:**
  - FLIGHT unit and SPARE unit
  - SPARE unit was used to flesh out procedures prior to running them on FLIGHT unit
  - SPARE unit provides a backup re-fly option in case something unexpected happens to FLIGHT unit during launch

- **Extra time due to launch delays has been used to reduce technical risk:**
  - Increased margin on deployment force
  - System-level rate gyro and accelerometer calibrations
  - Additional mission simulation testing to keep fresh on procedures
System Integration and Testing Timeline

- Mechanical Subsystem Integration
- Random Vibe
- Electrical Subsystem Integration

- Mass Properties Measurement
- Long Duration Storage Test

- Deployment Test
- System-Level Sensor Calibration

- Combined Systems Test
- Nano-ADEPT SR-1 Flight Test

- Simulated Mission Test
Mechanical Subsystem

- Four-layer 3D Woven Carbon Fabric
- Rib Tips
- Ribs
- Retention Cord Loops
- Push-off Springs
- Retention Cord
- Rails
- Moving Ring
- Latches
- Impact Attenuation Foam
- Second-Stage Springs
- First-Stage Springs
- Struts

International Planetary Probe Workshop 2018, Boulder, CO, USA
Electrical Subsystem and Operations

- GPS antenna
- SPOT Trace®
- Late Access Connectors / GSE Interface
- Connectors / GSE Interface
- Burn Wires
- Electrical Power System Board
- LED Board (Health Monitoring)
- AVA (IMU + Magnetometer + GPS Receiver)
- Backup IMU
- Battery Pack
- GoPro Hero 3®
- Full Deployment Indicator Switch
- C-Band Antenna
- Launch Vehicle Separation Sensors

- Blue: System turned on prior to launch
- Green: System turned on at sensed separation
Subsystem Developmental Tests

Target $\chi_{\text{COM}}/D = 0.150$
FLIGHT unit as-built $\chi_{\text{COM}}/D = 0.147$
Supersonic $\beta \sim 20 \text{ kg/m}^2$
Entry mass = 11.1 kg
Ballast mass = 0.6 kg
Ballast adds $\sim 1 \text{ kg/m}^2$ to $\beta$ and $< 1 \text{ m/s}$ to impact velocity
Integrated System Tests

- Magnetometer Calibration
- Accelerometer Calibration
- Rate Gyro Calibration
- Deployment Testing
- System-Level Sensor Calibration
- Long Duration Storage Test
- Combined Systems Test
- Simulated Mission Test
- Random Vibe
- Mass Properties Measurement

August 9th, 2018
September 12, 2018

Nano-ADEPT SR-1 Flight Test
Conclusions & Future Work

• Mark your calendars: Launch is September 12th 2018

• Building two nearly identical units added value by reducing risk
  – A small increment of time was spent building and testing SPARE unit
    • SPARE unit was used to flesh out procedures prior to running them on FLIGHT unit
    • SPARE unit has degraded robustness compared to FLIGHT unit, but it could be prepared to fly relatively quickly
  – Approach worked well at this small scale where the components are relatively inexpensive and assembly quickly

• What’s next for Nano-ADEPT?
  – FY18-19 Study: Mission design for Venus aerocapture (single-event drag modulation). See related talks:
    • Adam Nelessen et al., “Drag Modulation Aerocapture for Smallsat Science Missions to Venus”
  – FY18-19 Study: Guidance and control architecture and prototype development. See talk:
    • Sarah D’Souza et al., “Pterodactyl: Integrated Control Design for Precision Targeting of Deployable Entry Vehicles”
  – FY18-19 Study: Mission design for lunar sample return applications
ADEPT: Adaptable Deployable Entry and Placement Technology

- ADEPT is a mechanically deployed entry system
  - Stows during launch and cruise (like an umbrella)
  - Serves as both heat shield and primary structure during EDL
  - Enabling technology: 3D-woven carbon fabric (tows in all three dimensions)

- Nano-ADEPT is the application of ADEPT for small spacecraft where volume is a limiting constraint
  - NanoSats, CubeSats, other secondary payloads, etc.

- Why Nano-ADEPT?
  - Give rise to novel applications for small spacecraft by offering an entry system less constrained by volume
  - Achieve rapid technology development extensible to large ADEPT applications
Nano-ADEPT Development Roadmap to TRL 5

- Strategy addresses technical challenges with four system-level tests
- Common geometric features between design reference missions (DRMs), ground tests, and flight test help provide ground-to-flight traceability

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Primary geometric features of deployment prototypes, subsonic aeroloads wind tunnel test articles, sounding rocket flight test, and some DRMs