Adaptable Deployable Entry & Placement Technology (ADEPT) Project Status

Briefing to New Frontier Technology Day Workshop

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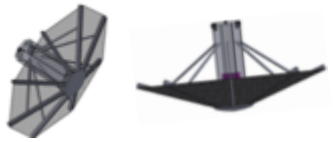
June 1, 2016

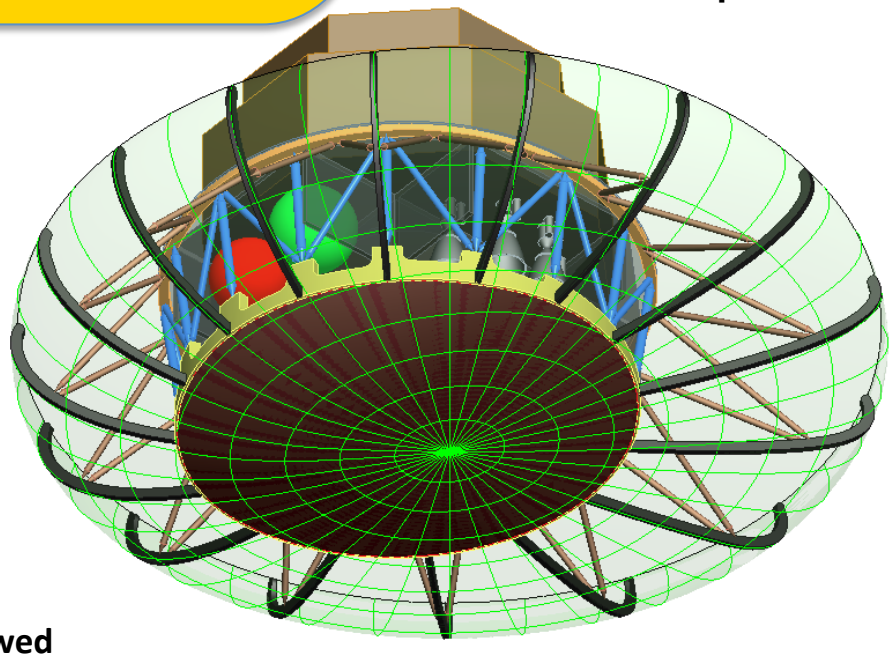
Adaptable, Deployable Entry and Placement Technology (ADEPT) Overview

- **ADEPT** is an atmospheric entry *architecture* for missions to most planetary bodies with atmospheres.
  - Current Technology development project funded under STMD Game Changing Development Program (FY12 start)
  - Stowed inside the launch vehicle shroud and deployed in space prior to entry.
  - Low ballistic coefficient (< 50 kg/m2) provides a benign deceleration and thermal environment to the payload.
  - High-temperature ribs support 3D woven carbon fabric to generate drag and withstand high heating.

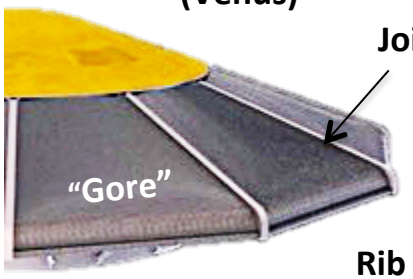
1m Nano-ADEPT (Mars)

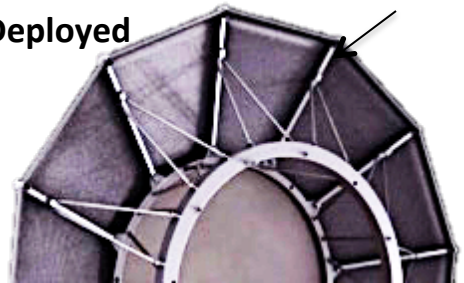


16m Lifting ADEPT Human Mars Exploration



6m ADEPT-VITaL (Venus)

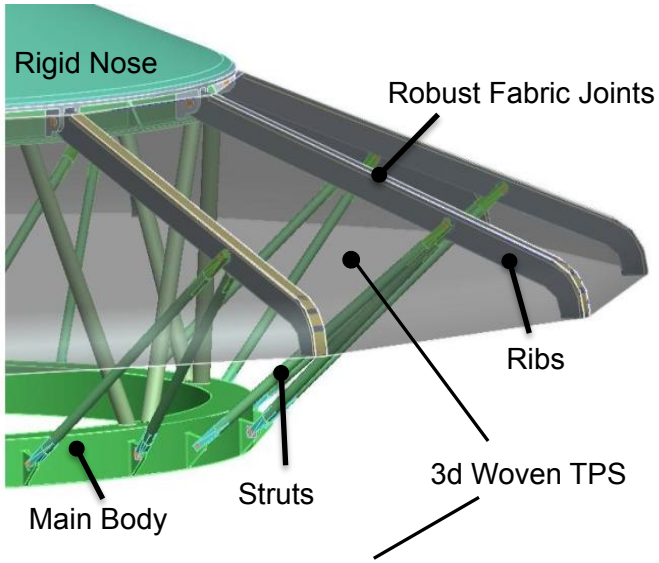


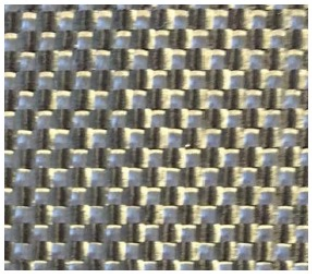


Stowed

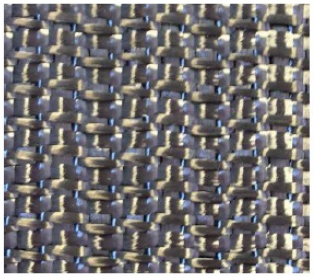
Adaptive Deployable Entry and Placement Technology (ADEPT)

Key ADEPT Components





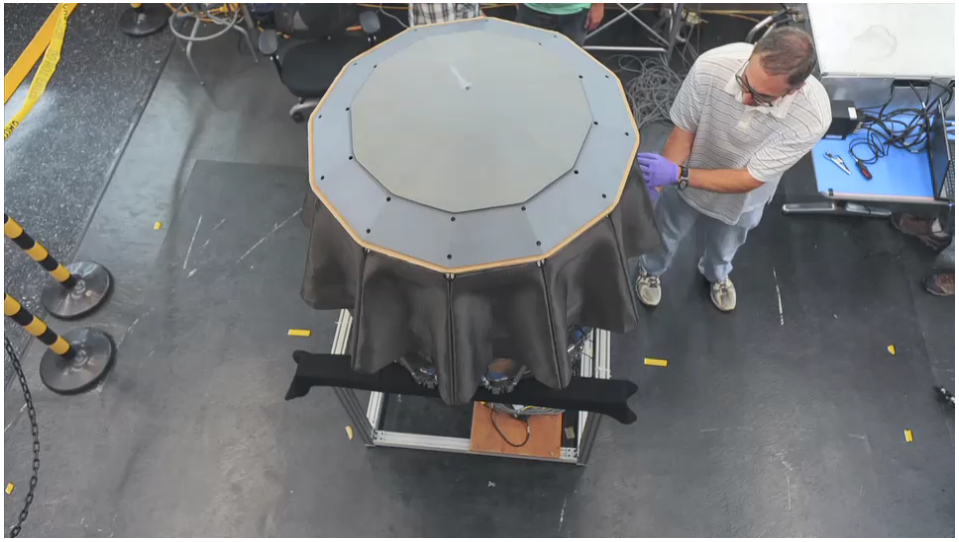
Front Surface- Plain Weave



Aft Surface- Ortho Weave

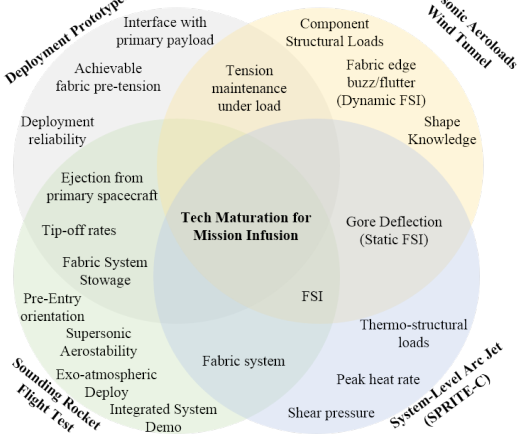
- **Develop and integrate technologies for a mechanically deployable decelerator for missions to Venus, Mars, and other destinations.**

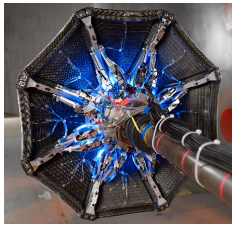
Deployment Prototype Time Lapse Video

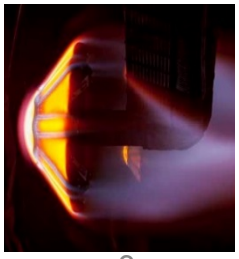


1 m Class Technical Maturation

See: B.P. Smith et al "Nano-ADEPT: An Entry System for Secondary Payloads" IEEE Aerospace Conf., 2015

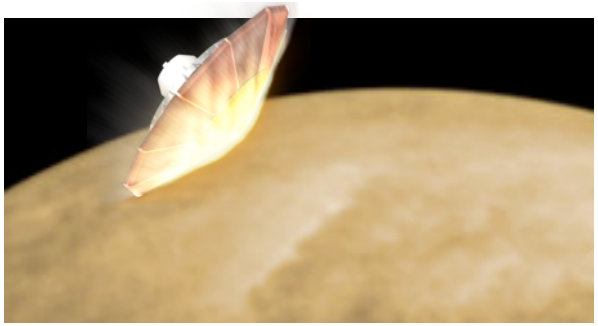






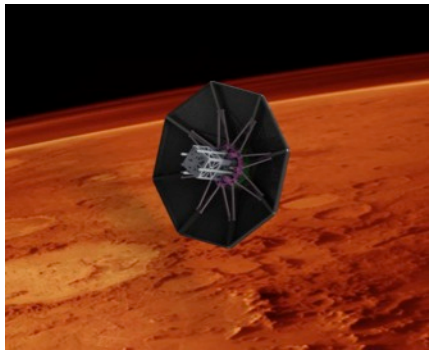
1m ADEPT Mission Infusion Examples

Venus



Science Pull:
- Delivery of In-situ atmosphere science instruments.
- Achieve low deceleration loads for sensitive instruments

Mars

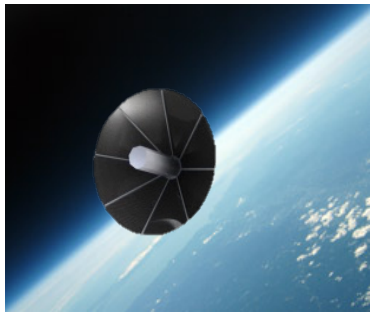


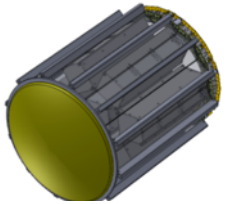
Science Pull:
- Global distribution, low cost
- Numerous landers

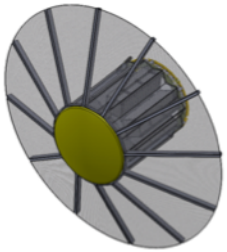
Dandelander (Malin SSS):
Cubesat distributed surface network concept

Earth

LEO Return: Secondary on Upper Stage, ISS Downmass or free-flyer on Super Strypi class LV

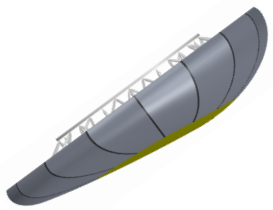






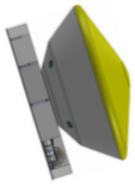
-De-orbit Capability
-22 N thruster incorporated with green propellant
-6 ea, 3U slots for subsystems or payloads

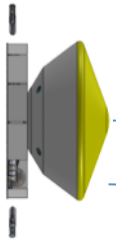
Titan



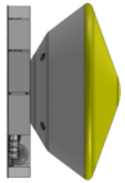
ADEPT 1m Mission Infusion Example: Mars Secondary Payload Network Landers

Interplanetary Cruise Phase:
~ 9 Months

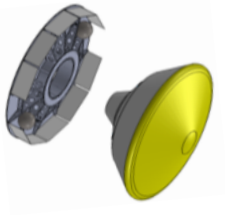




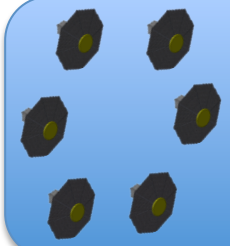
Secondary Payload Deployment Phase:
Up to 8 Secondary ADEPT landers sequentially deployed after last TCM, no sooner than 1 week from entry interface



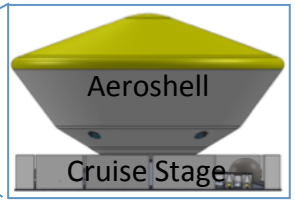
MSL Release from Cruise Stage

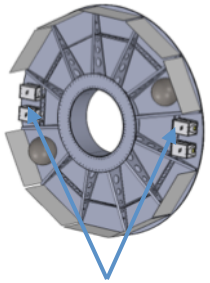


MSL EDL

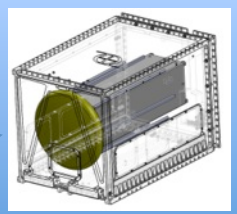


Nano ADEPT Network Entry:
Ballistic Entry, β=5-50 kg/m^2
Peak heating: 40-110 W/cm^2
Heat Load: 1-4 kJ/cm^2
Peak Decel: 16-21 g
Terminal Velocity: 40-90 m/sec



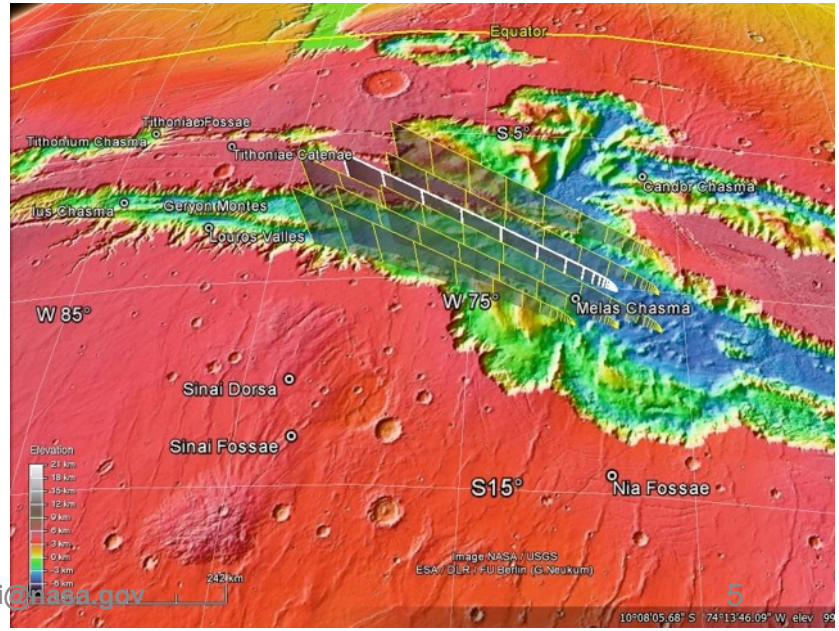


Cruise Stage Sep System Placement



Concept of sub m class ADEPT contained inside 12U Sep System

Launch
Atlas V 540

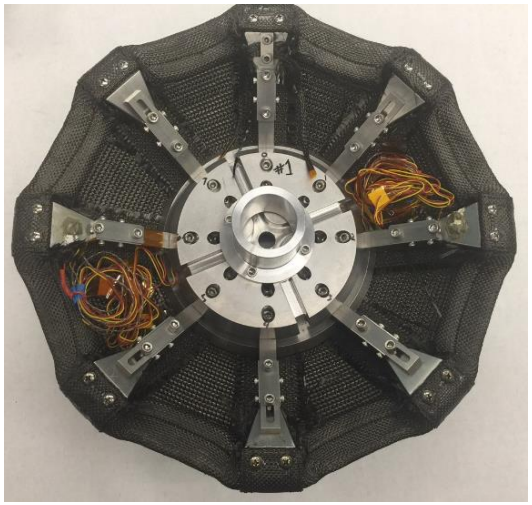


***Mission Concept from Malin Space Science Systems presented at CubeSat to Mars Workshop (CalTech Nov 20-21, 2014 https://marscubesatworkshop.jpl.nasa.gov)**

SPRITE-C Pathfinder Arcjet Test (2-day Test Completed Sept 29, 2015)

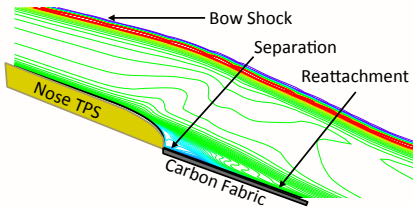
- **OBJECTIVE: Characterize response of system level design features under relevant aerothermal environments.**
  - Utilize flight-like interface designs (*Nose/fabric, Nose/Joint, Joint/Rib, Trailing Edge Close-out*)
- **APPROACH: A relevant scale, 360 degree test article allows for testing of multiple design features**
  - Heavily instrumented 4 test articles
  - Mars entry relevant environments
    - Heating rates on fabric (40-80 W/cm^2)
- **IMPACT:**

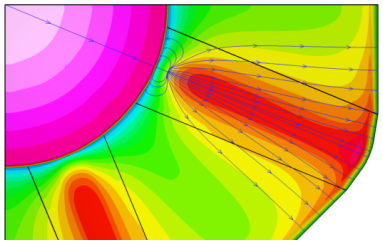
Embedded Instrumentation



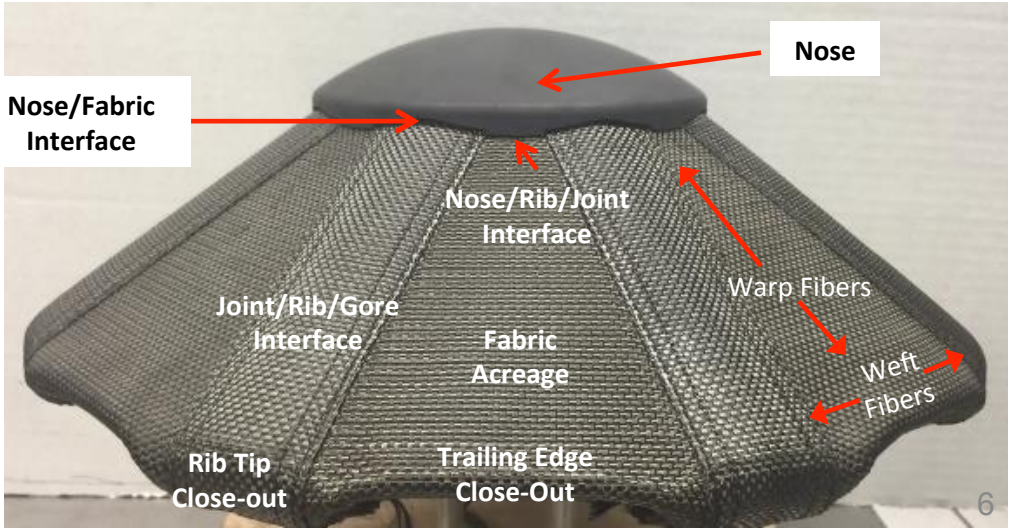
Achieves system-level aerothermal performance in relevant environments

FLOW FEATURES

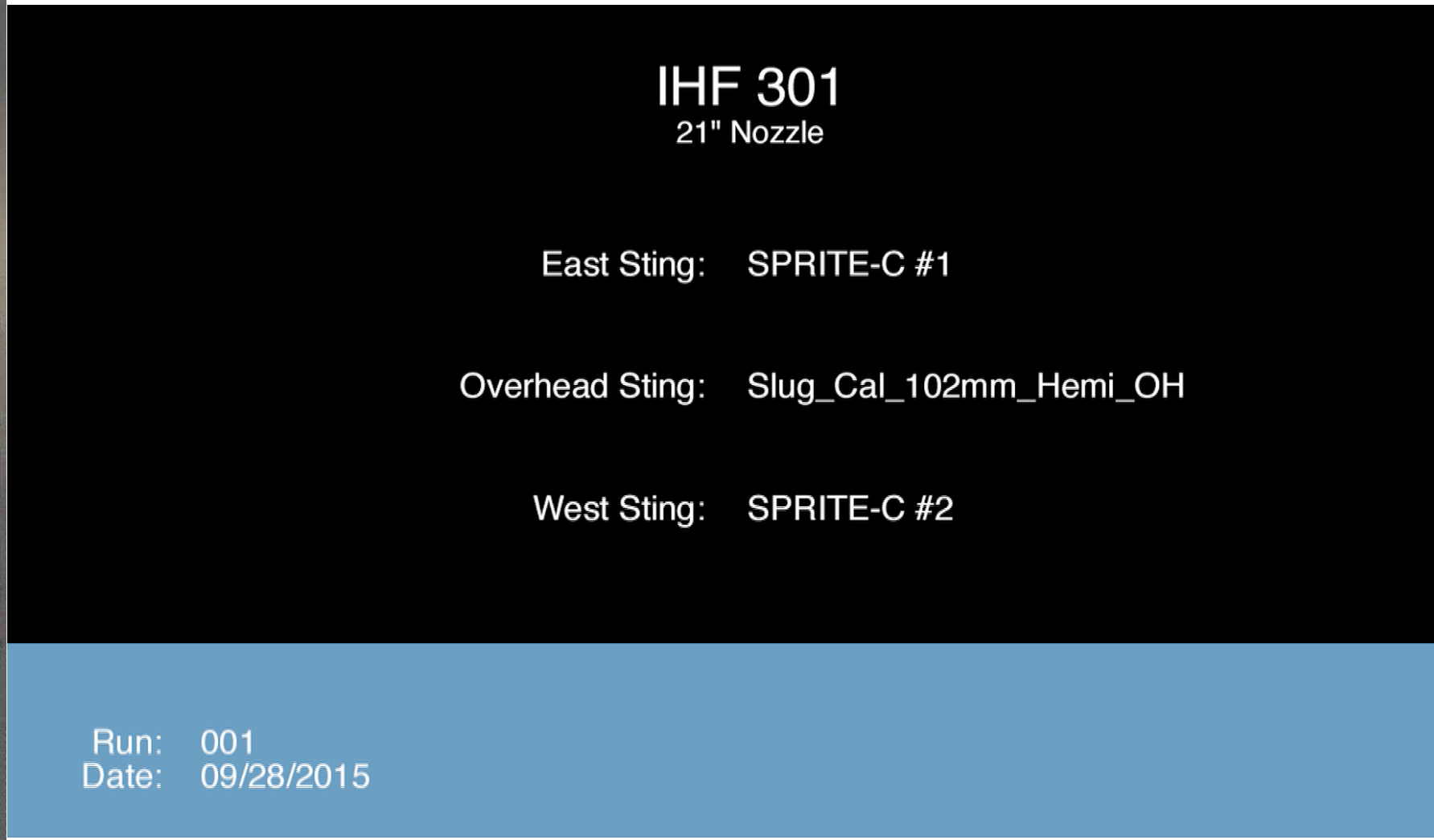




Streamlines & Heating Contours



SPRITE-C Pathfinder Test Article #2 Test Video (1st Pulse 40s duration)



ADEPT Project POC
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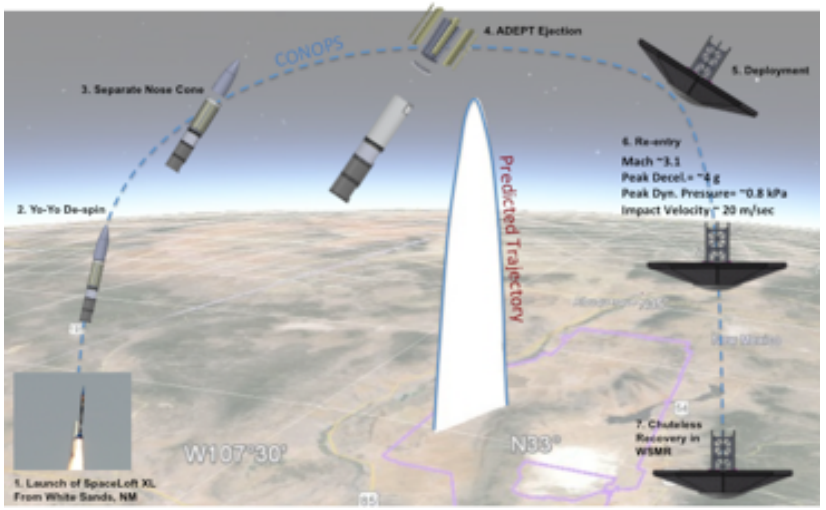
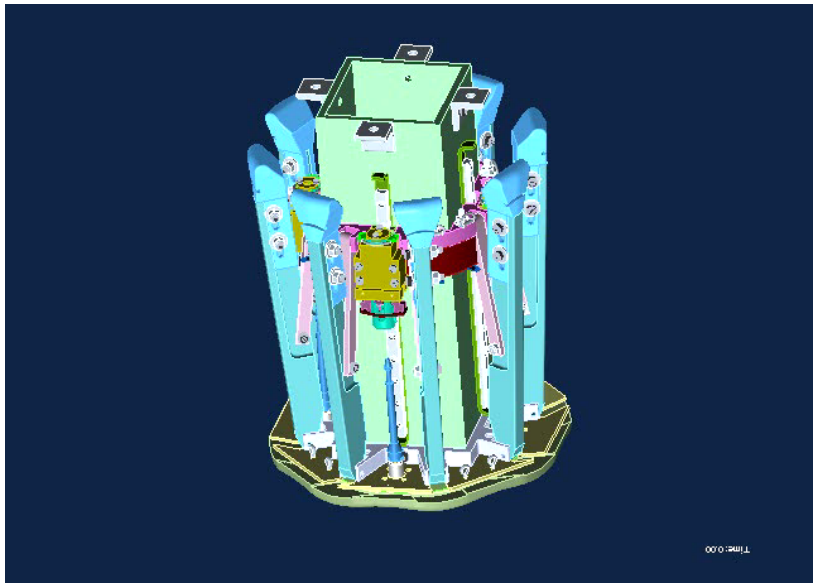
SR-1 Sounding Rocket (Mach 3) Flight Test (August 2017 Launch)

- **OBJECTIVE:**
  - Demonstrate launch vehicle separation and exo-atmospheric deployment.
  - Characterize aerodynamic performance from supersonic to subsonic flight regimes.
- **APPROACH:**
  - Demonstrate ADEPT 1 m class system flight performance. TAYF: FAYT
- **IMPACT:**
  - Demonstration of realistic end-to-end flight test for ADEPT configuration.
  - Technology First! Demonstration of 70° open-back blunt body (8 sided pyramid) flight from supersonic to subsonic
  - Critical first step in integrated flight hardware experience for ADEPT scaling to larger configurations and with lifting capability





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Summary

- ADEPT brings **High Value** return on technical development progress under limited budgets.
- Clear demonstration of multiple **STMD Programs working together** to achieve technology maturation success: GCD, SSTP, FO, SBIR
- System level testing in Arcjets and with Sounding Rocket using common configuration – Huge Challenge for EDL!
  - SPRITE arcjet testing of scaled ADEPT configuration (ablating nose, ribs, gores with joints, and trailing edge)
  - SR Flight will address exo-atmospheric deploy with flight relevant hardware and aero stability through critical supersonic-transonic flight regime
- ADEPT is a candidate EDL Architecture for Human Mars Exploration
- Continued Investment including SR-1 will Enable:
  - Highly visible, flight test experience advances confidence and **reduces implementation risk for ADEPT entry architecture**
  - Characterization and experience using 'real hardware' performance applied to larger scale ADEPT applications
  - SR-1 Flight test is key step to subsequent ADEPT demonstration of **guided lifting flight**

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