



Mary Poppin's Approach to Human Mars Mission Entry, Descent and Landing



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Ames 75th Anniversary Director's Colloquium
2014 Summer Series

ACKNOWLEDGEMENTS

- Efforts that are focused towards addressing long term challenges require a whole community of people.
 - ❑ EDL experts at NASA Centers (Ames, Langley, Johnson, Goddard), JPL and APL
 - ❑ Funding for large effort needs NASA HQ. STMD, SMD and HEOMD.
 - ❑ Facilities – Arc-jets and Wind-tunnels at Ames and JSC
 - ❑ Technology Partners – Bally Ribbon Mills and Thin Red Line
- ADEPT Project Leadership:
 - ❑ Paul Wercinski, Peter Gage, James Arnold, Dinesh Prabhu, Keith Peterson, Ken Hamm, Bryan Yount, Brandon Smith, Alan Cassell and numerous others at Ames.

GOLDEN AGE OF SPACE EXPLORATION 20TH CENTURY



Wright Brothers
Dec 17, 1903



JFK "To the Moon"
May 25, 1961



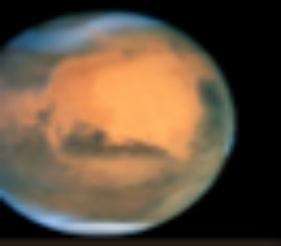
Apollo 11
July 20, 1969



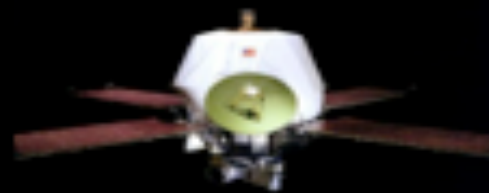
Space Shuttle
April 12, 1981



ISS
Nov. 20, 1998



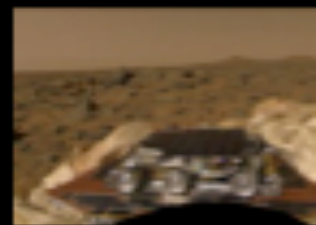
Mariner 9 Orbiter
Nov 14, 1971



Viking 1 Lander
July 20, 1976



Pathfinder Sojourner
July 4, 1997



21ST CENTURY ?



Shuttle Last Flight
July 8, 2011



Asteroid Redirect
~2020 ?



End of Station
~2025 ?



MERs
Jan 4, 2004
Jan 25, 2004



Phoenix
May 25, 2008



Curiosity/?
2012/2020



Human Mars Mission ~2035 ?



**HUMAN EXPLORATION
VISION AND PURPOSE
ARTICULATED**



Credit: NASA Website

REALIZING THE VISION ARTICULATED BY NASA LEADERSHIP

Expanding human presence in space and human Exploration of Mars

□ Faces considerable challenges:

- *Political, programmatic (budgetary included) and Technical.*

□ Technical Challenges:

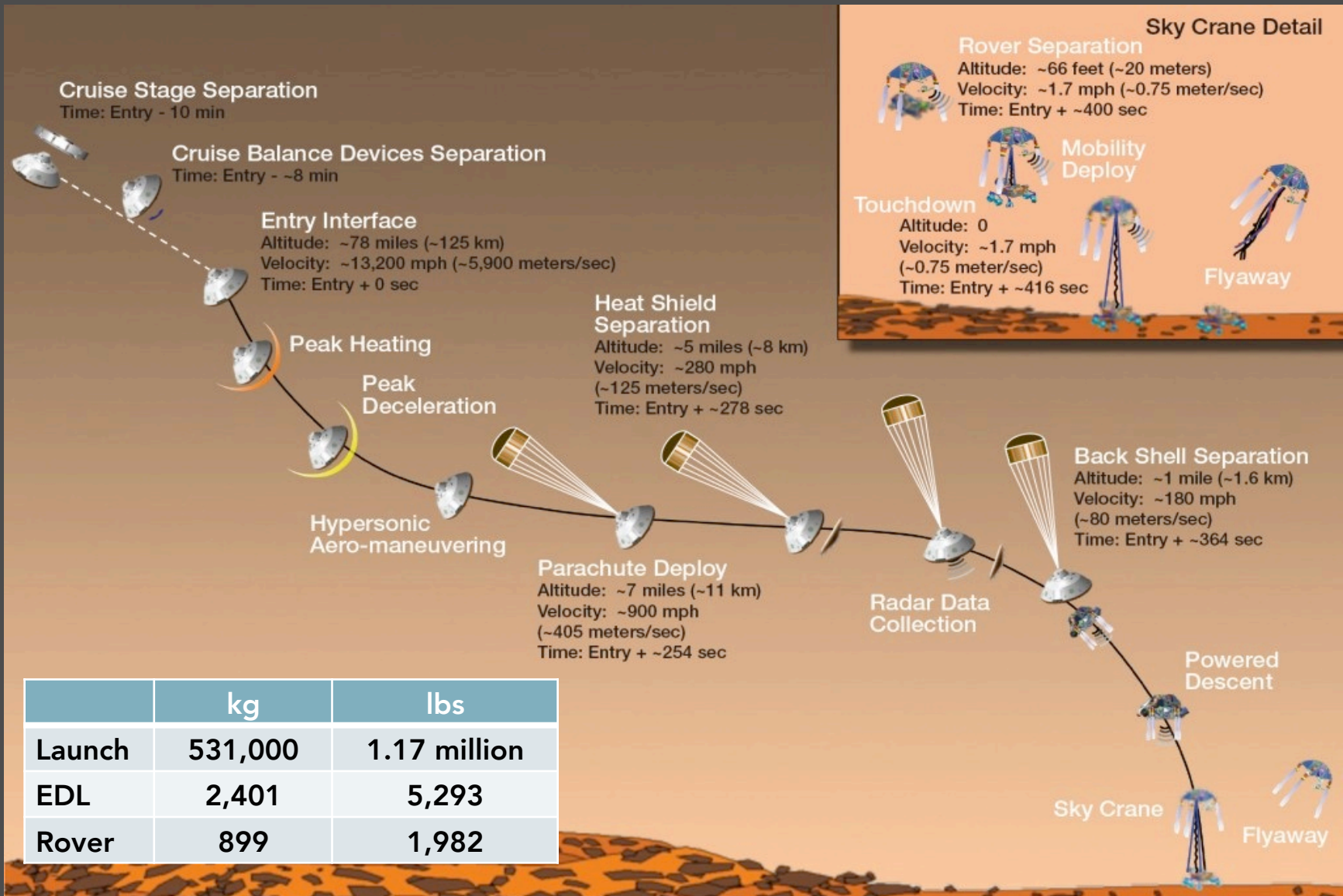
- *Multitude of areas such as Launch, interplanetary travel and the danger of space radiation to Astronauts, EDL, survival at the surface and safe Return to planet Earth.*
- *One critical area is:*
 - *Getting the human travelers safely through the atmosphere while slowing the vehicle and landing safely, either on to the surface of Mars or Earth.*

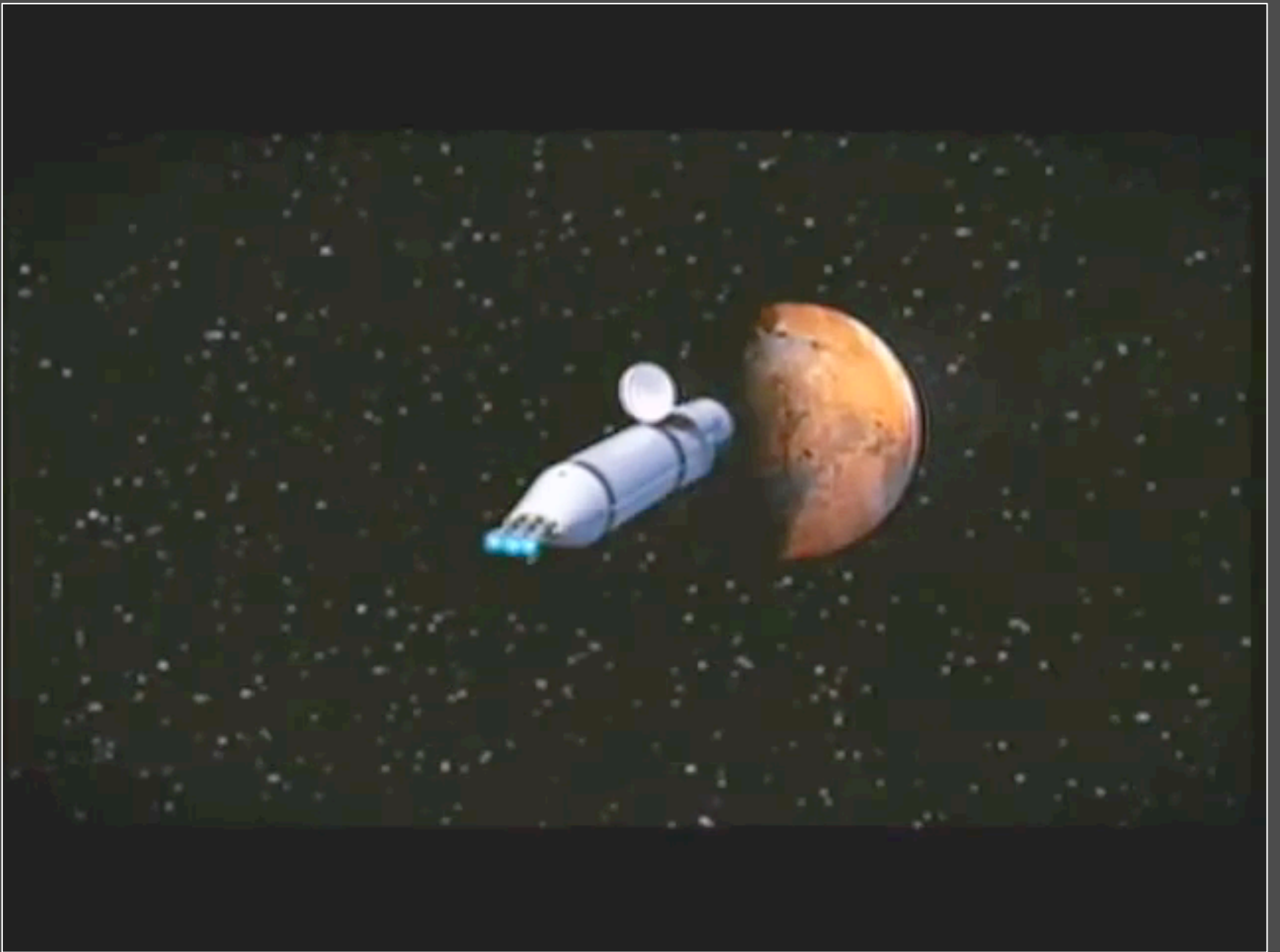
The Entry, Descent and Landing (EDL) for Human missions to Mars requires new and innovative technologies.

ENTRY, DESCENT AND LANDING

- We have perfected EDL on Earth
 - ❑ Apollo Capsule (1960's)
 - ◆ Basis for Orion or Multi Purpose Crew Vehicle (MPCV)
 - ❑ Space Shuttle Orbiter (1980's)
 - ◆ Lifting and guided entry
- U.S. is the only nation that has successfully landed on Mars
 - ❑ Multiple times
 - ❑ Currently exploring the surface of Mars – the only nation

MSL TIME-LINE





HUMAN MISSION TO MARS

Two big challenges: Getting there and coming back, safely.

- Getting to the surface of Mars safely and with precision
 - ❑ Humans are fragile – EDL has to be tailored for human survival
 - ❑ Human missions will require
 - ◆ ~40 mT of landed mass per launch
 - ◆ MSL landed mass of 899 kg required a launch mass of 531,00 kg

- Getting back to Earth from Mars
 - ❑ Orion derived capsule
 - ◆ Return velocity will be much higher than Lunar return
 - ◆ Thermal protection system for extreme entry

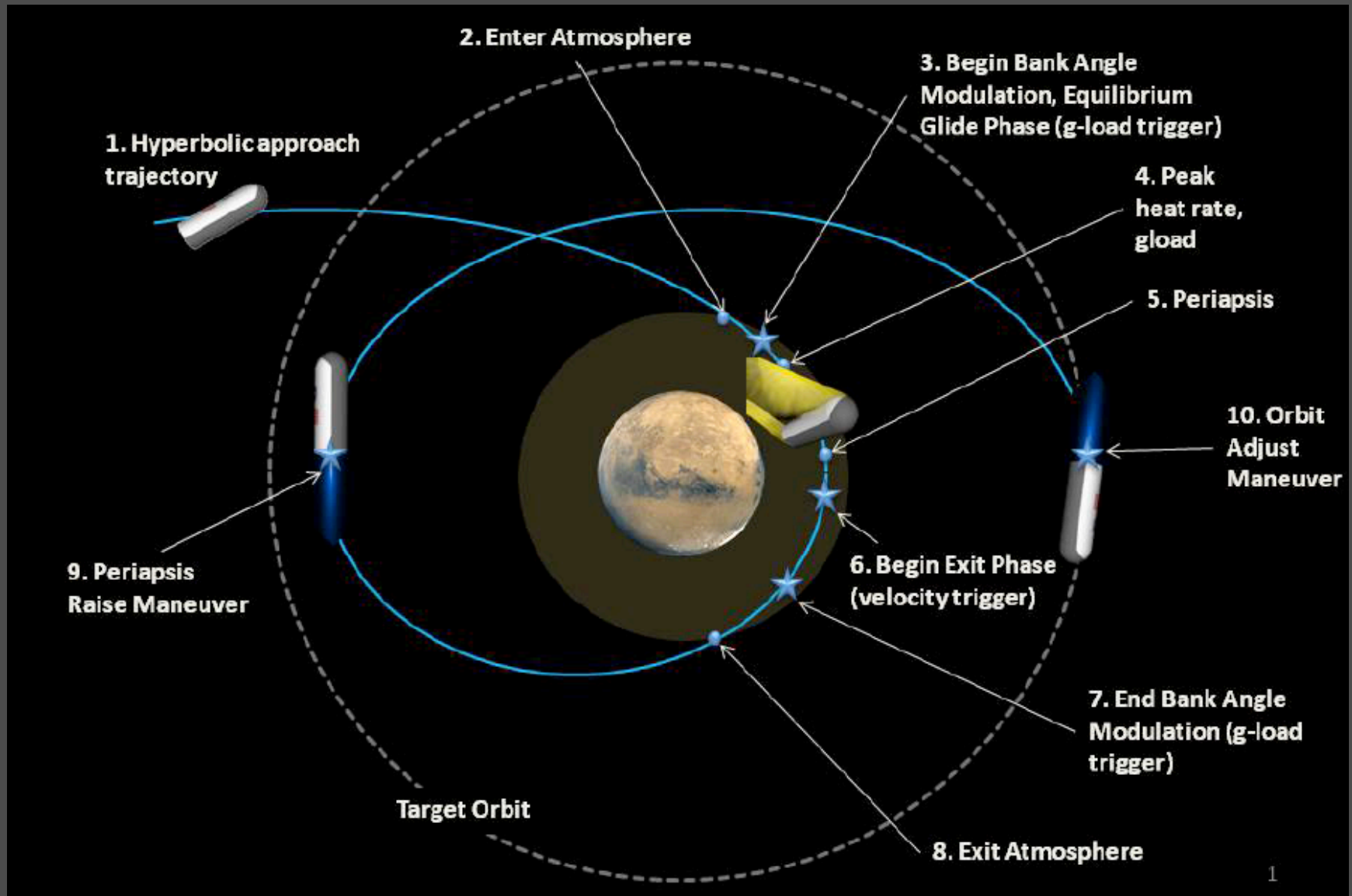
NASA, specifically NASA Ames, is working on both the challenges

- ❑ Mars Entry, Descent and Landing concept development
- ❑ Ablative thermal protection system for earth return

HIGH-LEVEL DESIREMENTS

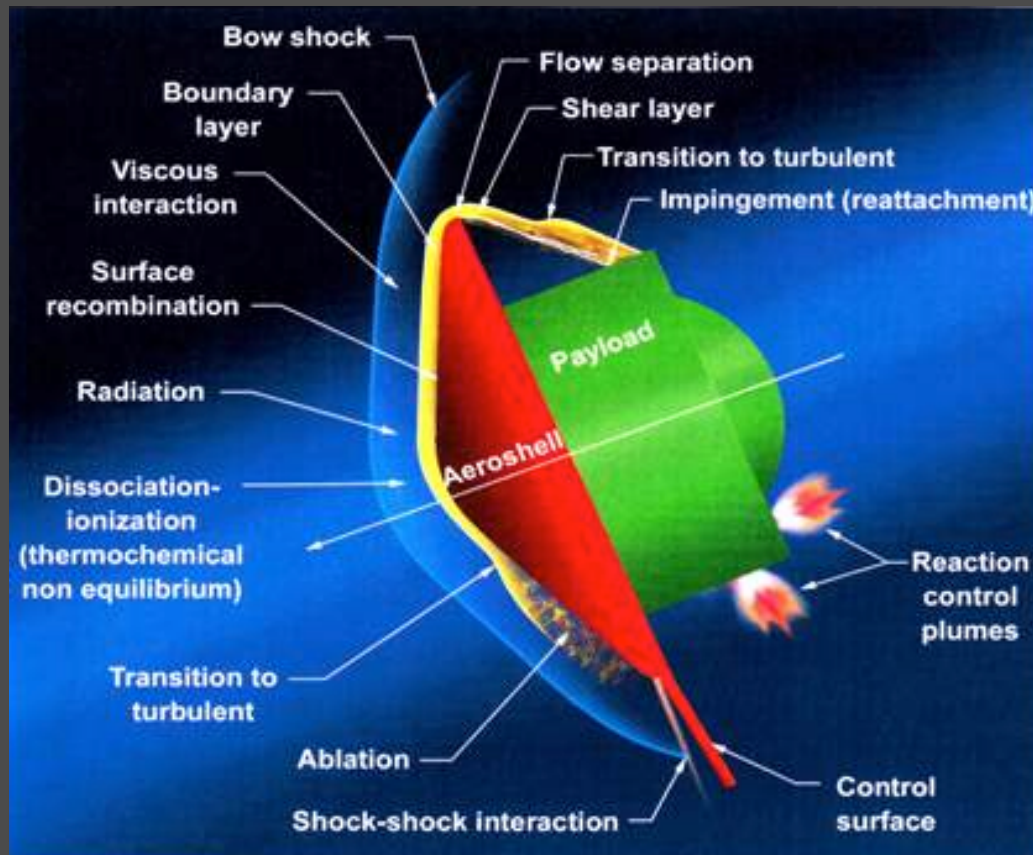
- Mass efficiency
 - ❑ A mass efficient EDL system for reduced cost and complexity of Launch
- Large drag EDL system
 - ❑ Mars requires large drag surface to slow down
- Pin-point landing
 - ❑ Precision in GN&C in all phases of EDL
- Operational Considerations
 - ❑ Aero-capture
 - ❑ Transitions – from Aerocapture to Entry to Descent and Landing
 - ❑ Heat-shield/aeroshell – Retain or Dispose?
- Risk Posture
 - ❑ Humans as cargo requires robustness
- Scale-ability

AEROCAPTURE - AN EXTENSION OF EDL MISSION SEGMENT



ENTRY PHYSICS

- Complex and our ability to predict has improved considerably
 - ❑ Computational simulations, ground test facilities, and flight data – needed and have played a role in our ability to design



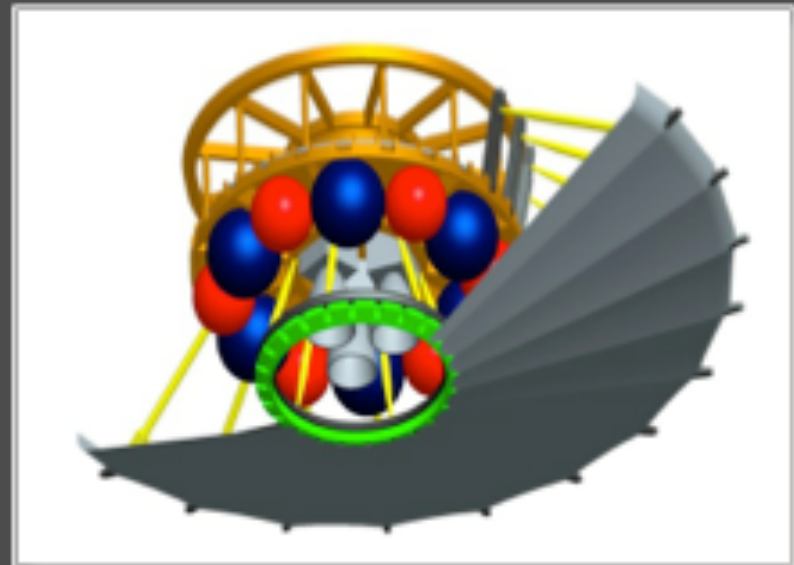
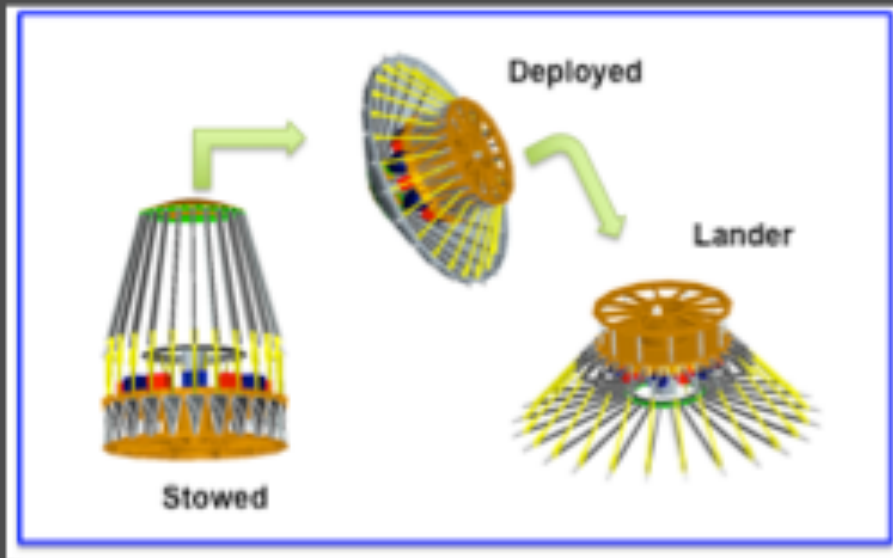
Credit: Brett Cruden

ADAPTIVE DEPLOYABLE ENTRY AND PLACEMENT TECHNOLOGY (ADEPT)

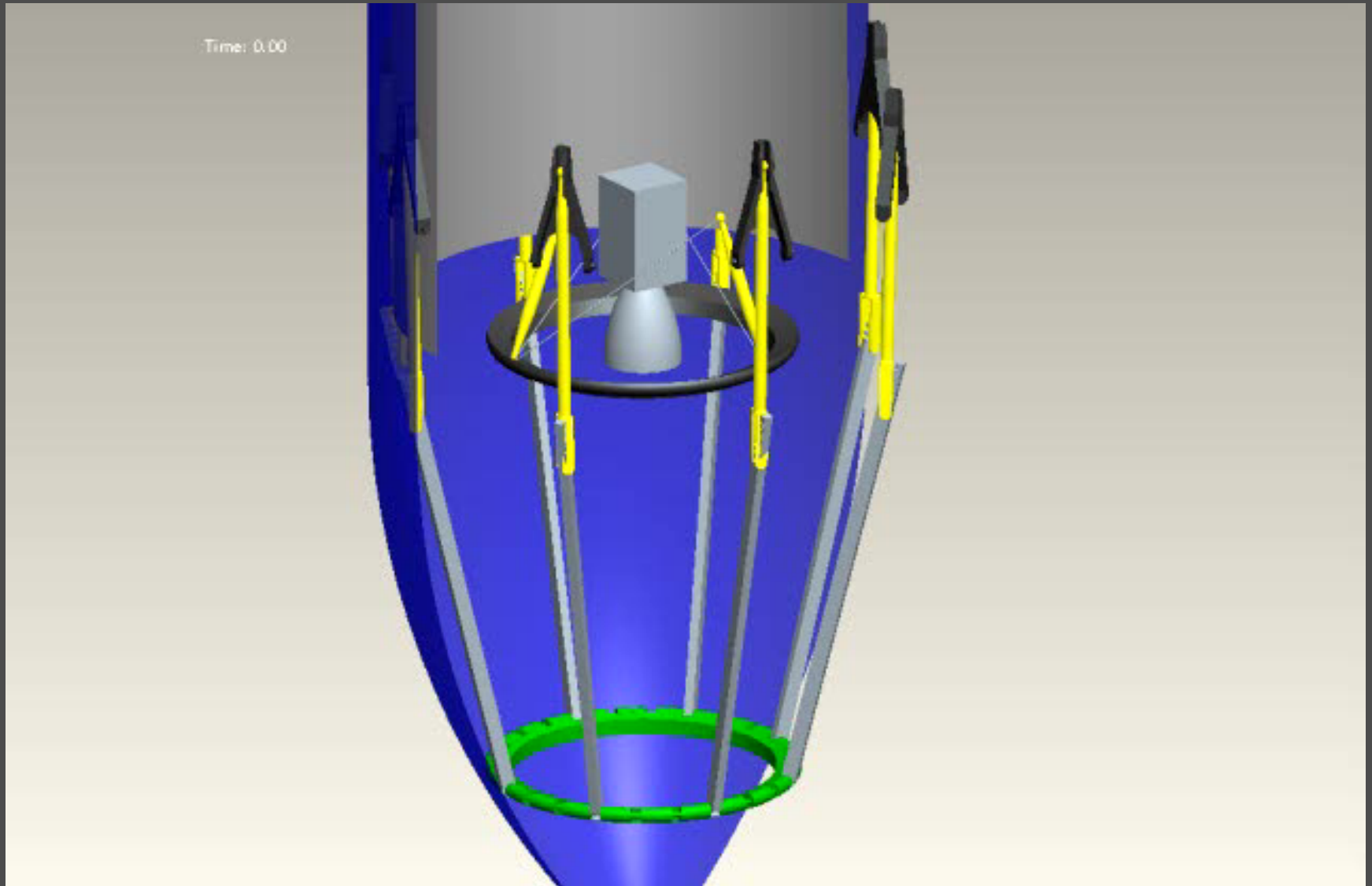


The mechanically deployable and transformable concept is similar to an umbrella but more complex functionally.

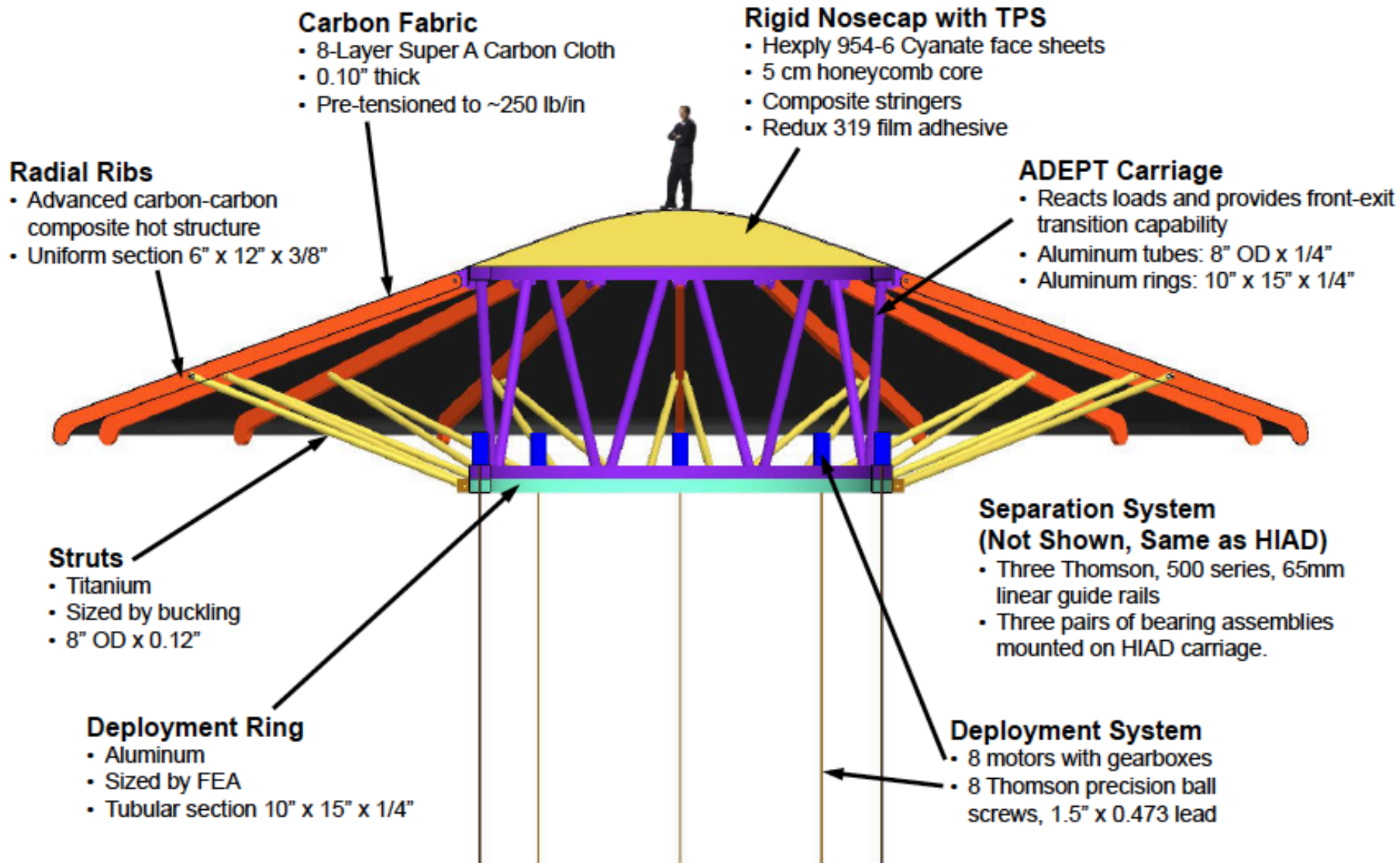
- ◆ A self-contained deployment system;
 - Deployable thermal protection and aerodynamic load bearing fabric system;
 - Deployable structure behind the that reacts to the primary aerodynamic load and provides a simple interface to the delivered payload;
- ◆ An ejectable nose heat shield for the retro-propulsion system function;
- ◆ A design that transforms the aeroshell into a lander configuration



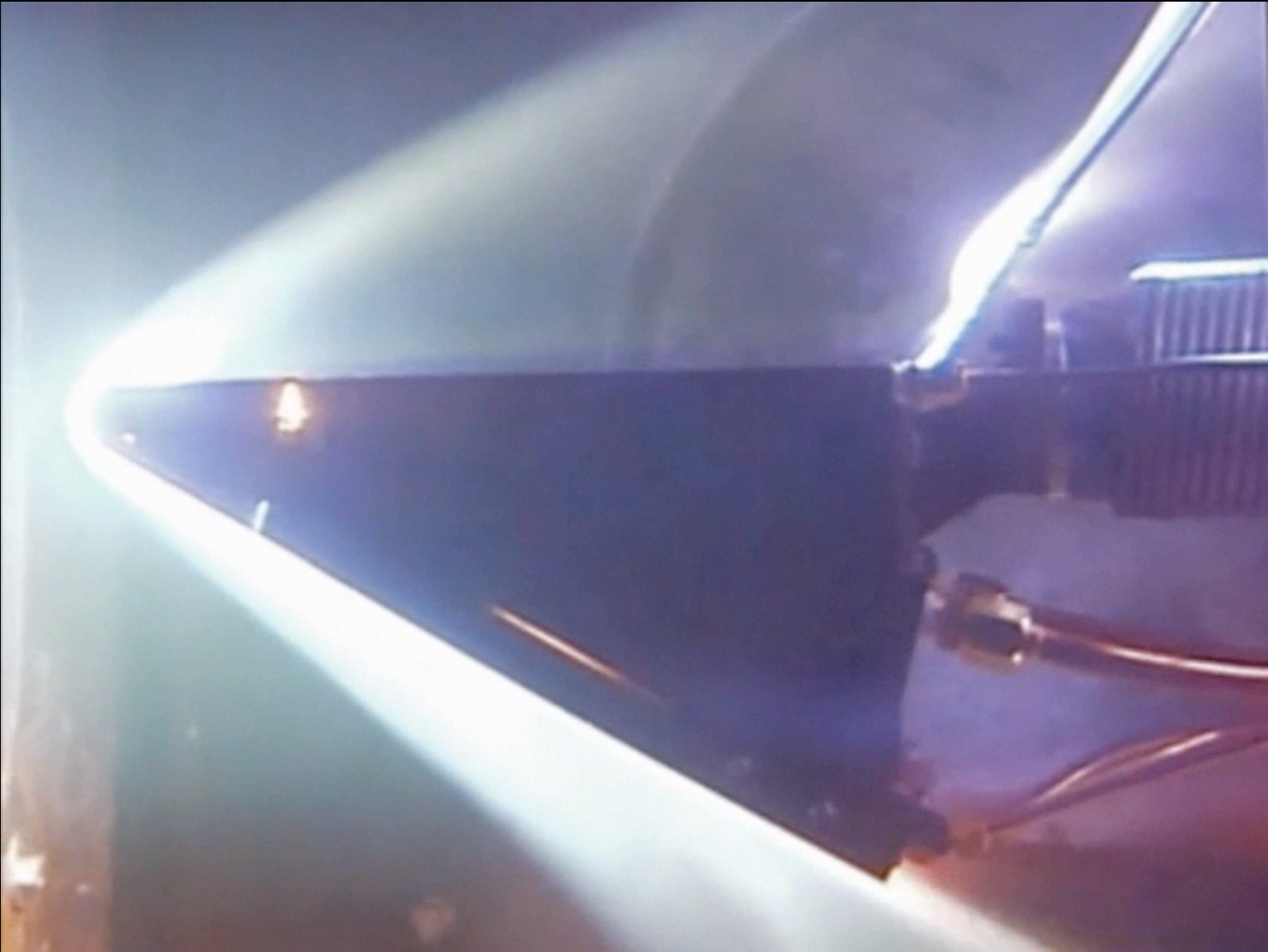
ADAPTIVE DEPLOYABLE ENTRY AND PLACEMENT TECHNOLOGY (ADEPT): DESIGNED TRANSFORMATIONS



ADEPT FOR HUMAN MARS MISSIONS

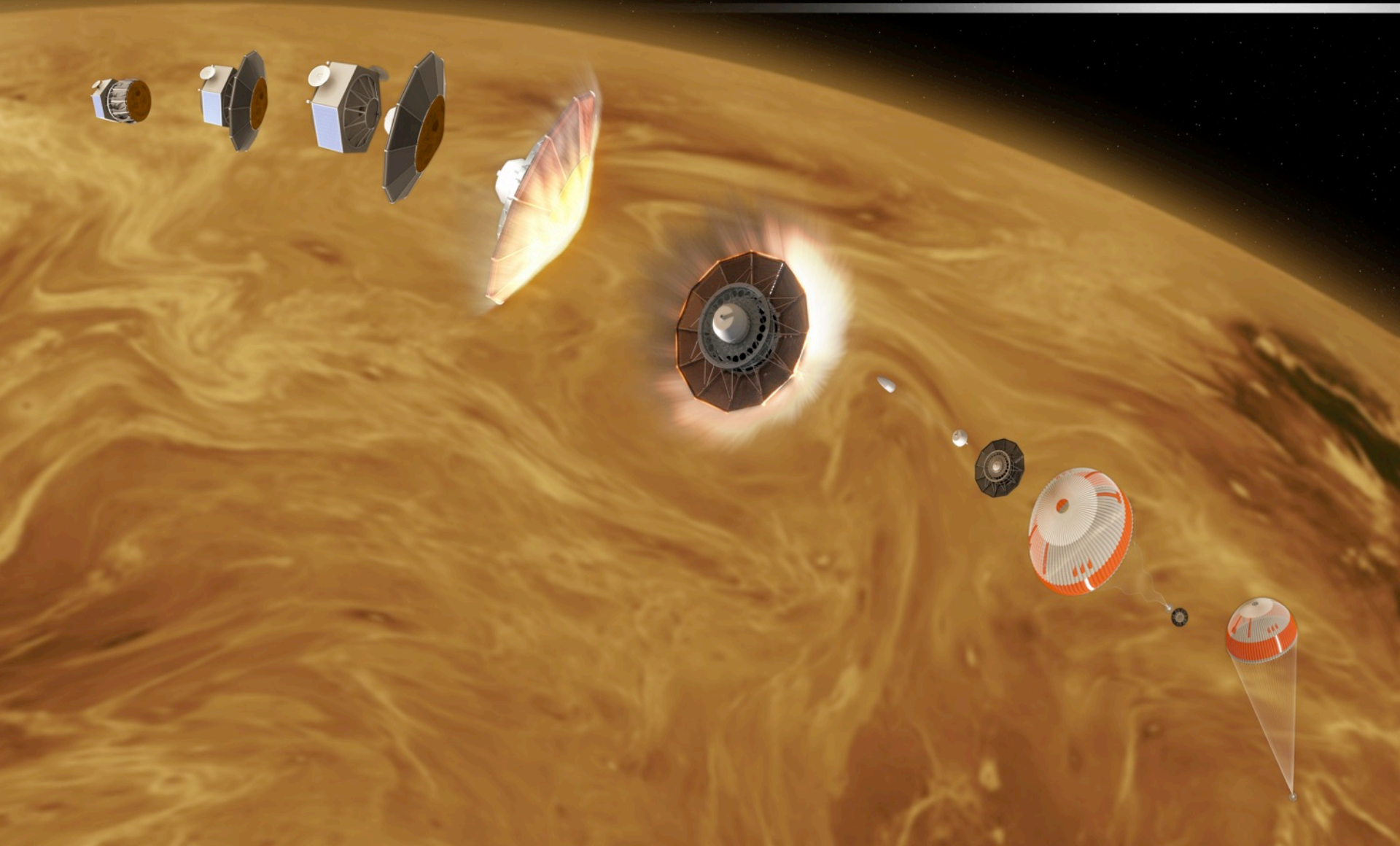


CARBON FABRIC TESTING AT VENUS RELEVANT CONDITIONS



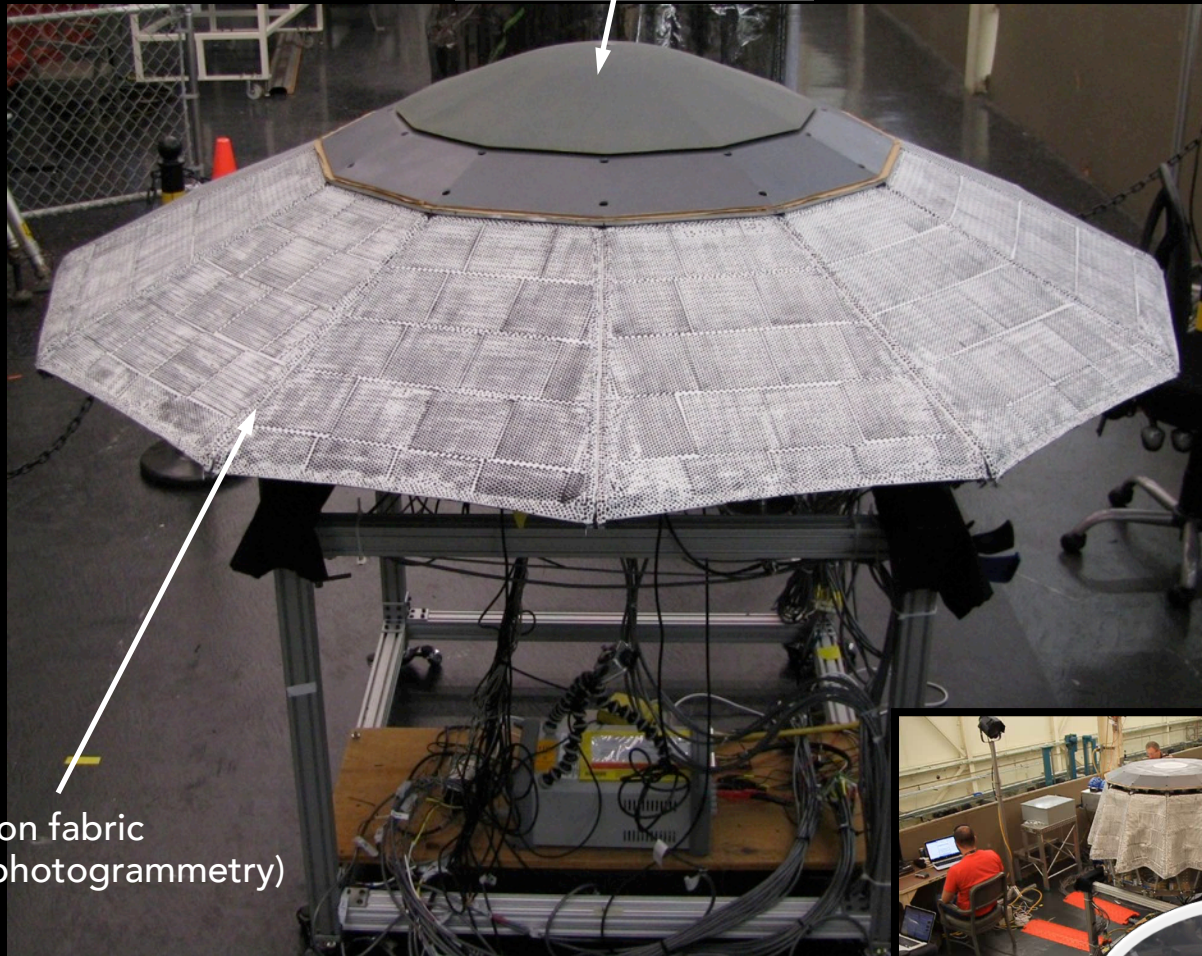
ADEPT

Adaptable, Deployable Entry and Placement Technology



2m GROUND TEST ARTICLE DESIGN, BUILD AND TESTING

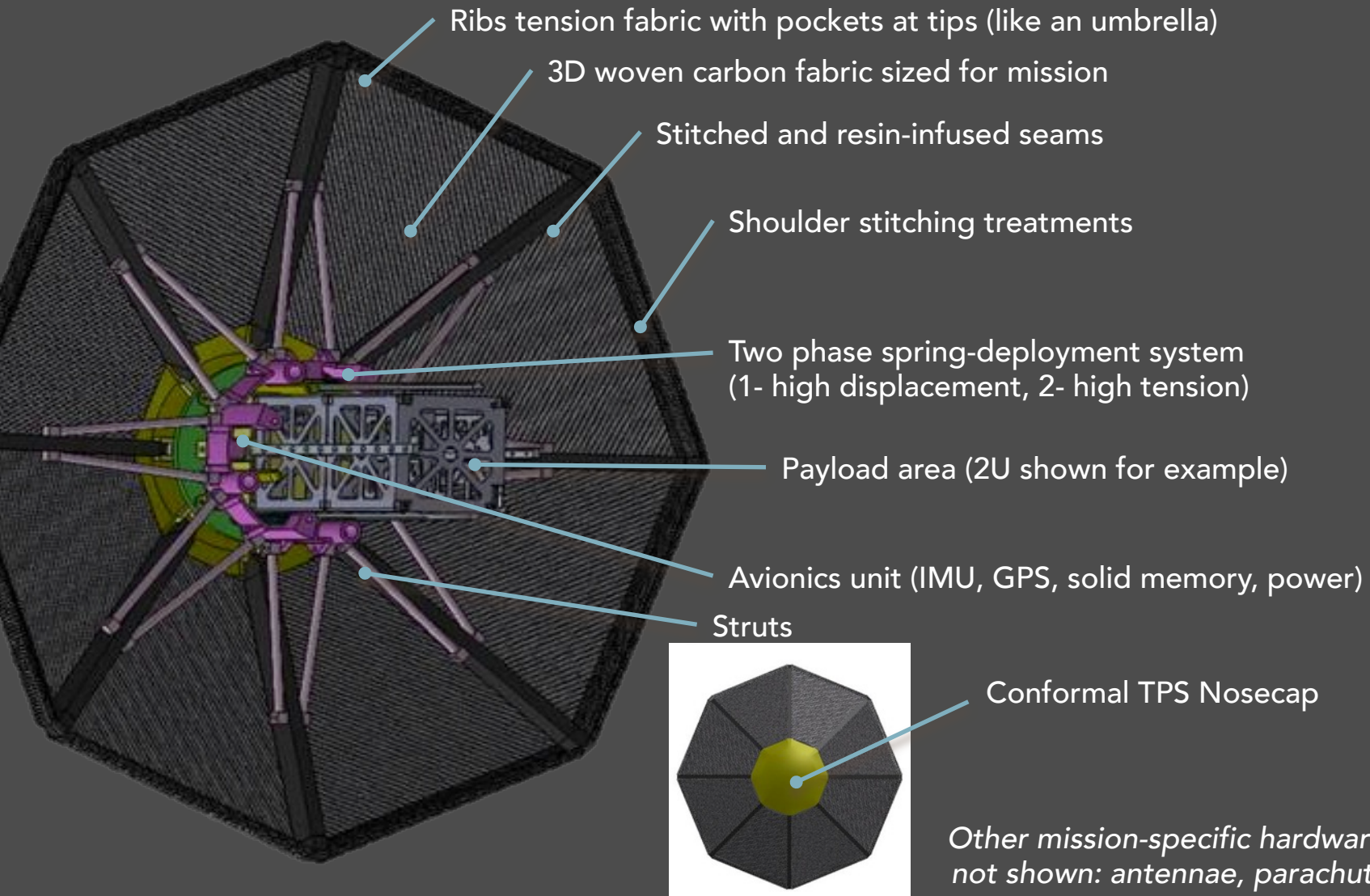
Rigid nose cap



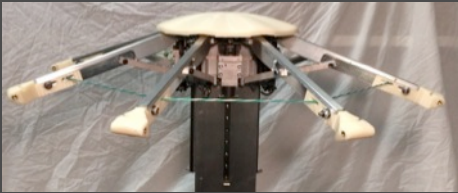
4 Layer carbon fabric
(painted for photogrammetry)



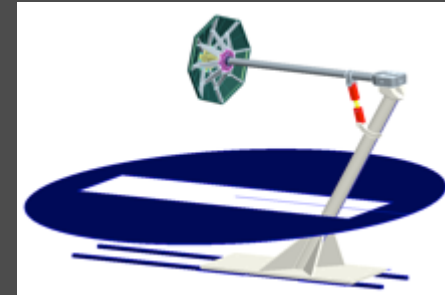
23 m (HUMAN MARS) - 6m VENUS TO - SUB 1m NANO-ADEPT



1m ADEPT Technology Maturation Approach FY15-16

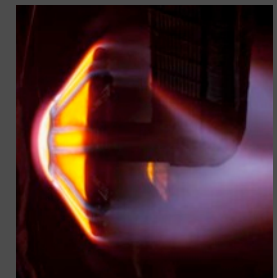


**Deployment
Prototype
Demonstration
(FY15)**

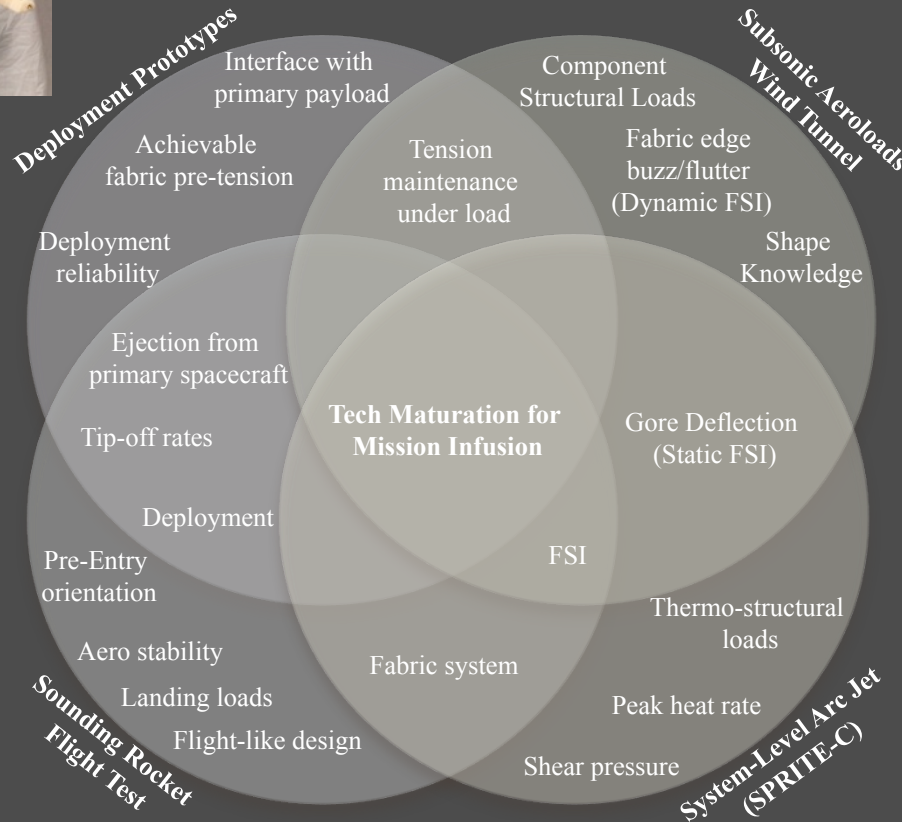


**7x10 Wind-tunnel
Aeroloads test
(FY15)**

**SPRITE C System
level Arc-jet
testing**

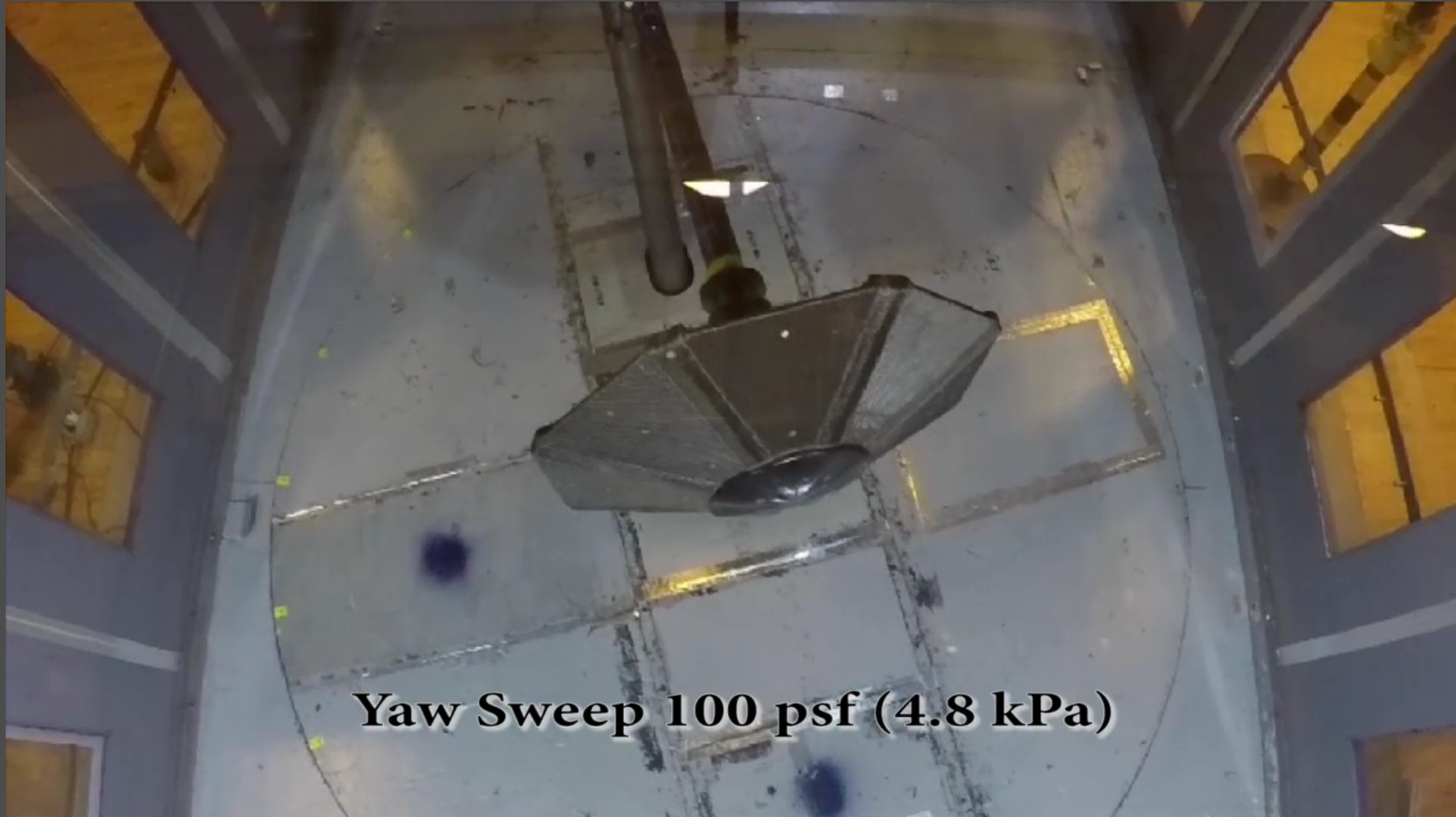


**Sounding Rocket
Flight Test**



Each test campaign provides system knowledge in more than one system attribute, and many system attributes are explored by more than one test.

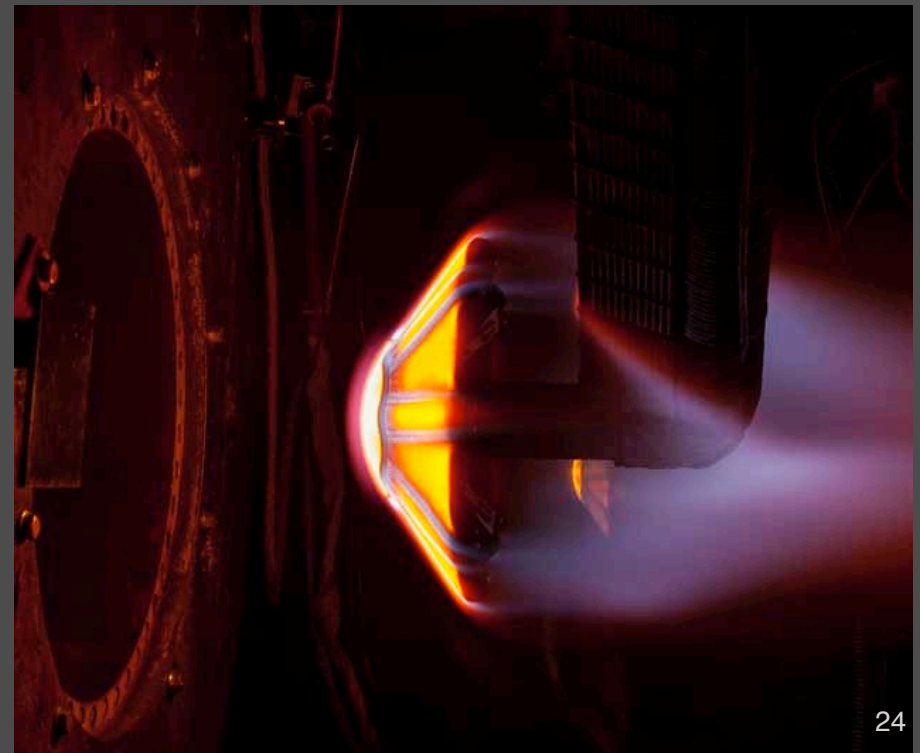
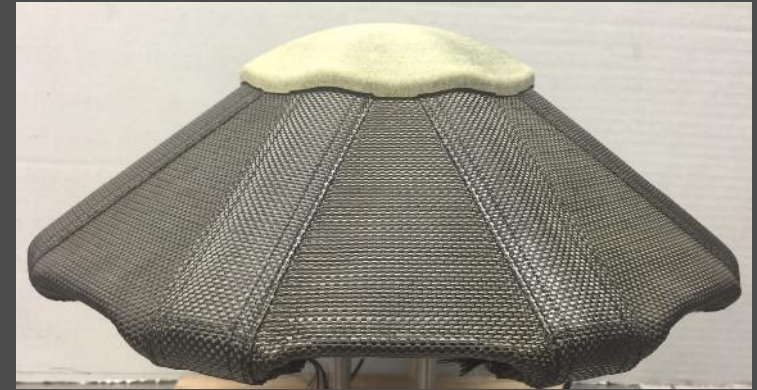
VIDEO HIGHLIGHTS FROM 7X10 TEST



Yaw Sweep 100 psf (4.8 kPa)

SPRITE-C Pathfinder Test Article #2

C-PICA Nose, 6 Layer, Phenolic Resin joint



SPRITE-C Pathfinder Test Article #2

Test Video (1st Pulse 40s duration)

IHF 301
21" Nozzle

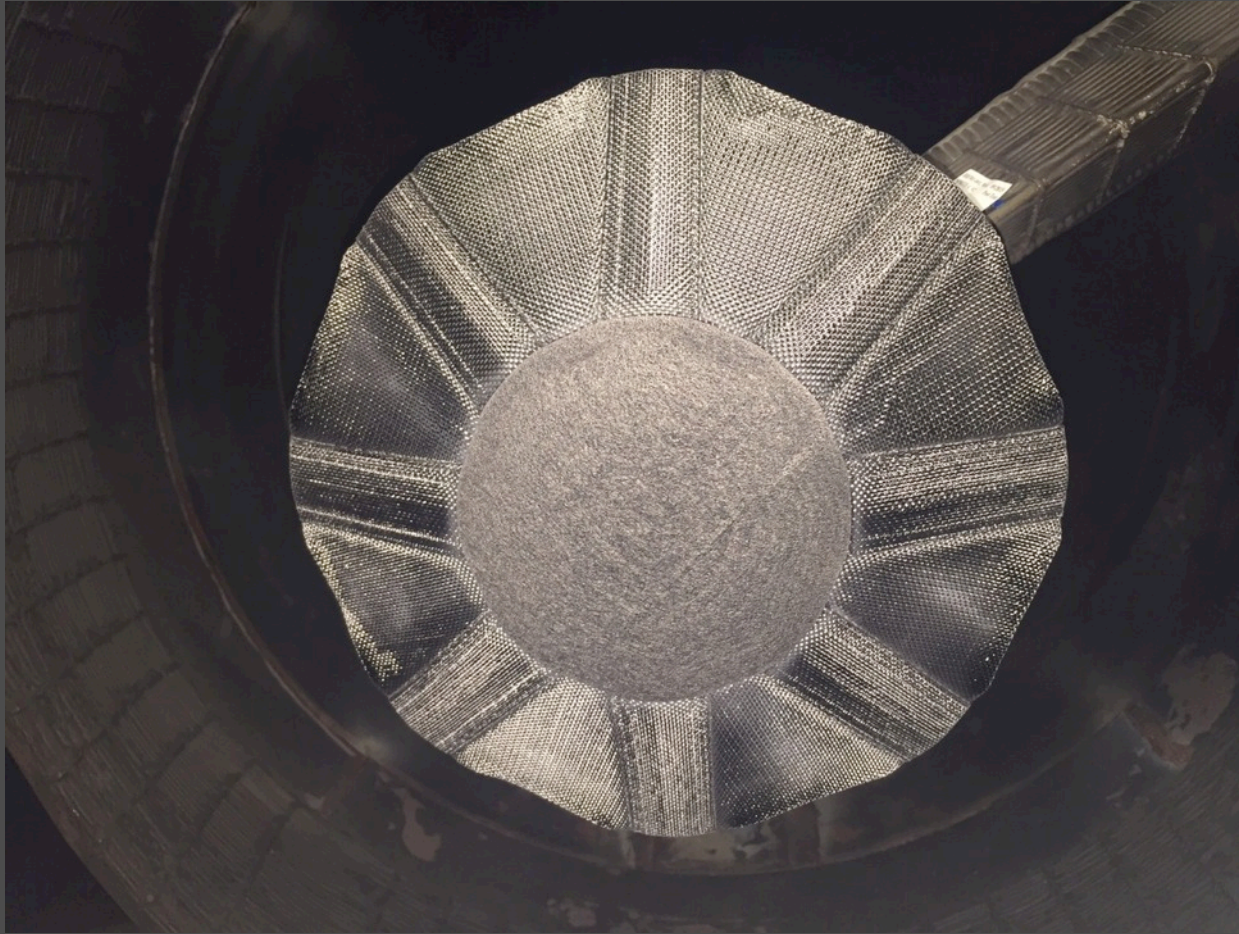
East Sting: SPRITE-C #1

Overhead Sting: Slug_Cal_102mm_Hemi_OH

West Sting: SPRITE-C #2

Run: 001
Date: 09/28/2015

SPRITE-C Pathfinder Post-Test Image



Dual heat pulse – 7.5 kJ/cm^2 total stagnation point heat load

SOUNDING ROCKET FLIGHT TEST (CY'15)

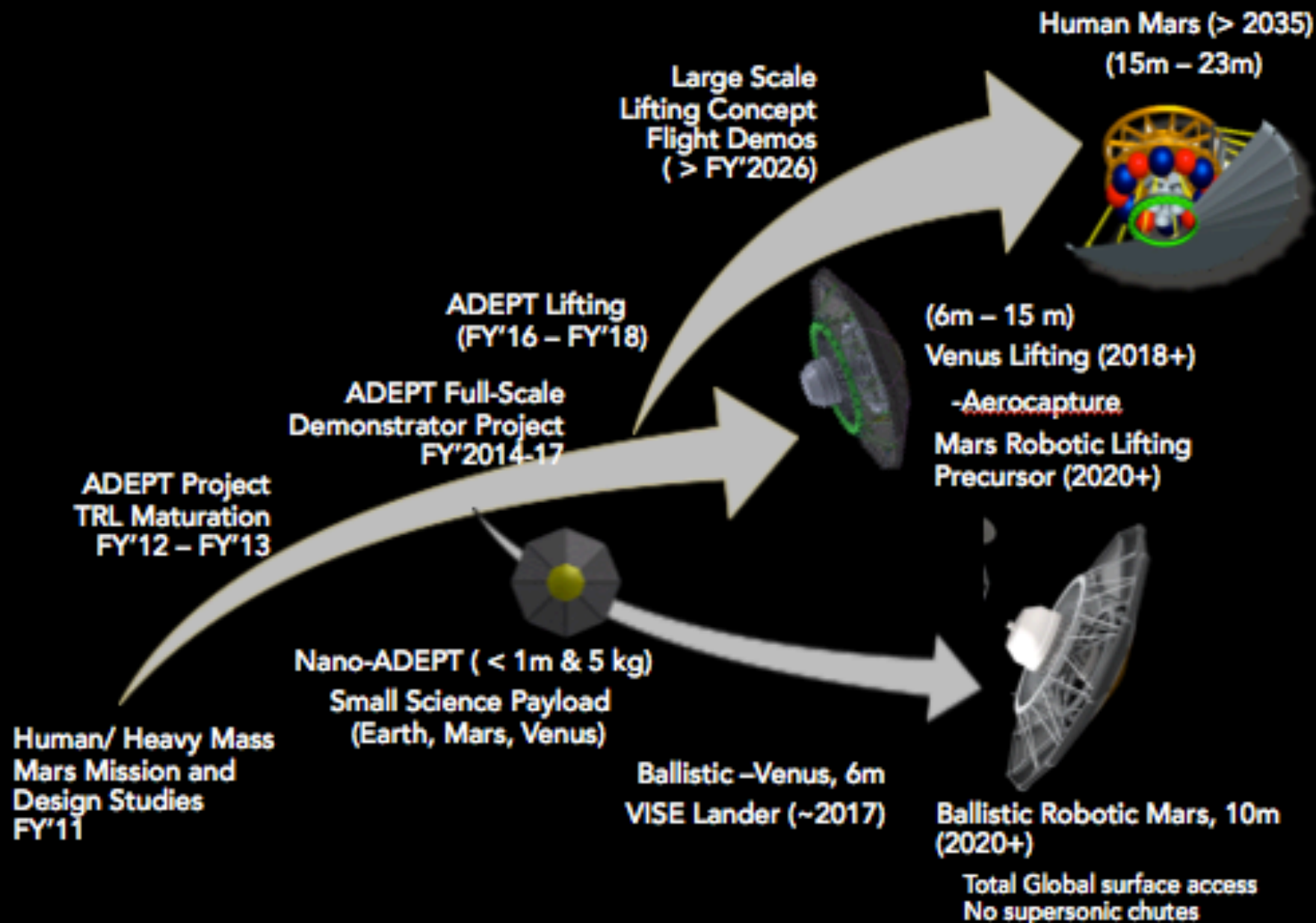


Deployment

(Prototype with carbon fabric skirt – Slo-mo)



A SCALABLE ADEPT EDL ARCHITECTURE MISSION INFUSION OPPORTUNITIES



SUMMARY REMARKS

- Mars has been and continues to be both an exciting and a challenging place to explore
 - ❑ We have reached the limit of EDL technology with MSL
 - ❑ Landing large payloads and human at Mars is a grand challenge
 - ◆ Combination of innovation and new technologies needed

- Mechanically deployable entry system, ADEPT, is a game changing concept that has the potential
 - ❑ Within 5 years, retrieving small-satellites from around earth orbit and send small payload to Mars and Venus.
 - ❑ Within a decade, enable cost effective, in-situ missions to robotic science exploration
 - ❑ In the longer term, the concept and the robotic experiences at earth, Venus and Mars can enable Human Mars missions

WHAT'S MARY POPPINS GOT TO DO WITH HUMAN MARS MISSION?



Screenshot of Julie Andrews from the trailer for the film
w:en:Mary Poppins (film) from:
[http://en.wikipedia.org/wiki/Mary_Poppins#mediaviewer/
File:Mary_Poppins13.jpg](http://en.wikipedia.org/wiki/Mary_Poppins#mediaviewer/File:Mary_Poppins13.jpg)



Frosty white water-ice clouds and swirling orange dust storms above a vivid rusty landscape reveal Mars as a dynamic planet

Credit: NASA and Hubble Heritage Team
(STScI/AURA)

Thank you very much for your time and attention

Ready to answer questions.