Code TS
Entry Systems and Technology Division

presented by

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December 8, 2018

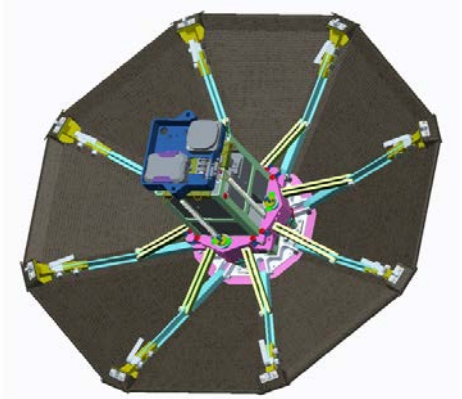
TS Division Overview

- The TS division (Entry Systems and Technology Division) includes people who:
  - Help design spacecraft for different exploration missions
  - Figure out how hot the environments around a spacecraft will get
  - Invent new materials that can protect the spacecraft
  - Figure out how those materials will behave on a spacecraft and how thick they need to be
  - Plan and perform tests on those materials and spacecraft designs to prove they will fly successfully
  - Instrument vehicles in order to get flight data on the materials
  - Build and launch demonstration vehicles!

Spacecraft Design

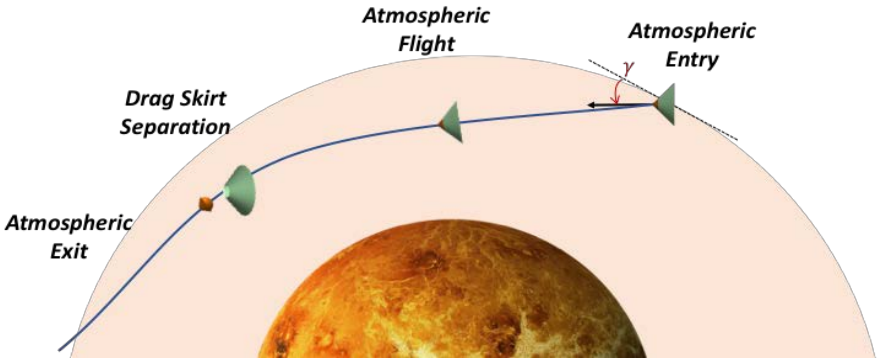
- TS has been developing new, unique spacecraft designs
  - ADEPT – Adaptable Deployable Entry and Placement Technology heatshield to allow large heatshields to fit on standard launch systems

Stowed
(like an umbrella)



Deployed

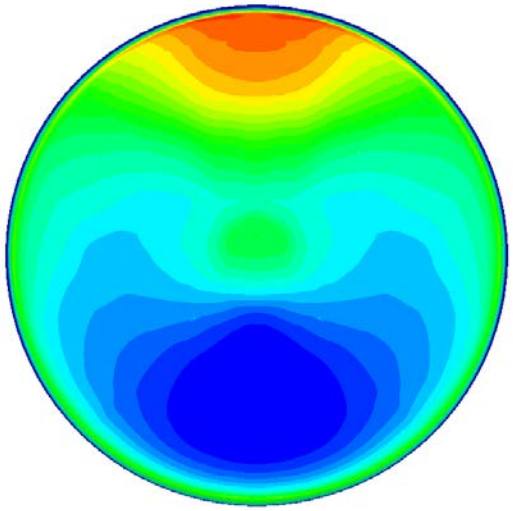
  - Drag Modulated Aerocapture Vehicle – to allow placement of small vehicles into planetary orbit without carrying a lot of fuel to slow it down



Spacecraft Environments

- The TS Division wrote two computer programs that won "Software of the Year" awards: DPLR and NEQAIR that, together, tell us how high the heating on the spacecraft will be

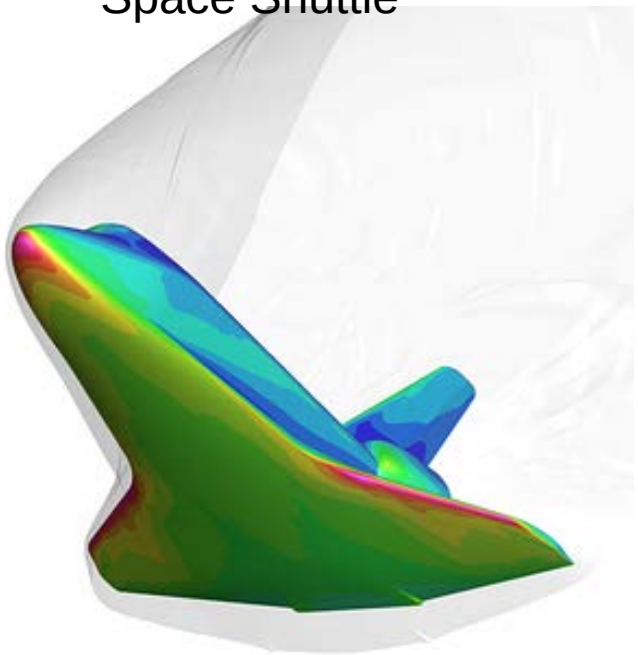
Mars Science Laboratory (MSL) Heatshield



RED = HOTTER!

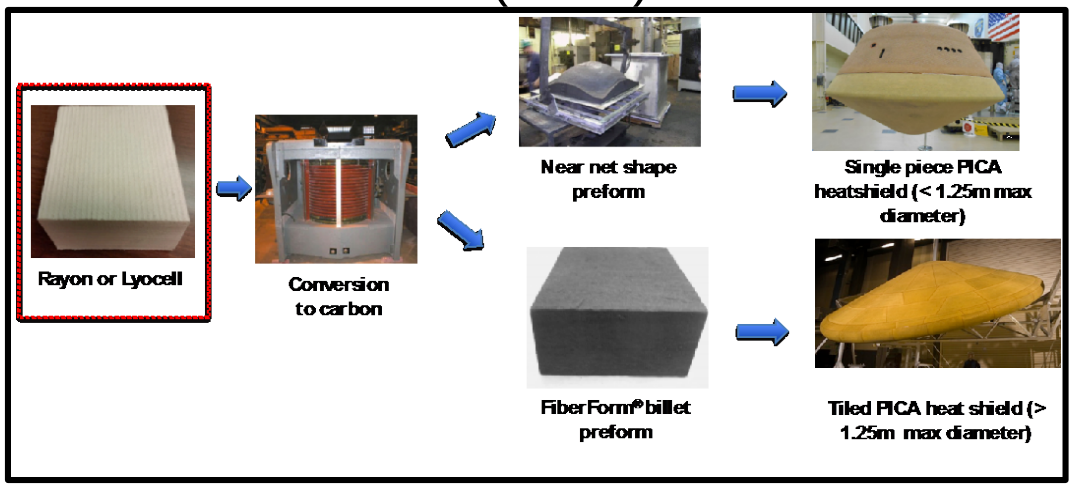
BLUE = HOT

Space Shuttle



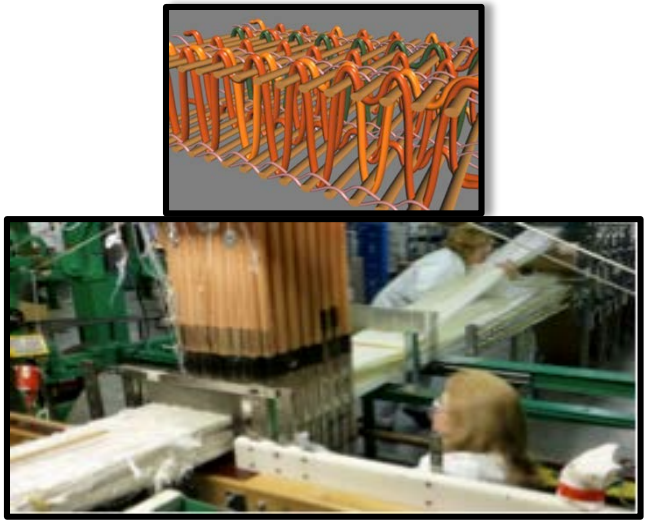
TS Materials Development

- TS developed the “Invention of the Year” material, Phenolic Impregnated Carbon Ablator (PICA) that flew on Stardust and MSL



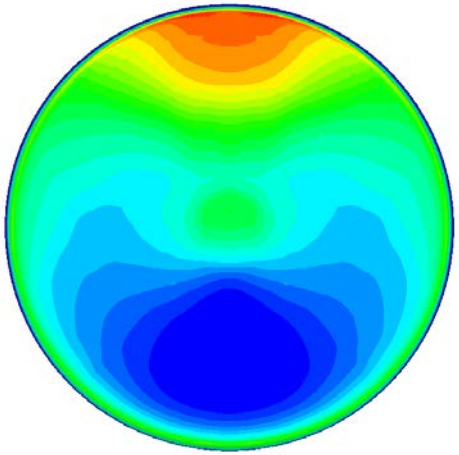
  - TS has also extended this technology to a conformal, less brittle version, C-PICA

- TS has developed a new material (HEEET) to survive extreme (very high heating) entry environments based on a 3-D woven substrate



Heatshield Design

- TS takes the heating information and the material properties and calculates the thicknesses required to survive the planetary entry



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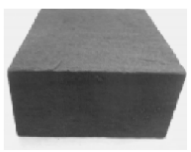

FiberForm® billet preform

Material Properties Measurements

FIAT Analysis Tool

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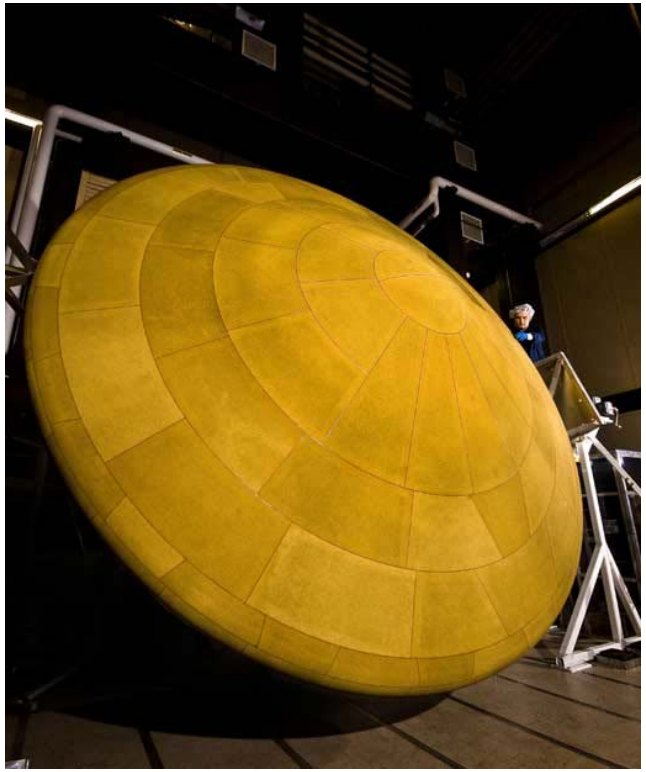
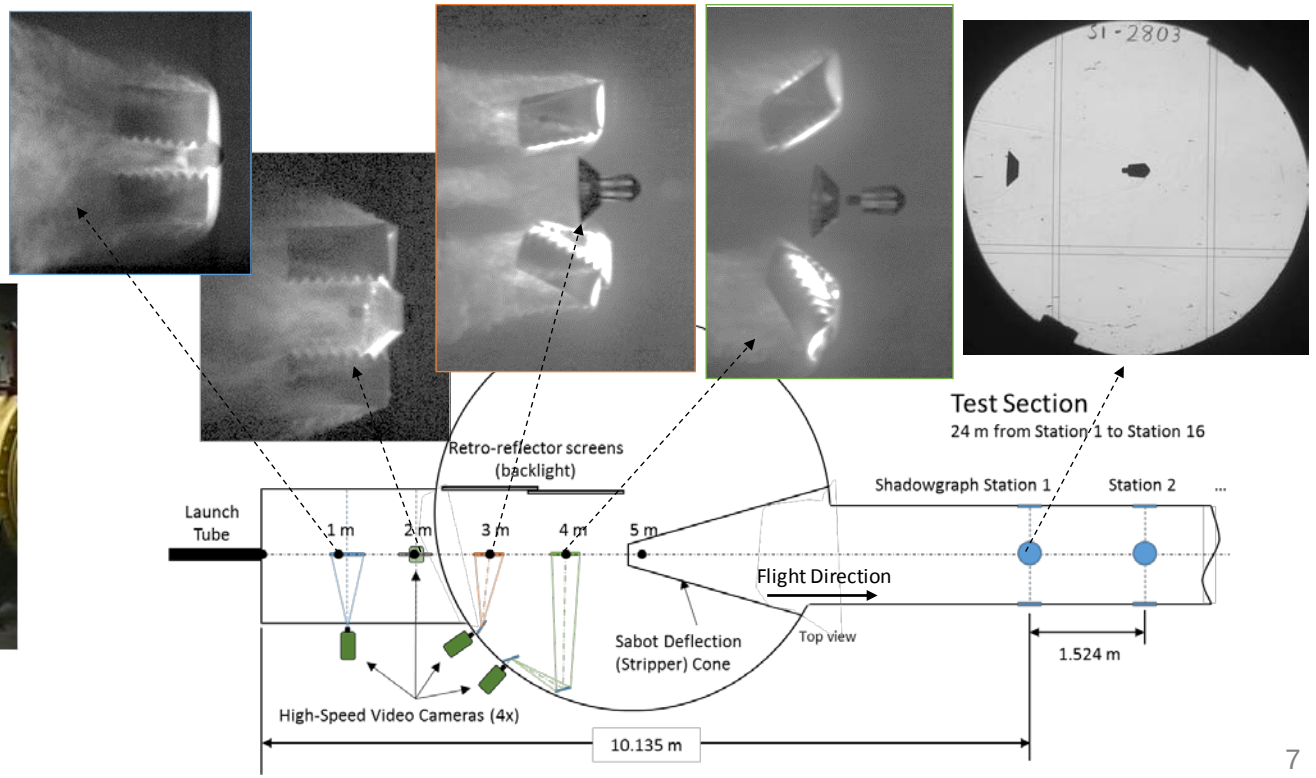


TS Testing – 1

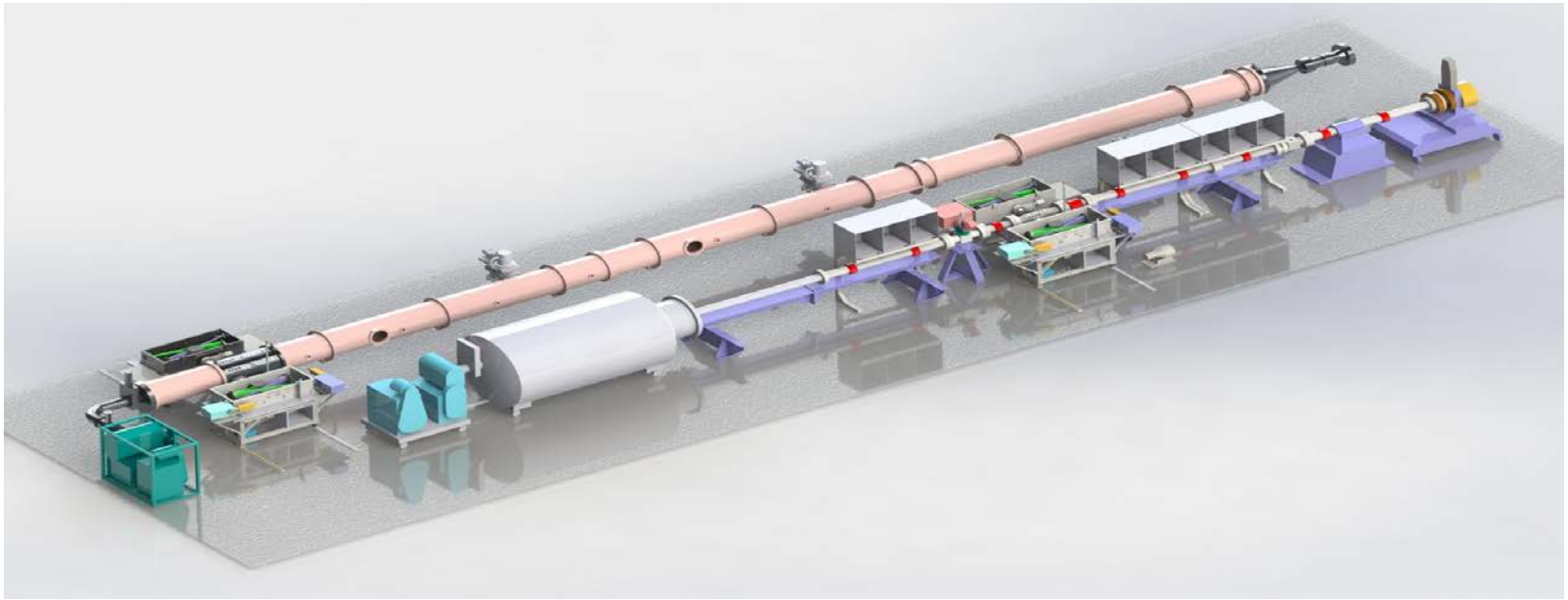
- The Hypervelocity Free Flight Aerodynamic Facility (HFFAF) uses model-launching guns to accelerate small-scale models of various size, shape and material composition to velocities in excess of 8 km/sec (>17,800 miles per hour!!!!)

Testing the Drag Modulated Aerocapture Vehicle



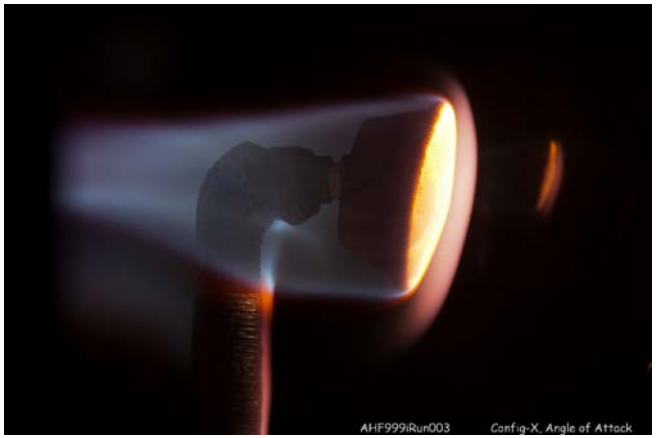
TS Testing – 2

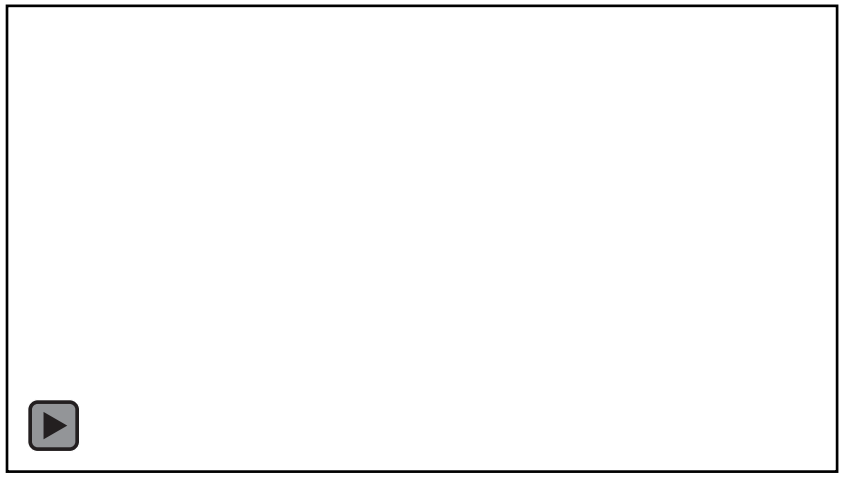
- Ames Electric Arc Shock Tube (EAST) Facility is the only shock tube in the U.S. capable of simulating shock-heated gas environments with velocities up to 46 km/s (>100,000 mph)
- We use the data to help calculate the radiant heating on planetary entry vehicles



TS Testing – 3

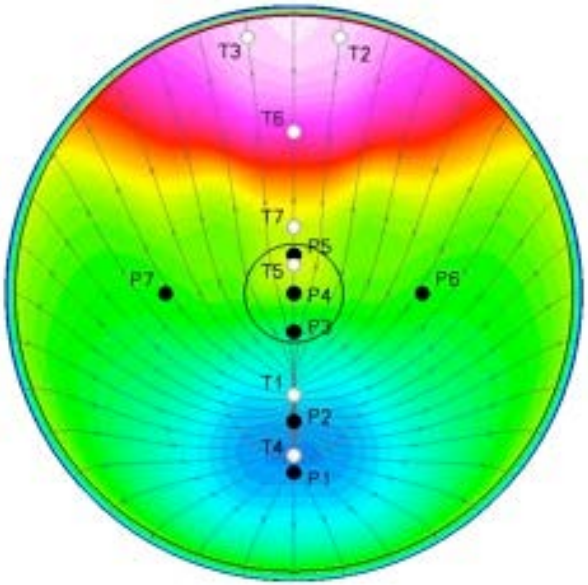
- NASA Ames Arc Jet Testing Complex contains 4 different arc jet test bays with 4 different arc jet configurations
  - An arc jet is a device in which gases are heated and expanded to very high temperatures and supersonic/hypersonic speeds by a continuous electrical arc between two sets of electrodes
- The Ames Arc Jet Complex has a rich heritage of over 55 years in Thermal Protection System (TPS) development for every NASA Space Transportation and Planetary program including Apollo, Space Shuttle, Viking, Pioneer-Venus, Galileo, Mars Pathfinder, MER heatshield, Stardust, NASP, X-33, X-34, SHARP-B1 and B2, X-37 WLE TPS, Orion heatshield development and MSL TPS
- The arc jets are used for the three major areas of TPS development: selection, validation and qualification

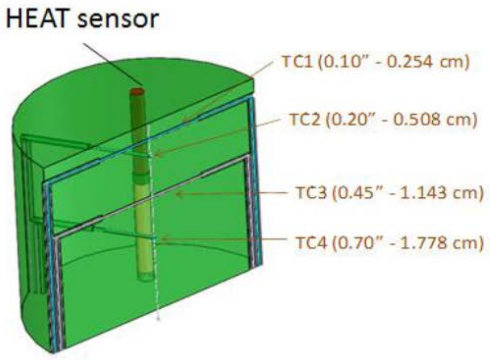


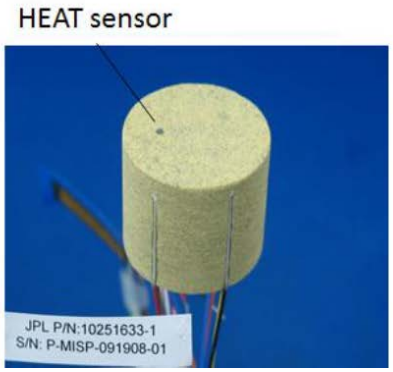


TS Flight Vehicle Instrumentation

- TS has been “instrumental” in designing instrumentation on flight vehicles
  - MSL Entry Descent and Landing Instrumentation (MEDLI)
  - Orion Entry Flight Test #1 (EFT-1) Development Flight Instrumentation
  - Mars 2020 Entry Descent and Landing Instrumentation (MEDLI-2)

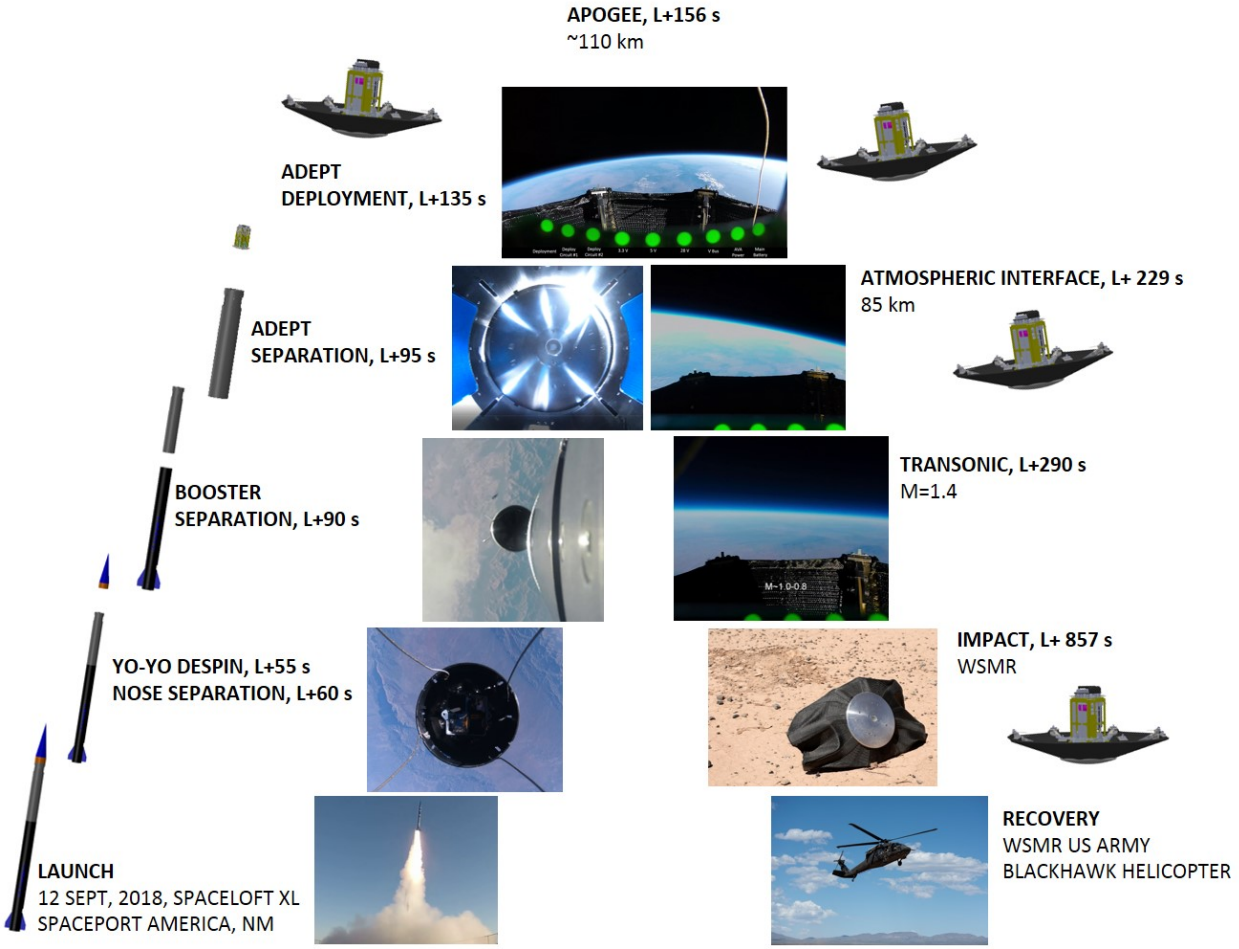






TS Launches the ADEPT Vehicle

- In September 2018, launched a small ADEPT demonstration vehicle

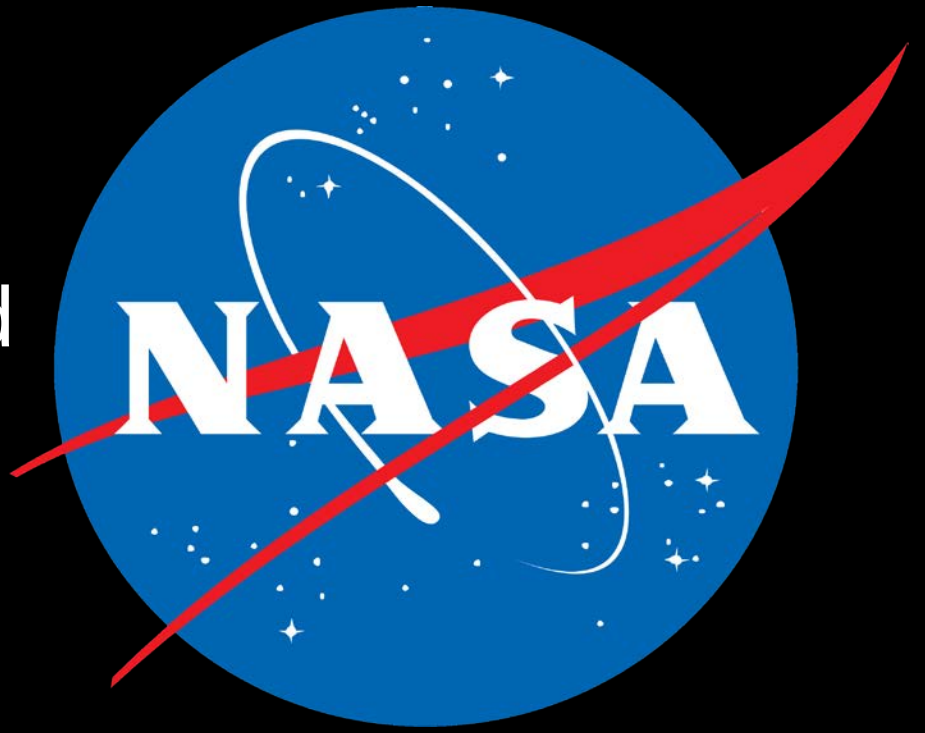


Conclusions

- Wow, TS does a lot of things!!!!

Questions?

National Aeronautics and
Space Administration



Ames Research Center
Entry Systems and Technology Division