DRAGONFLY

A relocatable lander to explore Titan's prebiotic chemistry and habitability

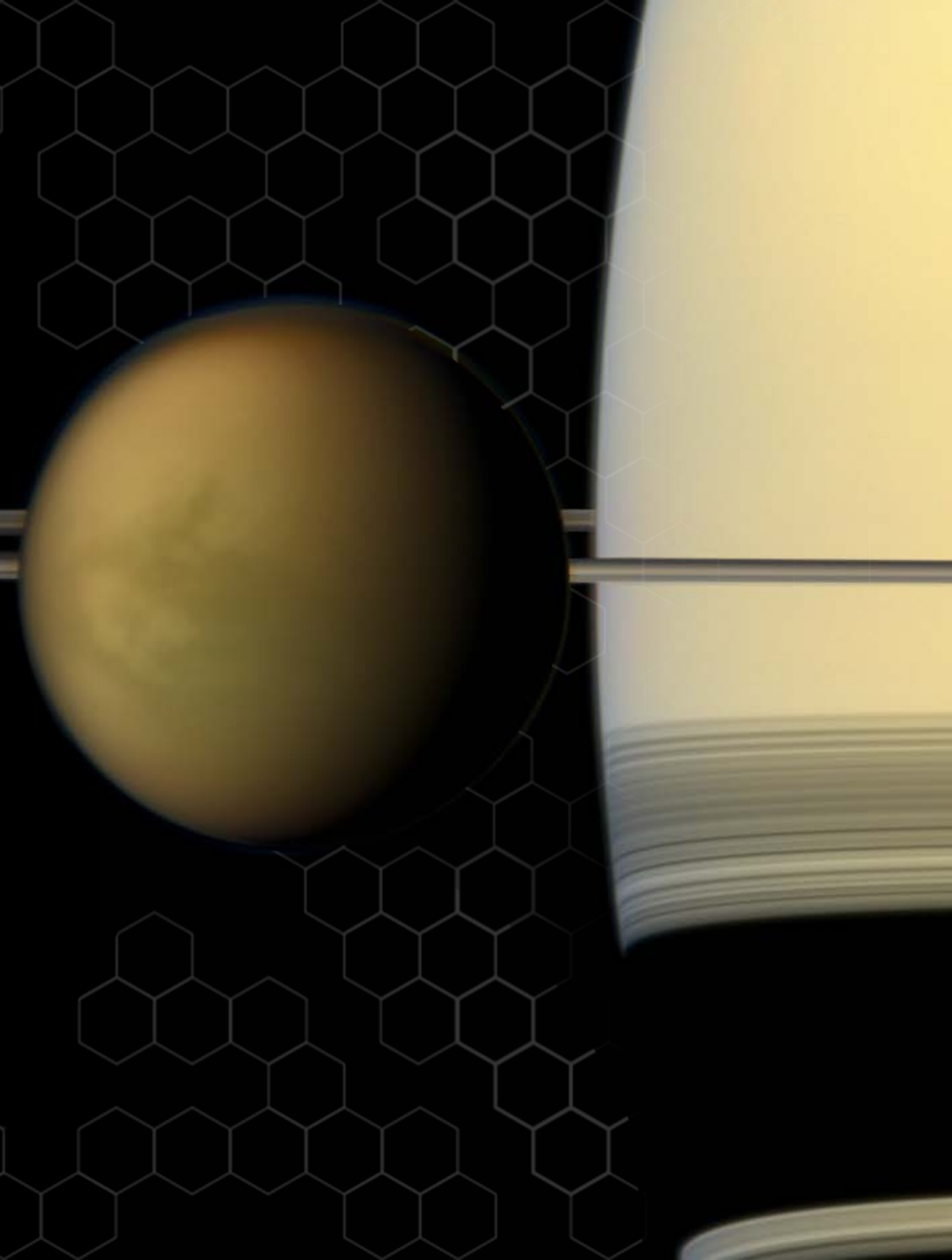
The Dragonfly Entry and Descent System

IPPW 2019; Oxford, UK

July 12, 2019

Michael Wright (Dragonfly EDL Phase Lead)

Jeff Herath, Helen Hwang, Jim Corliss, Aaron Brandis, Dave Buecher, Doug Adams, Ralph Lorenz



Introduction

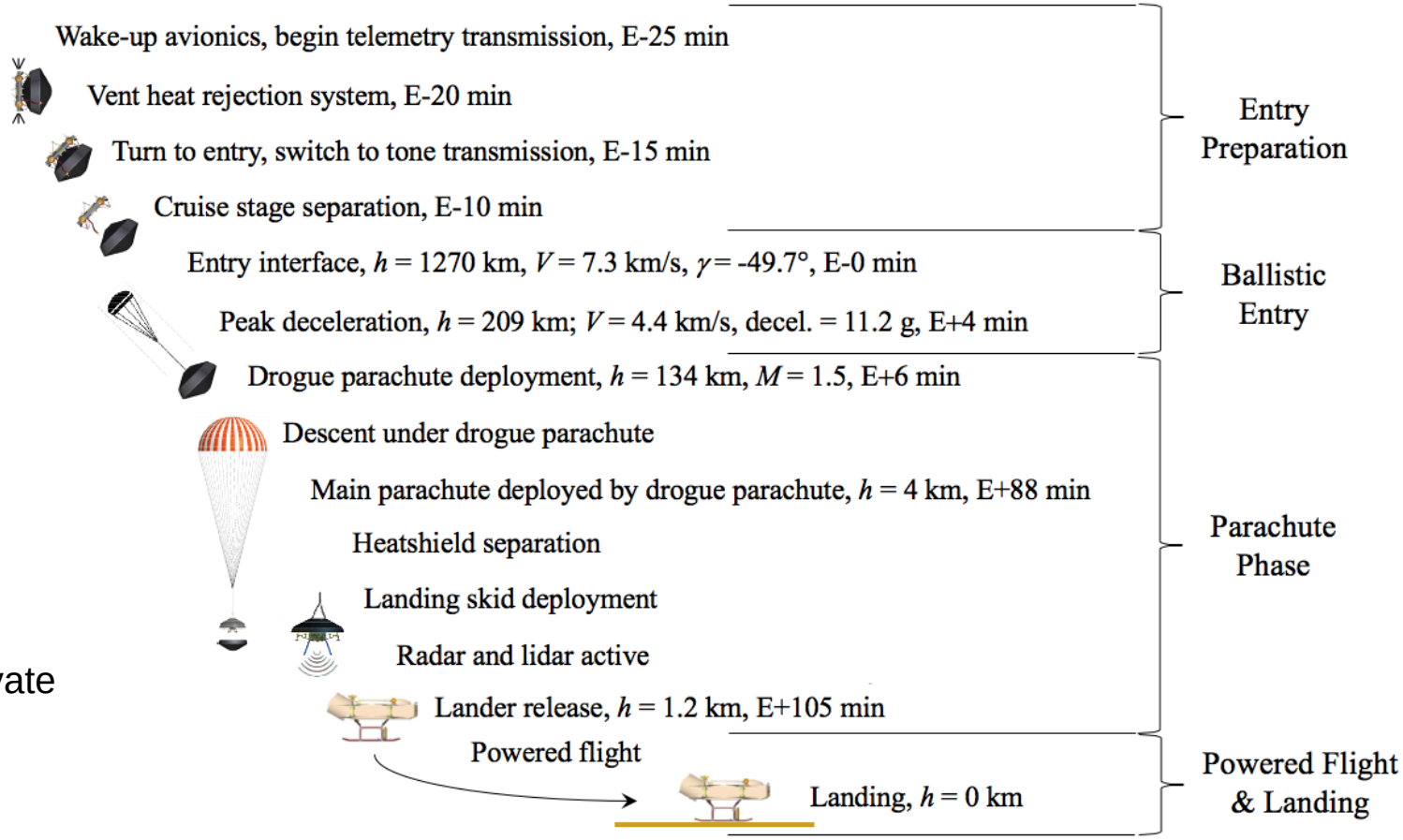
- **As of June 27, we are going to Titan!**
  - launch 2026, arrival 2034
- **This talk will focus on the Entry and Descent system that will deliver the rotorcraft safely to its release point**
  - see talks by Ken Hibbard (Tuesday) and Doug Adams (tomorrow morning) at this workshop for more details how we get from there to the ground!
- **Dragonfly EDL team combines expertise from NASA Ames/Langley and Lockheed Martin**
  - Aeroshell hardware provider (LM) has extensive hardware expertise for all relevant EDL missions since Pathfinder
- **Titan EDL is well understood with robust performance margins across the subsystems**
  - Extensive heritage exists that can be adapted to this mission application
  - Prior work for Huygens risk review (2004) and In-Space Propulsion Program lay the foundation for current EDL models
  - Titan EDL is more straightforward than Mars in several important ways

EDL Video

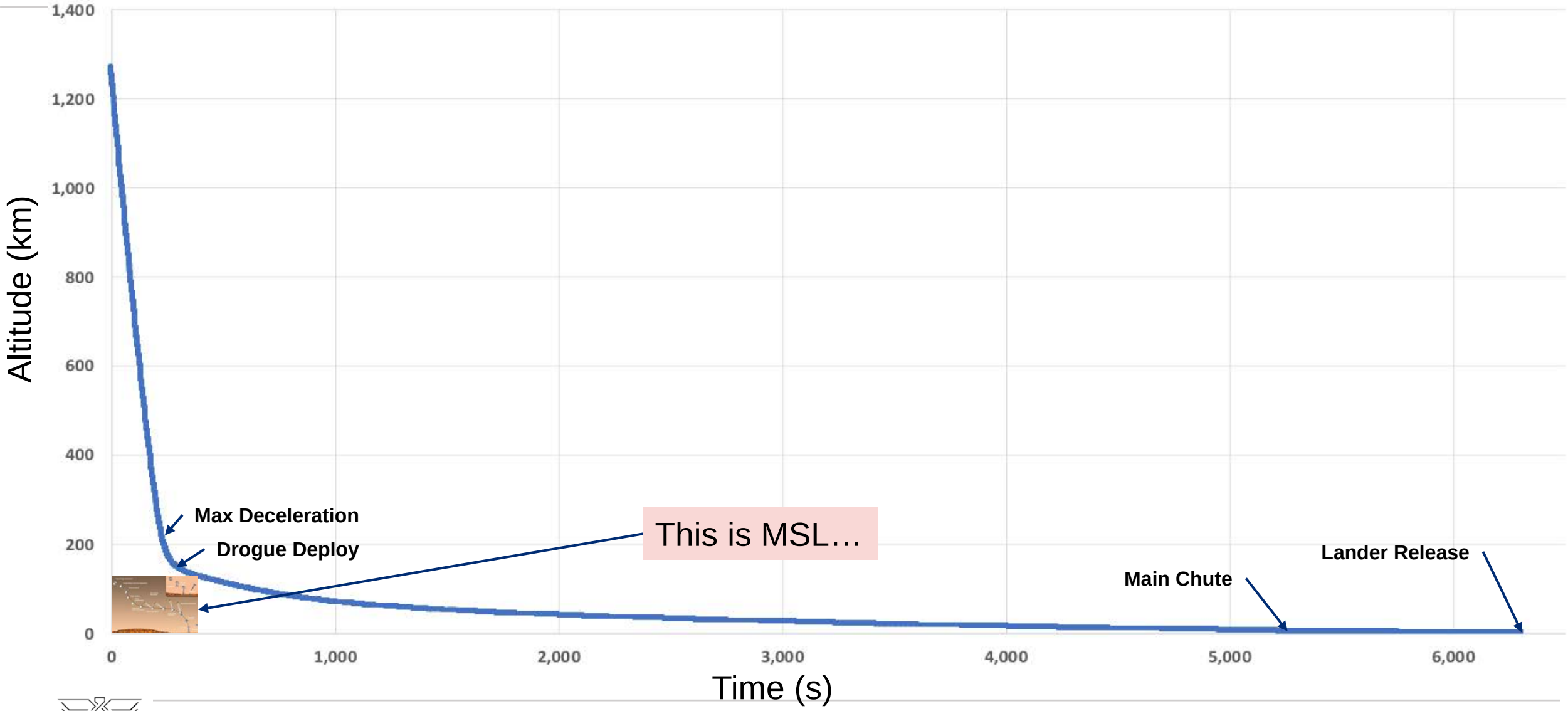
Not included at the moment in the interest of file size for editing

EDL Concept of Operations

- Entry Interface 1270 km
  - Spin stabilized to 2 RPM
- Entry heat pulse: 250 sec.
  - Peak heat flux 250 W/cm^2 margined
- Drogue deploy E+6 min, ~Mach 1.5.
  - More than 80 minutes spent on drogue
- Main chute deploy E+88 min.
  - Low velocity & opening load
- Lander Release E+105 min.
  - Plenty of time to stage heatshield separation, activate radar & lidar, deploy landing legs

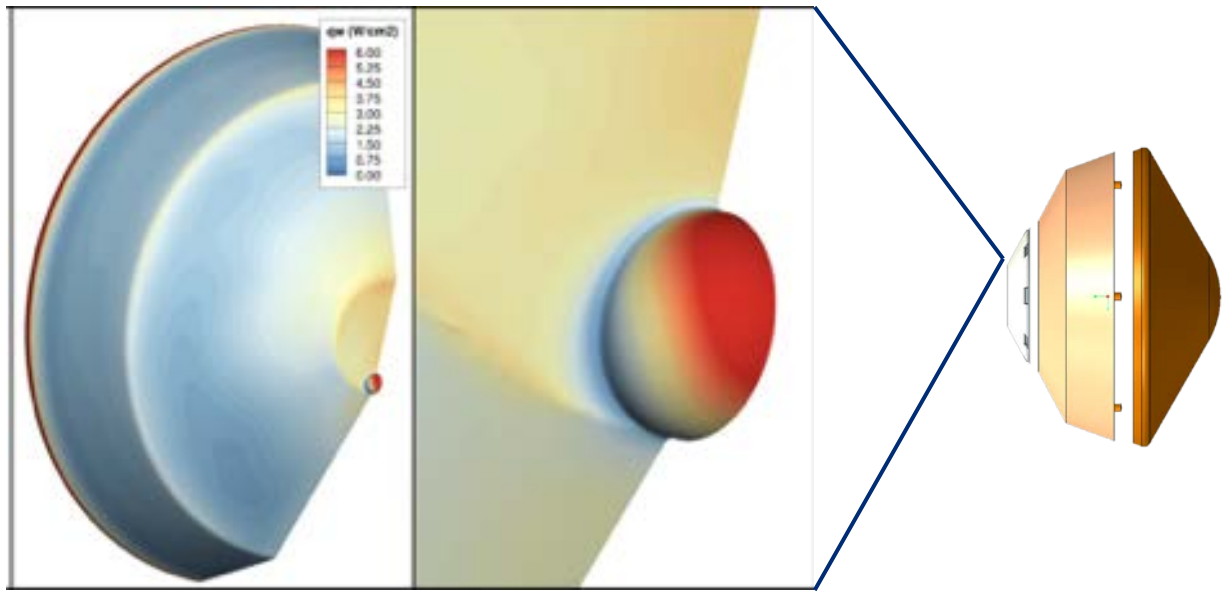


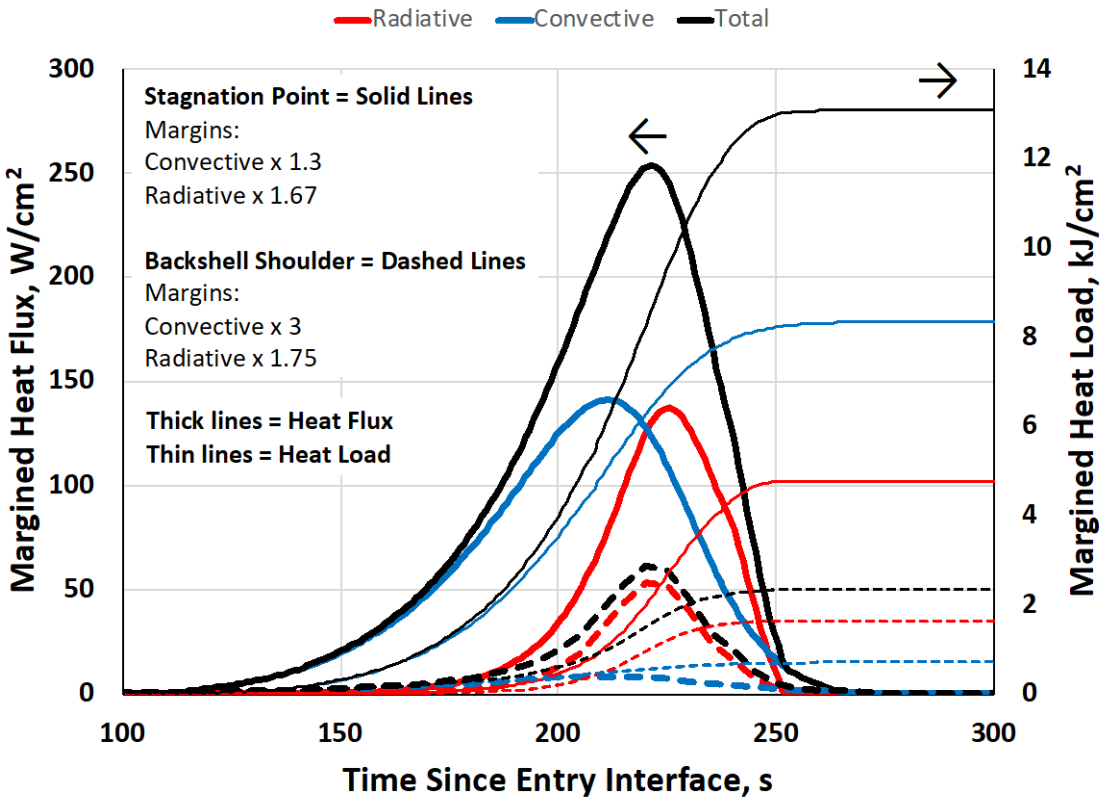
EDL Timeline Comparison…



Aerothermal Environments

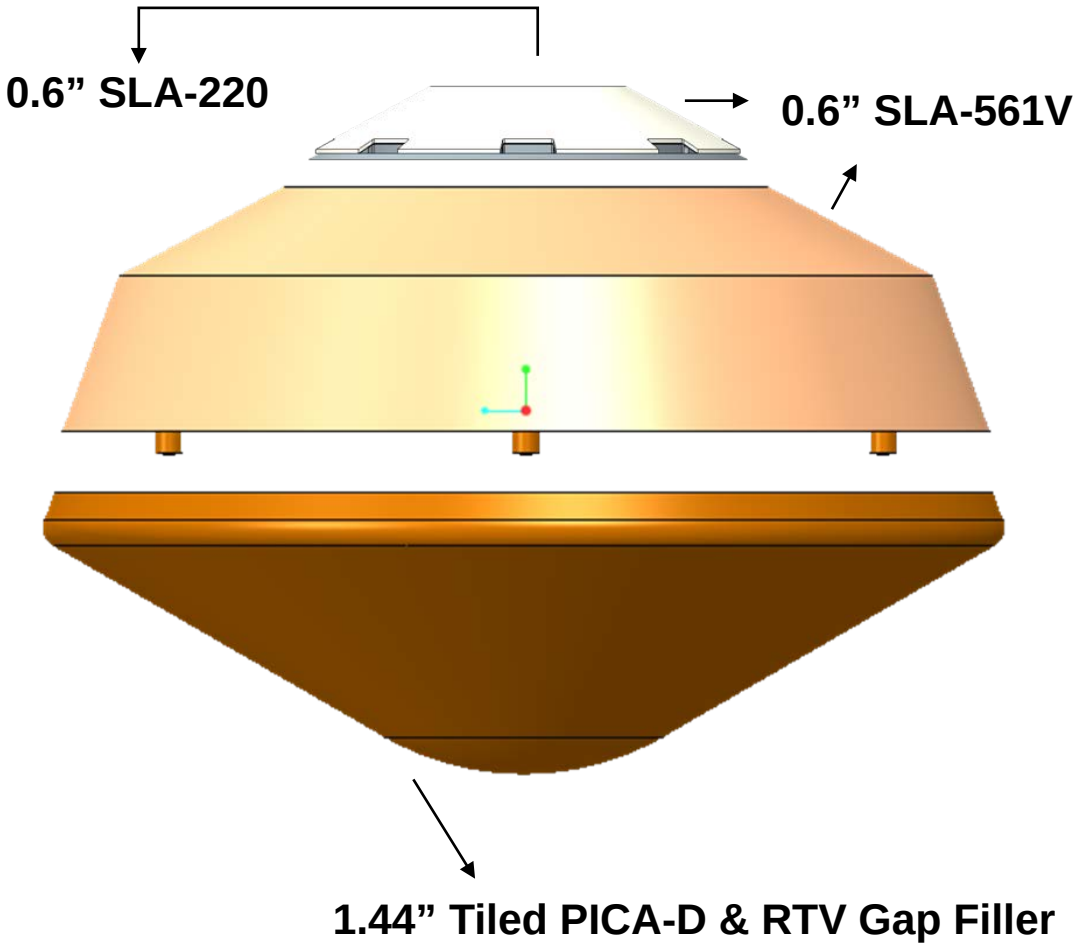
- NASA standard aerothermal (convective + radiative) models based tuned for Titan entry
- Total heating calculated over entire aeroshell
  - Conservative margins applied (Orion/MSL methodology)
  - Margined values well within tested limits for chosen TPS
  - Detailed simulations underway ahead of normal design cycle





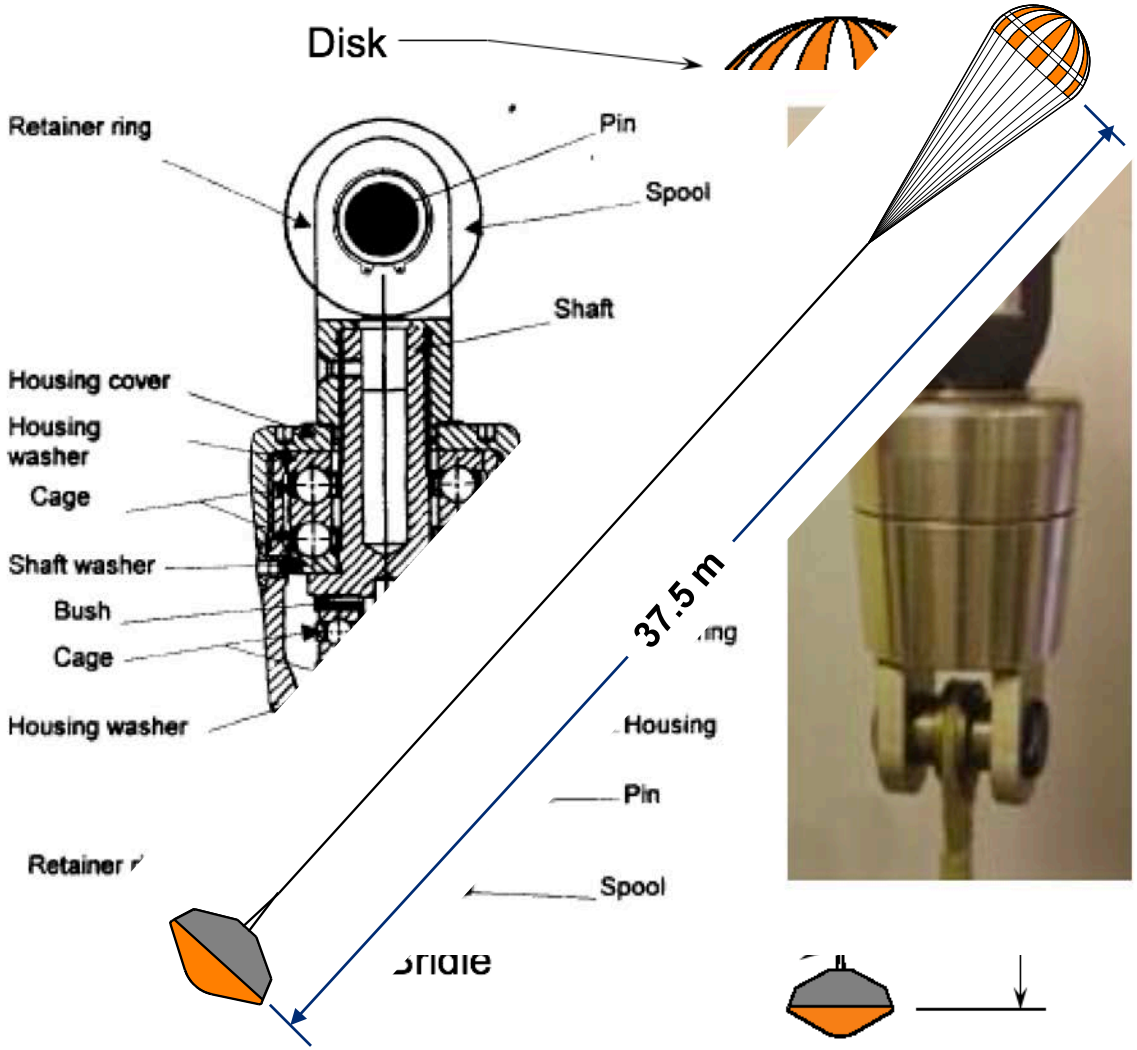
Thermal Protection System

- Three TPS materials:
  - High TRL and used well within tested limits
  - Arc jet testing confirms performance
  - SMD funded PICA-D will be a drop-in replacement for heritage PICA. Ready by the end of 2019
- TPS sizing analysis uses mature processes developed during MSL/Orion
  - Design thicknesses carry unallocated margin
- TPS manufacture, testing, qualification and assembly follow standard procedures developed at LM and NASA ARC



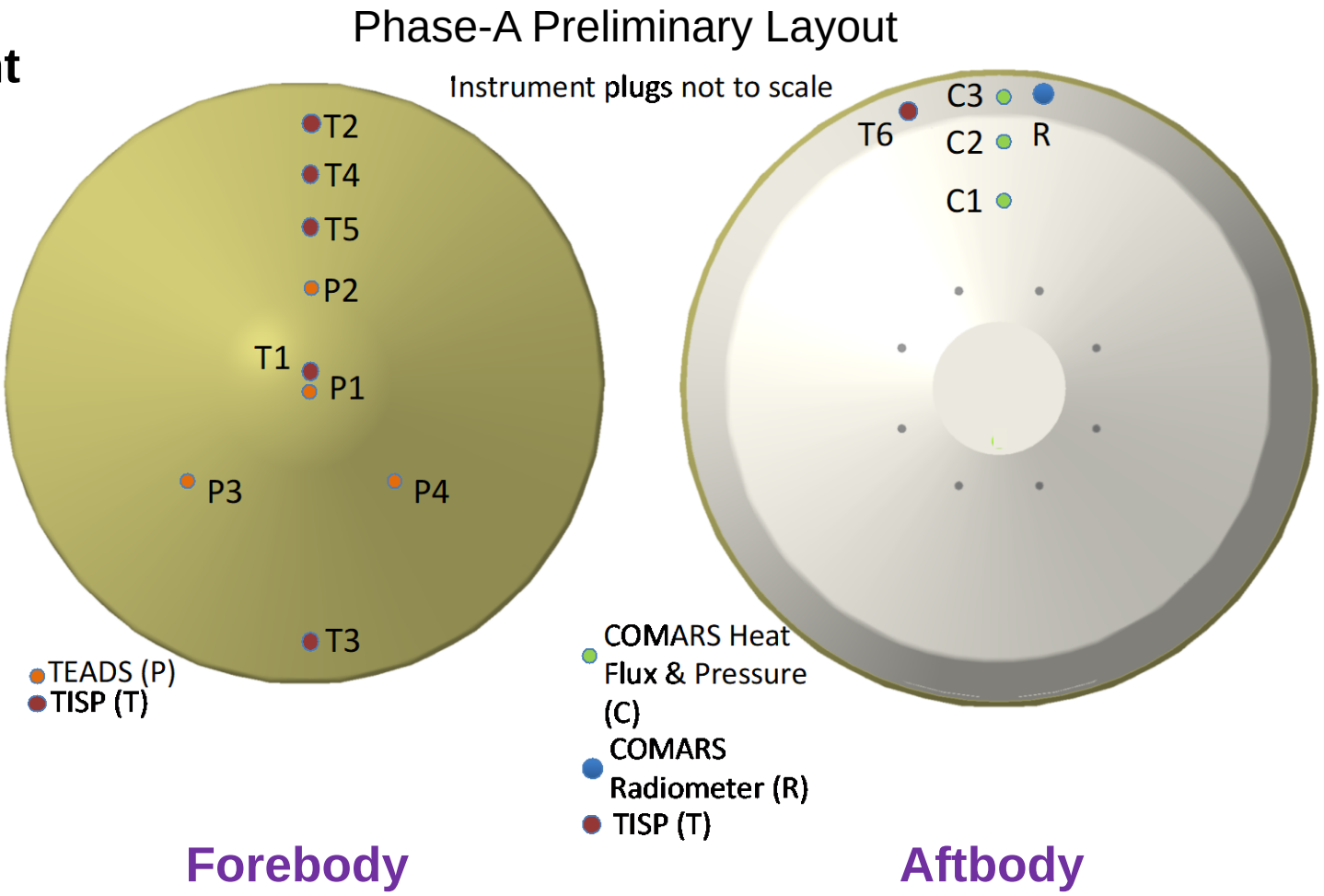
Parachute Deceleration System

- Drogue Parachute (4.5m DGB)
  - Mortar deploy via trigger at Mach 1.5
  - Functions: stabilize capsule, decelerate through atmosphere, extract main chute
- Main Parachute (13.44m DGB)
  - Low speed subsonic deploy
  - Includes inversion netting
- Huygens heritage swivels prevent line twisting



Engineering Science Investigation

- **Dragonfly is the first NASA competed mission subject to the ESI requirement**
- **ESI Goals:**
  - Near surface and in-depth TPS temperature
  - Surface pressure
  - Total and radiative heat flux
- **ESI Implementation:**
  - Partnership with German Space Agency (DLR)
  - NASA provided MEDLI-style TC plugs and pressure ports on the heatshield and afterbody
  - DLR provided COMARS sensor suite on the afterbody
  - DLR provided data acquisition system for all instrumentation



Conclusions

- **Dragonfly EDL system uses mature, high TRL, flight proven components**
  - 3.75m Genesis derived aeroshell, flight proven TPS solutions, Viking derived parachute system
  - Aeroshell provider (LM) has extensive hardware expertise in all relevant EDL missions since Pathfinder
- **EDL is well understood; with robust performance margins across the subsystems**
  - Titan EDL is more straightforward than Mars in several important ways
  - Timeline is not a significant constraint in EDL design
  - Experienced analysis team is using NASA-standard processes and tools with appropriate modifications for Titan
  - A lot of analysis has been already done to reduce risk heading into Phase-B
- **ESI will collect the most flight data ever from any destination other than Earth or Mars**
  - Enabled by strong partnership with DLR

We are ready for Titan!


DRAGONFLY

EDL Monte Carlo Analysis

- Full analysis in POST2 from EI to lander release
- Delivery accuracy ~149x72 km at release
  - Easily affords lander sufficient accuracy to navigate to selected landing zone
- Dispersions sources
  - Latitude: navigation errors
  - Longitude: on-chute winds