Mars Entry, Descent and Landing (EDL)

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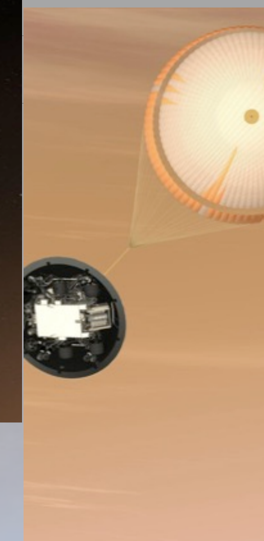
Entry, Descent and Landing (EDL)

- Process of delivering a vehicle from the top of the atmosphere to the surface and landing safely

- Three phases of flight
  - Entry – Hypersonic flight: Guide to the target
  - Descent – Supersonic flight: Turn on engines
  - Landing – Subsonic flight: Extend landing gear and throttle engines for touchdown

- EDL is riskiest part of Mars exploration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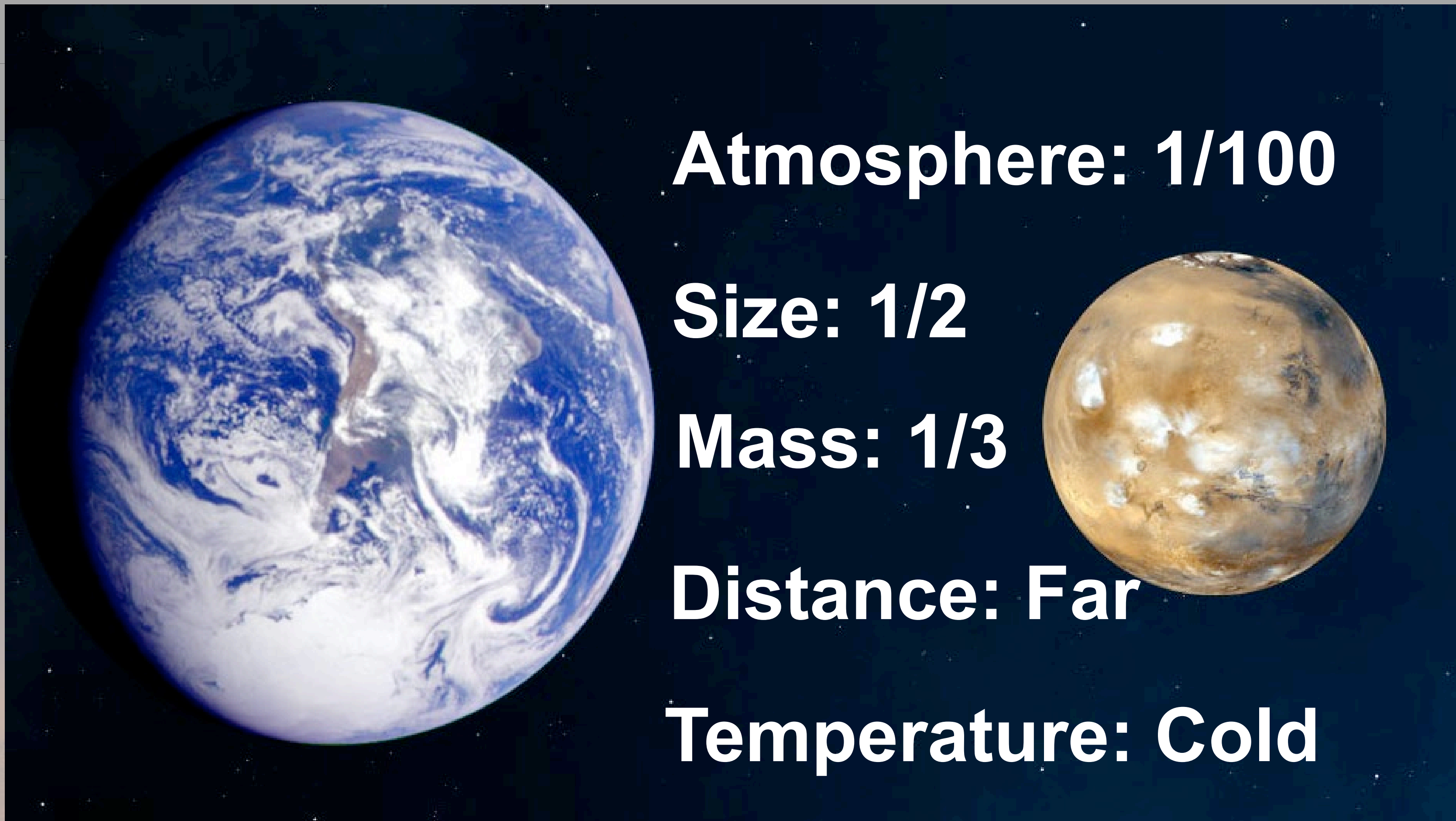
Why is Landing on Mars Hard?



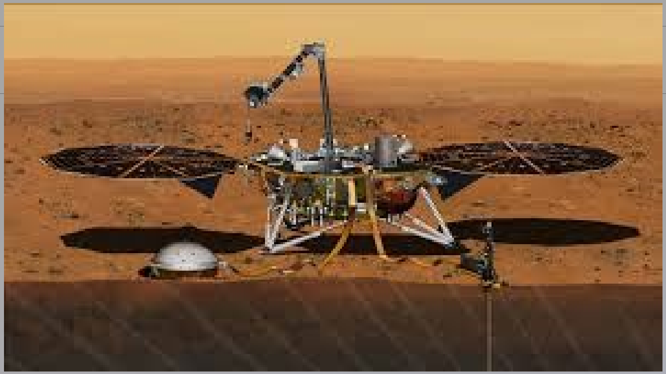
NASA's Mars Landing Missions


Photo Credit: NASA

Viking 1 & 2
1976


Spirit and Opportunity - 2004

Phoenix - 2008



InSight - 2018

Pathfinder
1996

Curiosity - 2012

Mars 2020 - Perseverance

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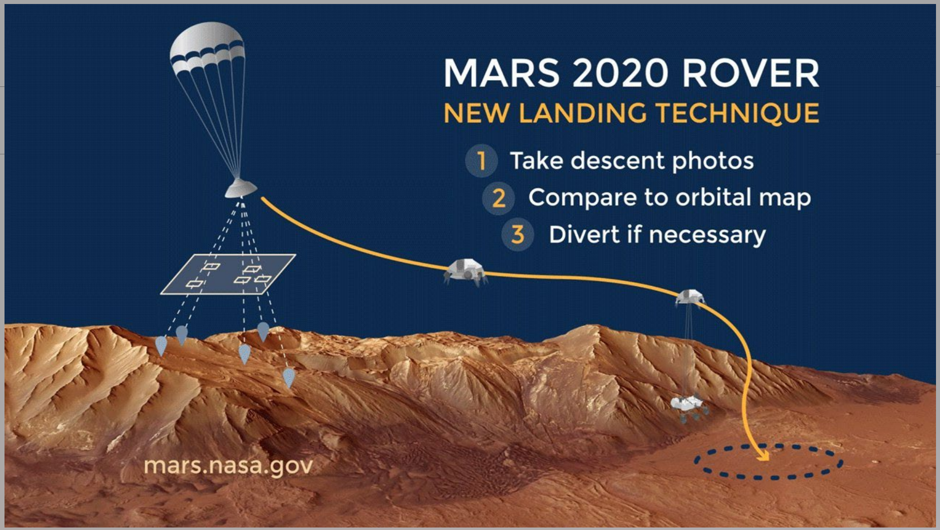
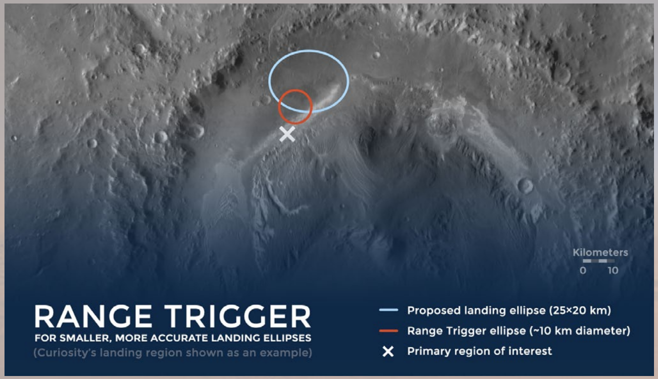
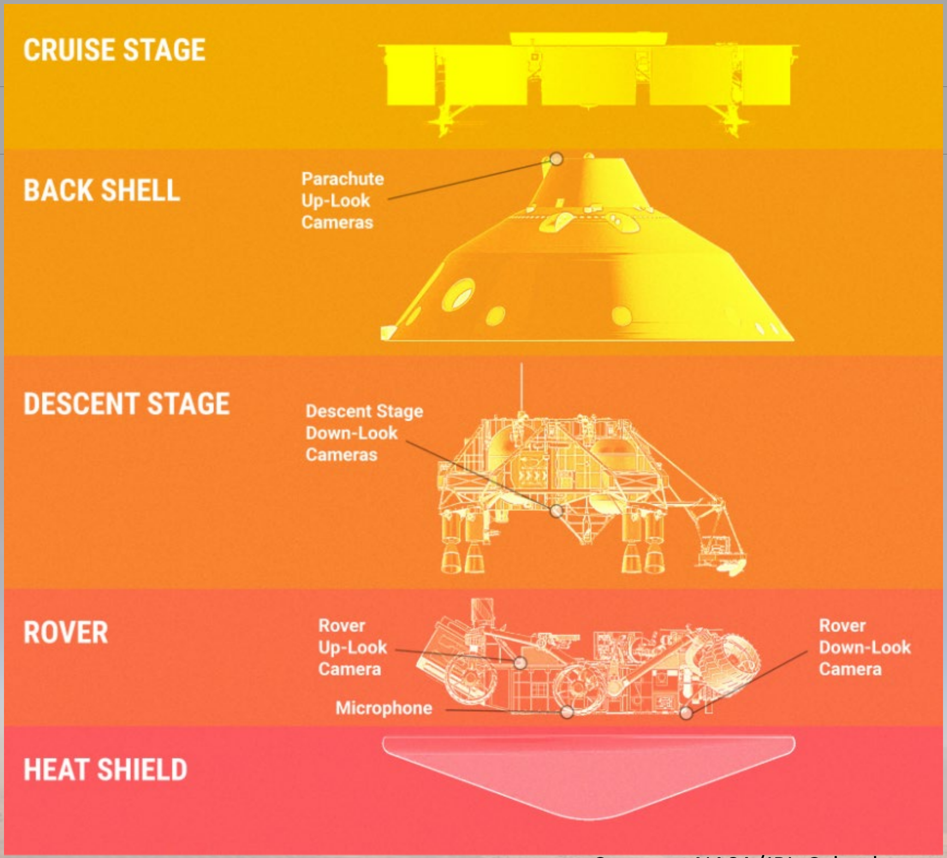
What's New About Perseverance EDL?

More Precise Landing



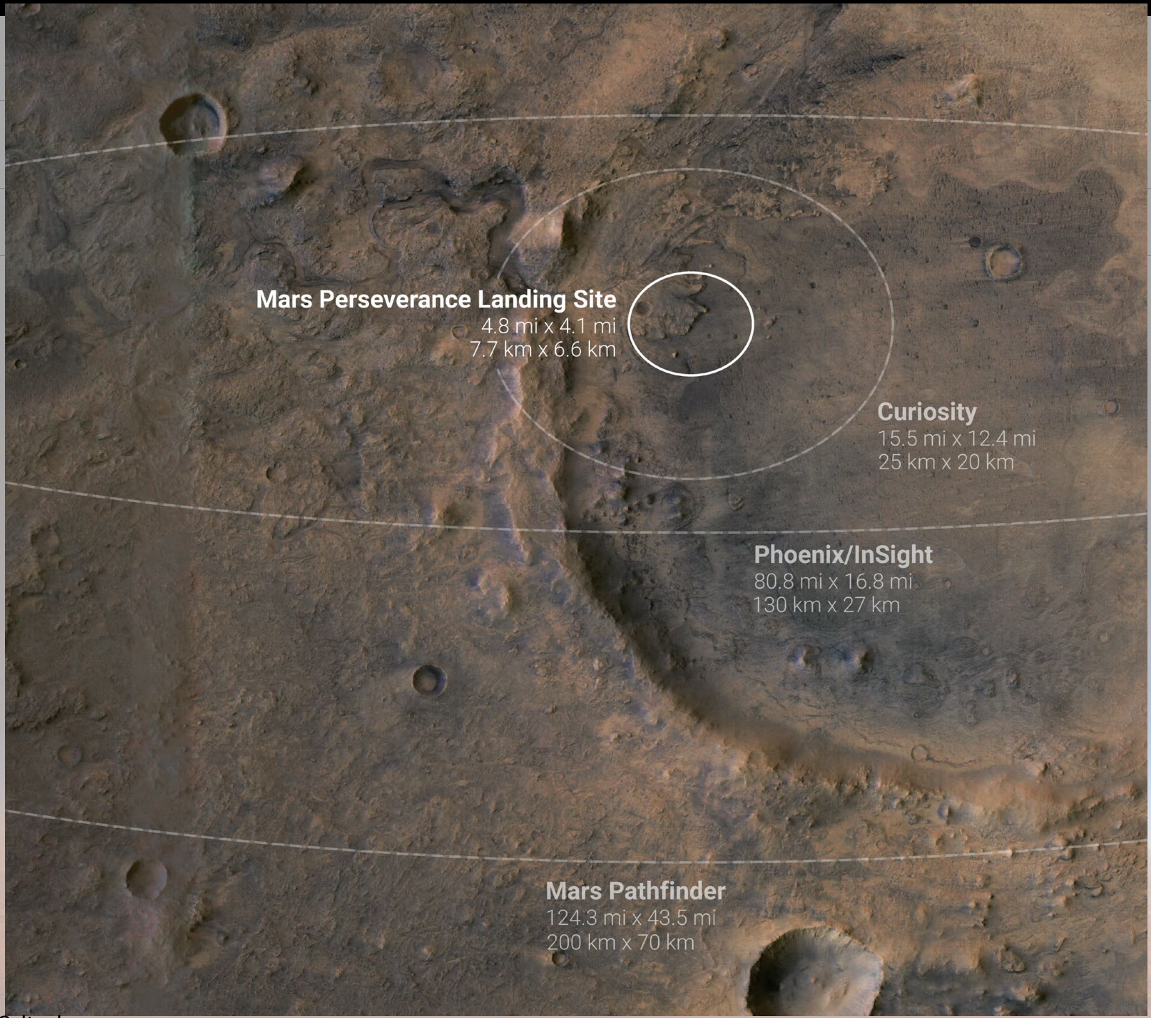


More EDL Views!



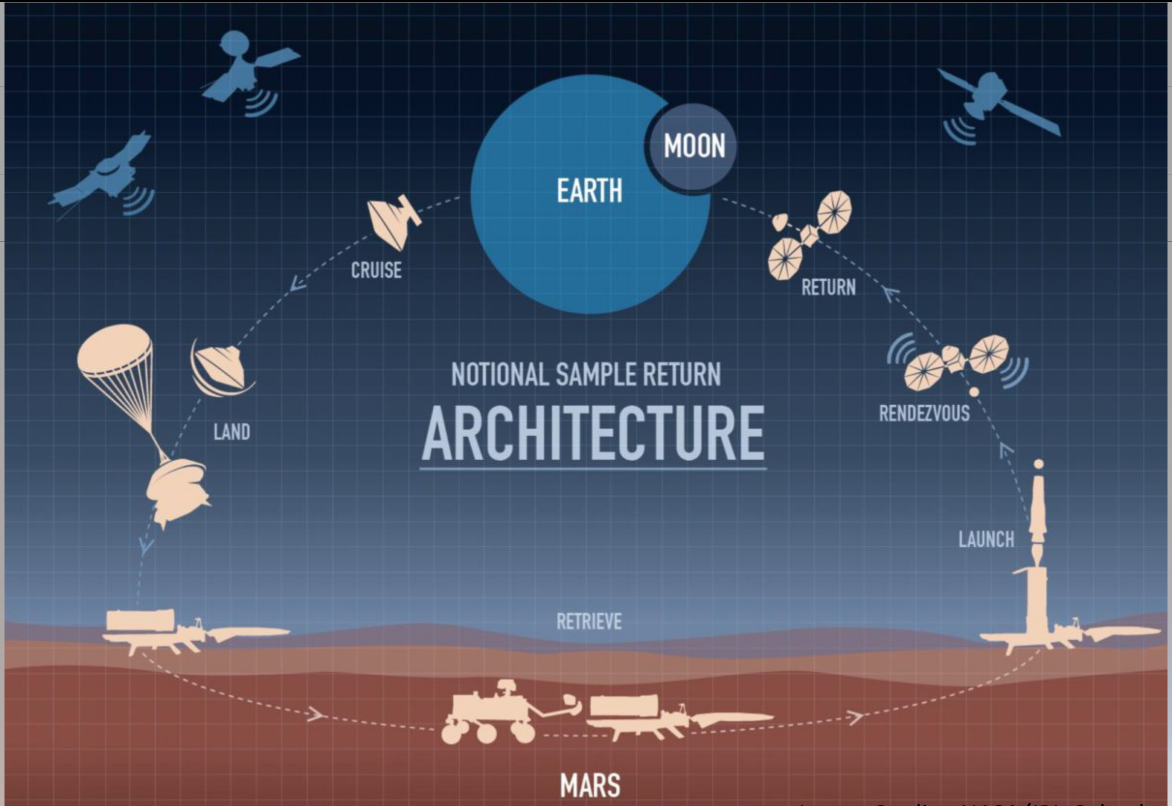
Courtesy NASA/JPL-Caltech

Landing Footprint Size Comparison



Courtesy ESA/DLR/FU-Berlin/NASA/JPL-Caltech

The Next Step: Mars Sample Return



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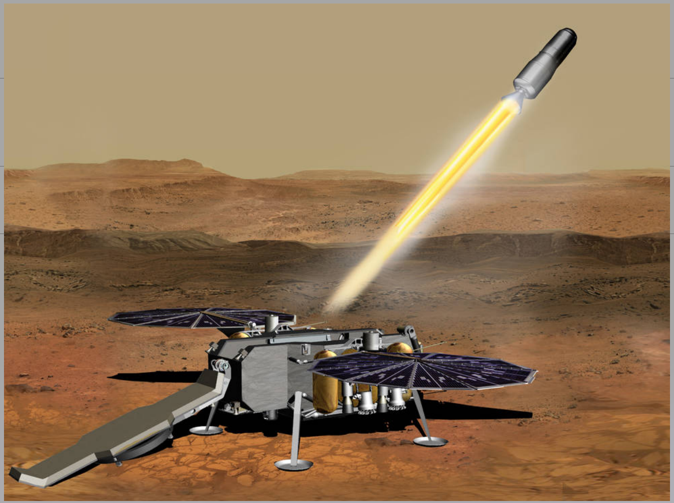
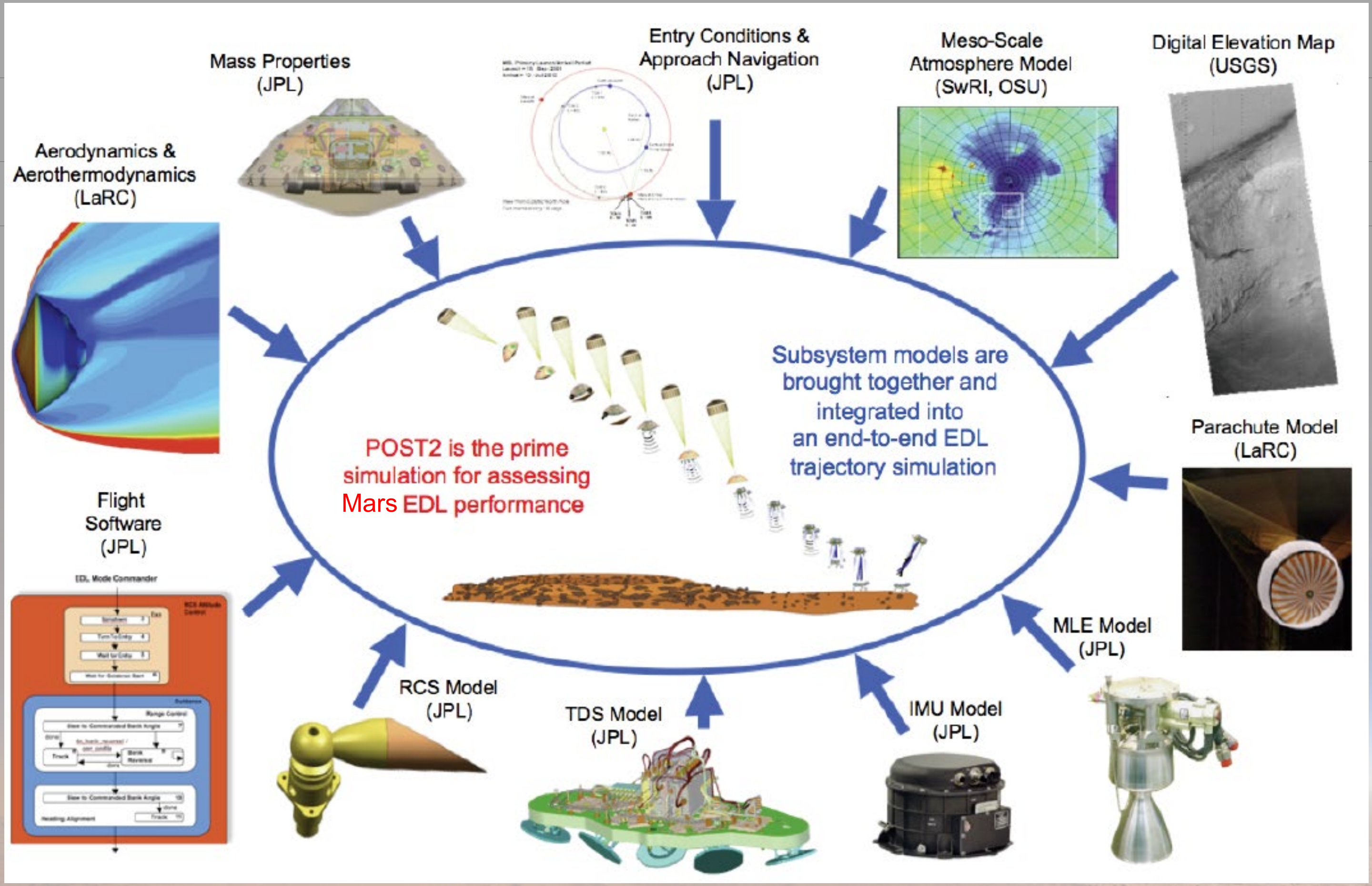



Image Credit: NASA/LaRC

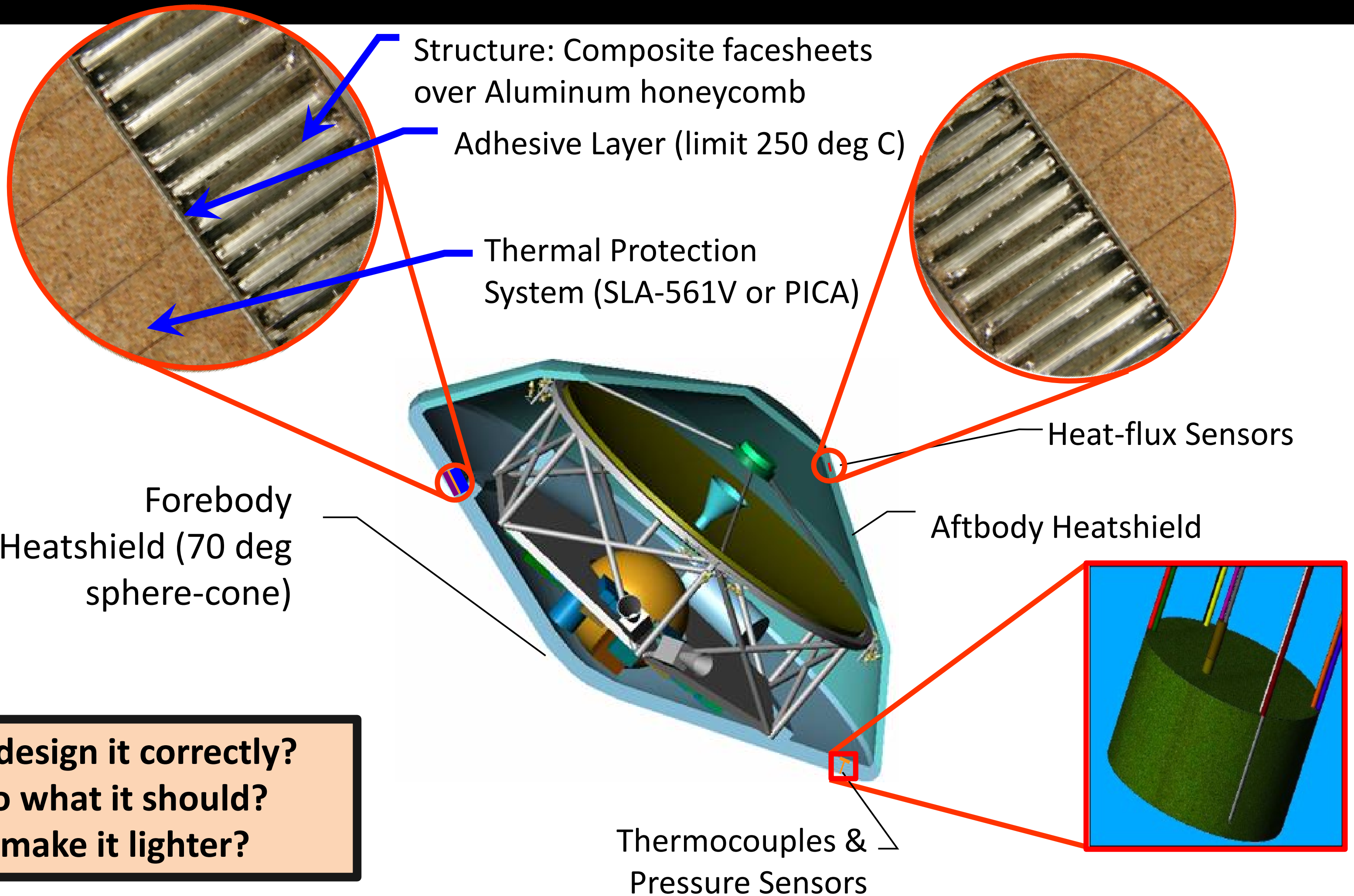
CHALLENGES: “Pinpoint” landing, MUCH heavier than M2020

We Can't Test it Together, So We Model



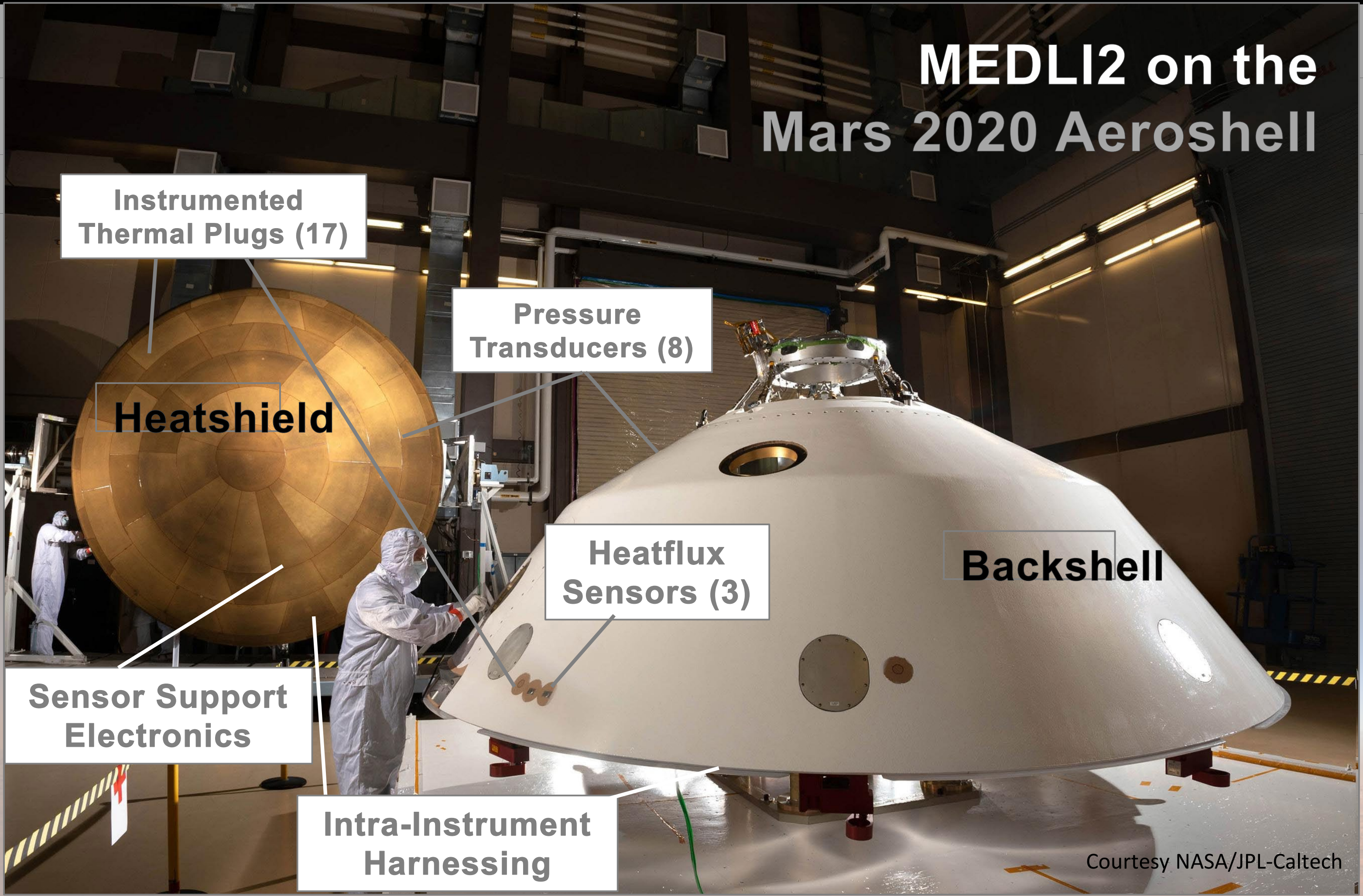
Earth-based Tests ➡ Models ➡ Computer Simulation

Traditional Heatshield System



Did we design it correctly?
Did it do what it should?
Can we make it lighter?

Aeroshell Instrumentation on Mars 2020



Mars Landers: Comparison

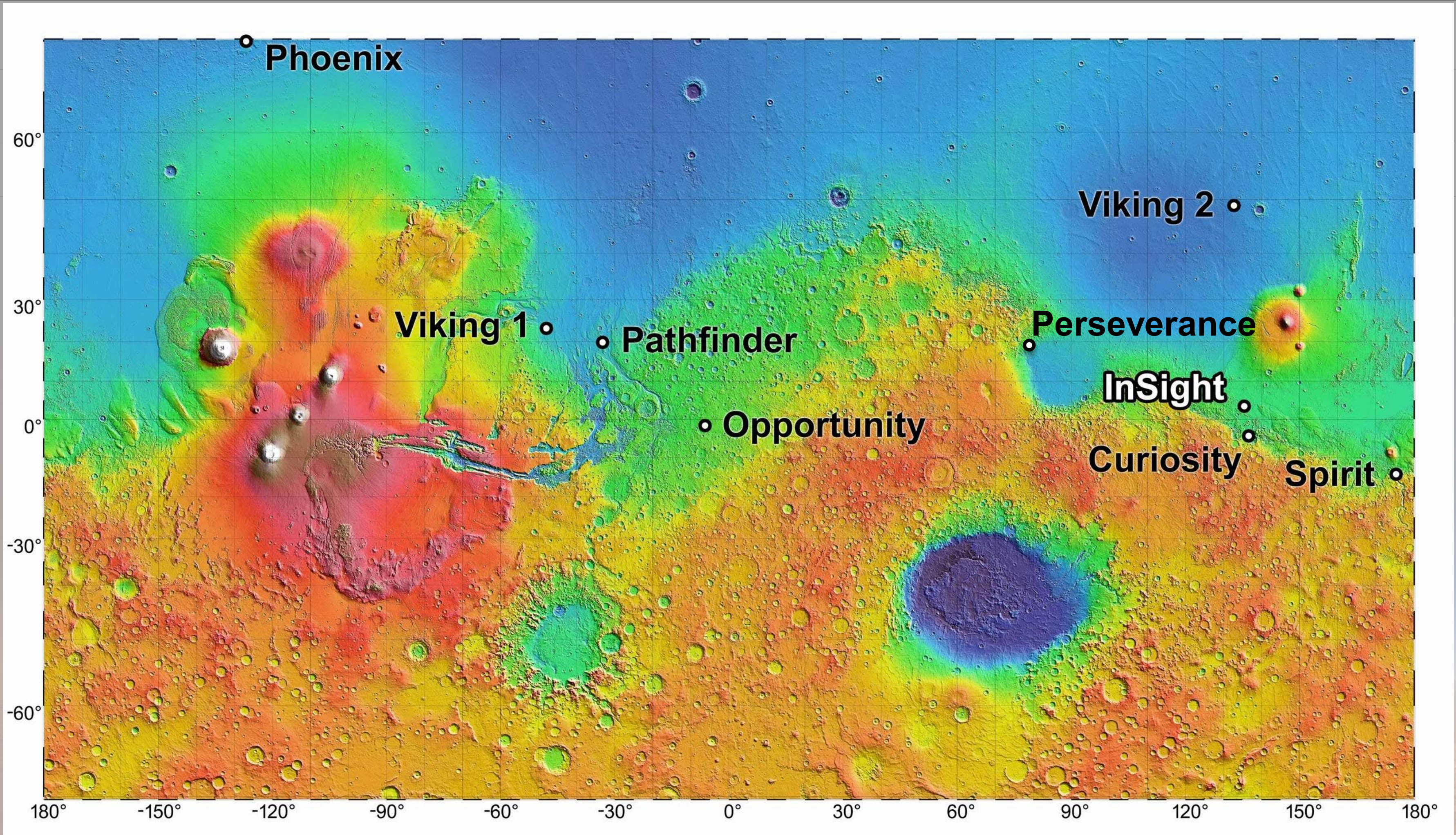
	Viking	Pathfinder	MERs	Phoenix	MSL	InSight	M2020
Entry Capsule							
Diameter (m)	3.505	2.65	2.65	2.65	4.52	2.65	4.5
Entry Mass (t)	0.930	0.584	0.832	0.573	3.153	0.608	3.440
Parachute Diameter (m)	16.0	12.5	14.0	11.8	19.7	11.8	21.5
Parachute Deploy (Mach)	1.1	1.57	1.77	1.65	2.2	1.66	1.75
Landed Mass (t)	0.603	0.360	0.539	0.364	0.899	0.375	1.050
Landing Altitude (km)	-3.5	-2.5	-1.4	-4.1	-4.4	-2.6	-2.5
Terminal Descent and Landing Technology	Retro-propulsion	Airbags	Airbags	Retro-propulsion	Skycrane	Retro-propulsion	Skycrane

Steady progression of "in family" EDL

Payloads up to 1 t

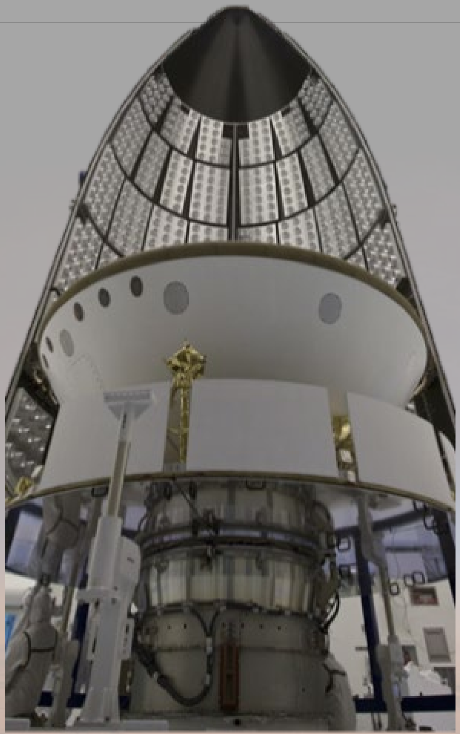
- Viking-heritage Entry, Descent, and Landing (EDL) technologies cannot land masses required for human Mars exploration
- Supersonic parachutes cannot be extended to high-mass EDL
- Propulsive descent and landing are enabling for human-scale EDL at Mars

Mars Landing Sites are at Low Altitude



Inflatable Heatshields Open Possibilities

To slow down a big Mars lander, we need a larger heatshield than will fit inside a launch vehicle



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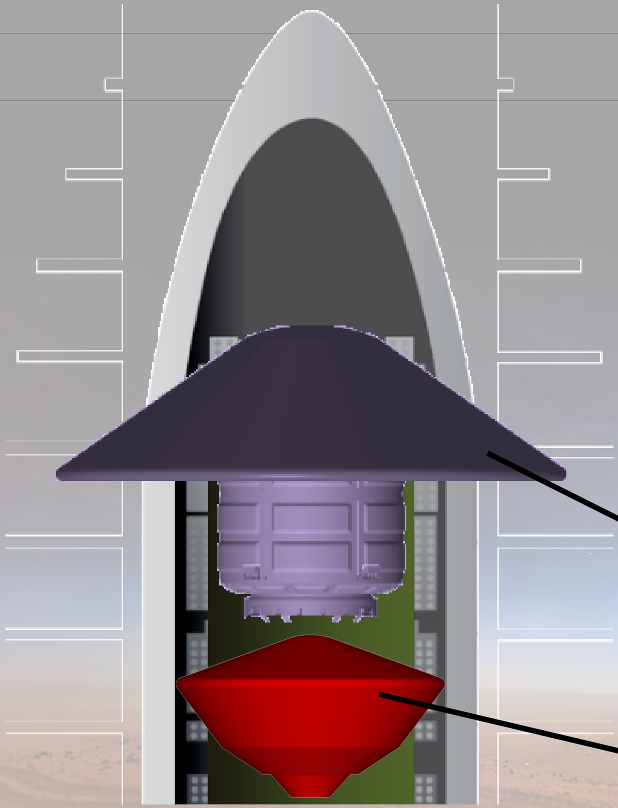
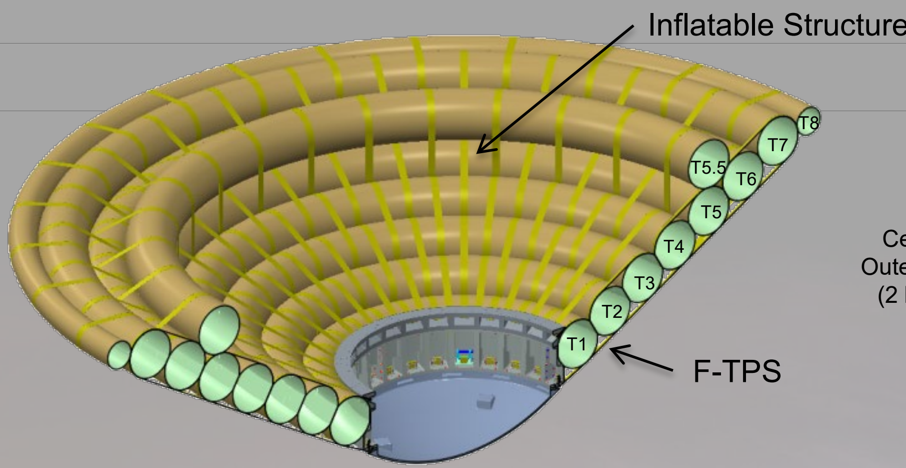
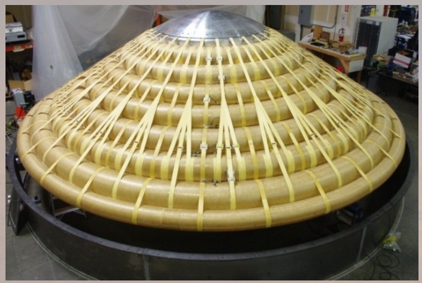


The inflatable heatshield is packed to a small diameter for launch, then deploys outside the atmosphere to full size.

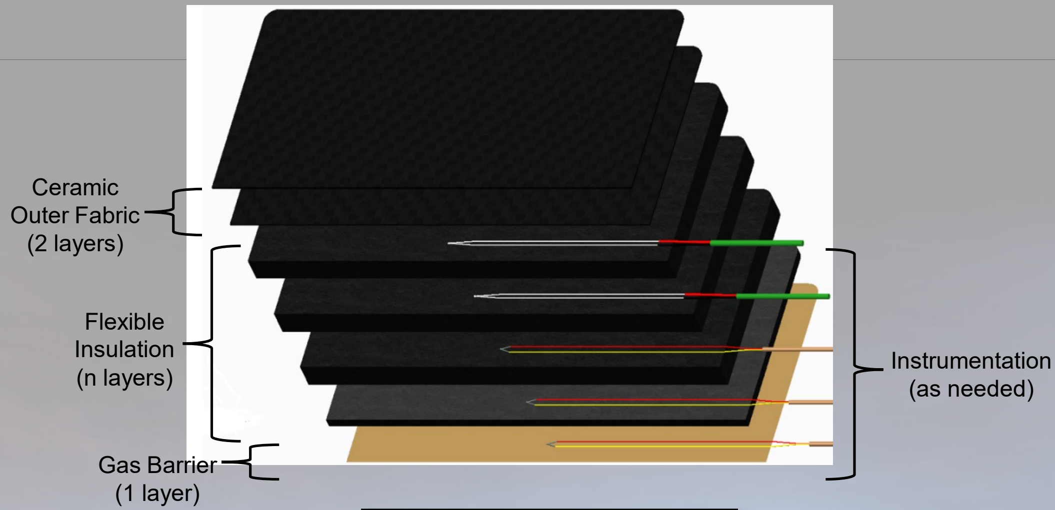
Anatomy of an Inflatable Heatshield

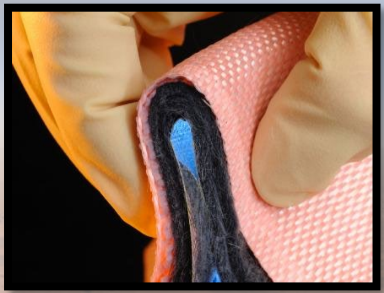
Inflatable Structure: Stacked torus design with straps to establish shape and distribute loads





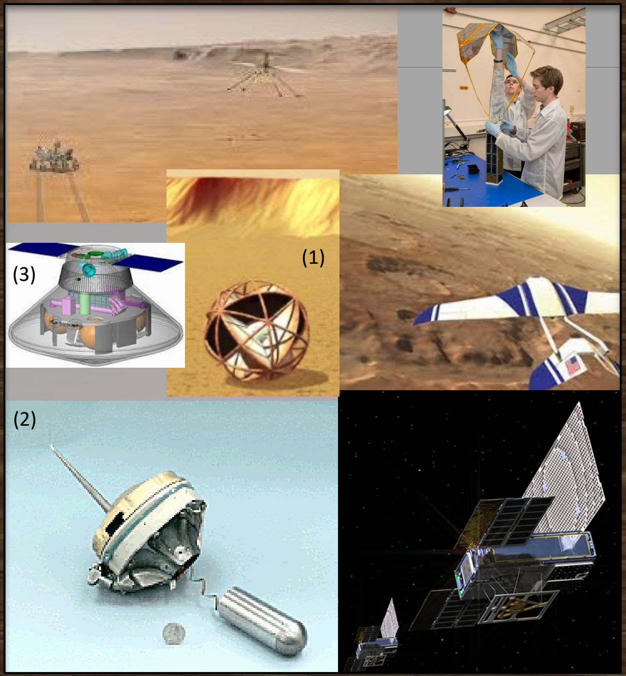
Flexible TPS: Robust high-temperature outer layer, tailorable multi-layer insulation, and flexible gas barrier to protect the structure from heating





What Does the Future Look Like?

Small, Science-Focused?



Large, Human-Forward?

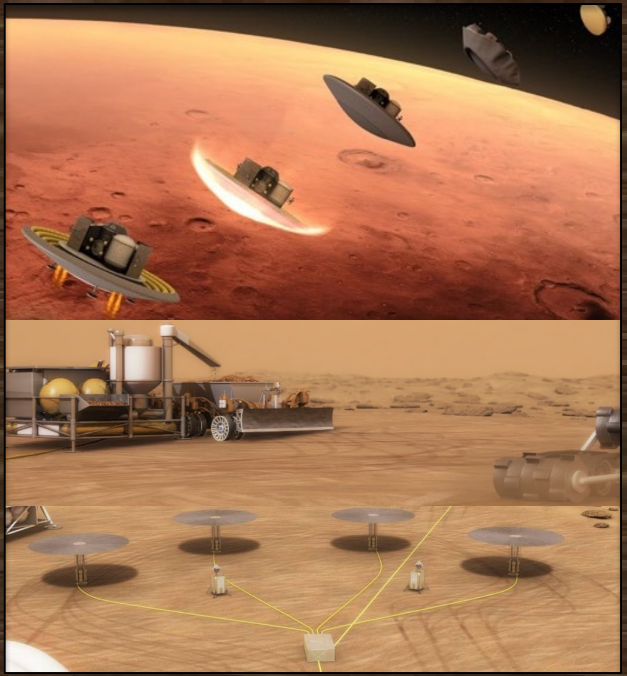


Image Sources: (1) https://www.lpi.usra.edu/meetings/marsconcepts2012/pdf/4142.pdf (2) https://nssdc.gsfc.nasa.gov/ (3) https://www.lpi.usra.edu/meetings/marsconcepts2012/pdf/4219.pdf

Summary

- **Mars landers have increased in size and complexity over the past 50+ years but are limited by Viking technology**
- **Challenges remain, for Mars Sample Return and beyond**
  – Increased mass
  – More precise landings
  – Higher altitude terrain
  – Access to hazardous locations
- **New EDL systems will be needed for landing humans and their cargo (large aeroshells, efficient propulsion)**
- **Numerous options exist for delivering small science payloads that may fill Strategic Knowledge Gaps**
  – Planetary CubeSats will play a prominent role
  – New delivery methods are worth consideration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MOON to MARS