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Planetary Probes as Precursors For a Human Mars Mission

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Probes Becoming Precursors

- **President of the United States has set a challenge of humans to Mars orbit by 2030s**
- **One possible scenario is humans to Mars orbit by 2033 followed by a landing in 2038**
- **That would leave 25 years from IPPW 10 to a human landing on Mars**
- **Key events on the road to a human landing**
  - Identification of a baseline EDL architecture to land humans safely
  - Development of the key EDL technologies to execute the architecture
  - Precursor missions to demonstrate developed EDL technologies
- **NASA has mandated all robotic Mars missions shall contribute toward a human Mars mission**
- **Arrived at the point where future robotic science mission planning merges with human precursor mission planning**

NASA's Mars Design Reference Architecture 5

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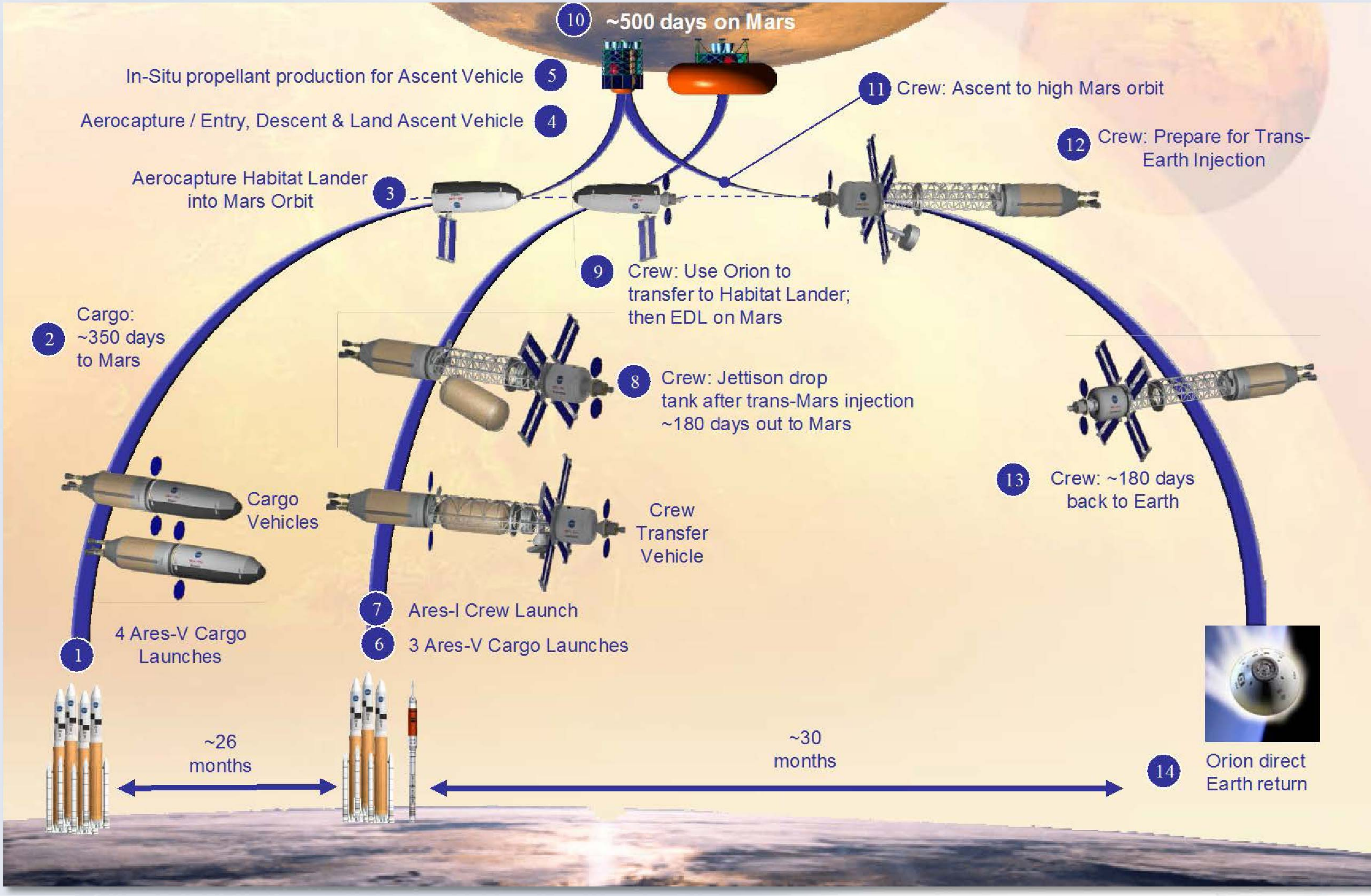

Current EDL Baseline Architectures

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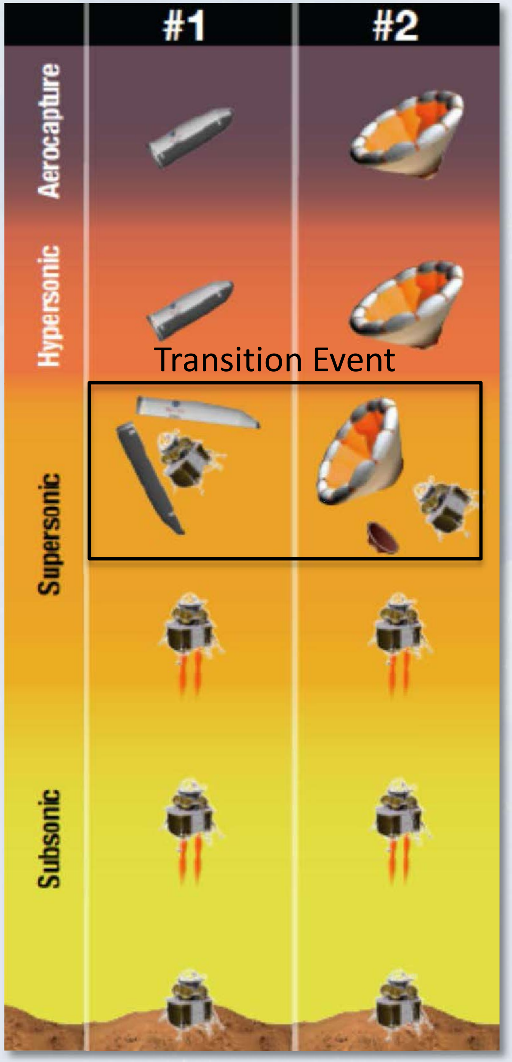
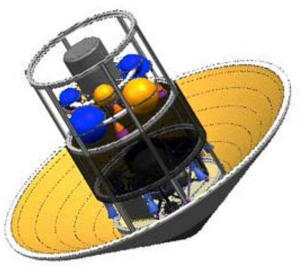
NASA EDL-SA Architectures



- **Element Masses**
  - 80 to 100 ton entry mass
  - 40 ton landed payload
- **EDL Sequence of Events**
  - **Entry** from Mars orbit at 4.8 km/s
  - **Hypersonic and supersonic** flight with aeromaneuvering for precision landing
  - **Transition event** from supersonic flight to powered descent under rocket power at about Mach 2 to Mach 3
  - Maneuvering for **precision landing** followed by **soft touchdown**

JPL TeamX HIAD Concept



23 m Diameter

10 x 30 m Mid L/D Aeroshell

NASA Habitat Lander Concept

NASA Cargo Lander Concept

NASA OCT EDL Roadmap

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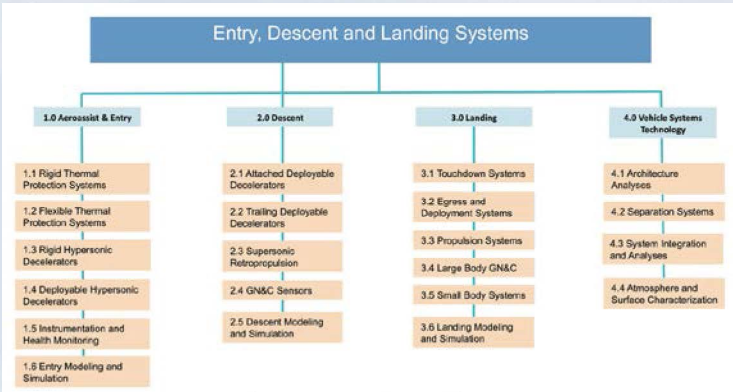
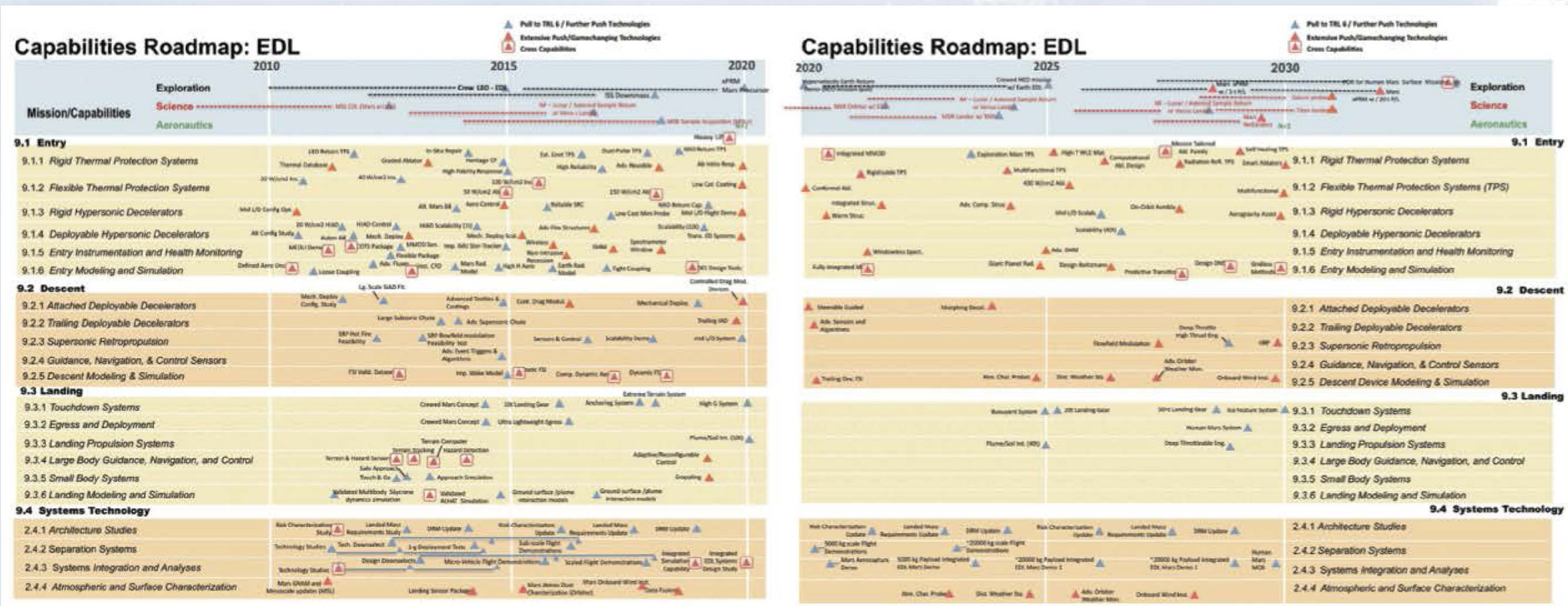


- **NASA Office of the Chief Technologist Technology Roadmaps**
  - EDL Roadmap – Technology Area 9
  - Charts out path for developing key EDL technology areas



Enabling EDL Technologies (1/2)

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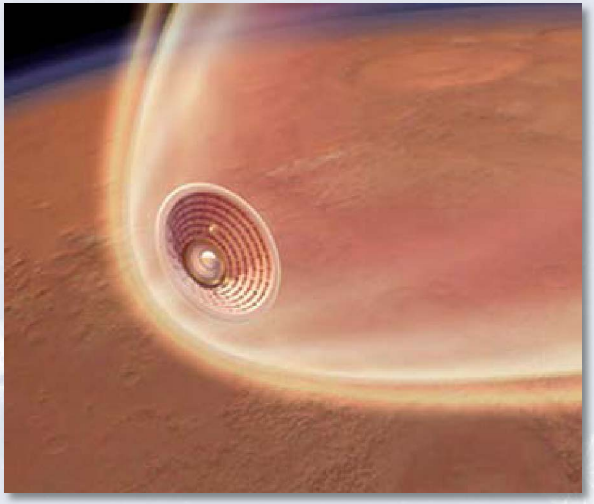
Thermal Protection Systems

- Dual-pulse capable TPS
- Flexible TPS for inflatables
  - Stowable & capable of 20-150 W/cm^2

Inflatable Decelerators

- HIAD for hypersonic deceleration
  - Guidance & control method challenges
  - Flexible structure leading to potential for fluid/structure interaction
- SIAD to augment supersonic deceleration
  - Augment separation events



HIAD Entry at Mars

SIAD Rocket Sled Test Apparatus

Enabling EDL Technologies (2/2)

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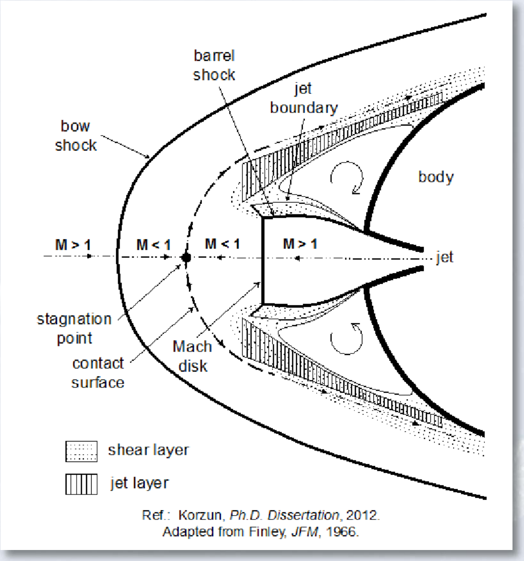
Supersonic Retro-Propulsion (SRP)

- Forces and torques from start up transients are a concern
- Structural dynamics induced in engine structure also a concern



SRP Fluid Structure

Deep Throttle Descent Engines

- Deep throttle engines required to allow both high thrust deceleration and low thrust soft touchdown

Plume-Soil Interaction / Site Alteration

- Potential of high thrust engines to significantly excavate surface

MSL Plume Site Excavation

Precursor Missions

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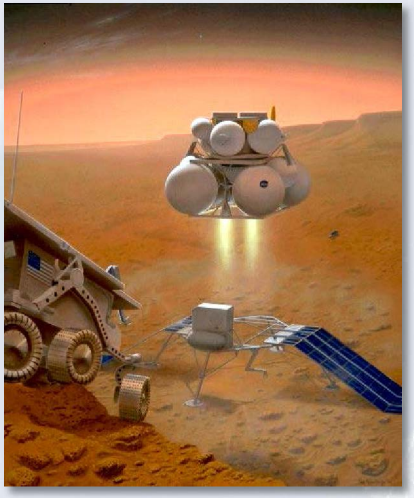
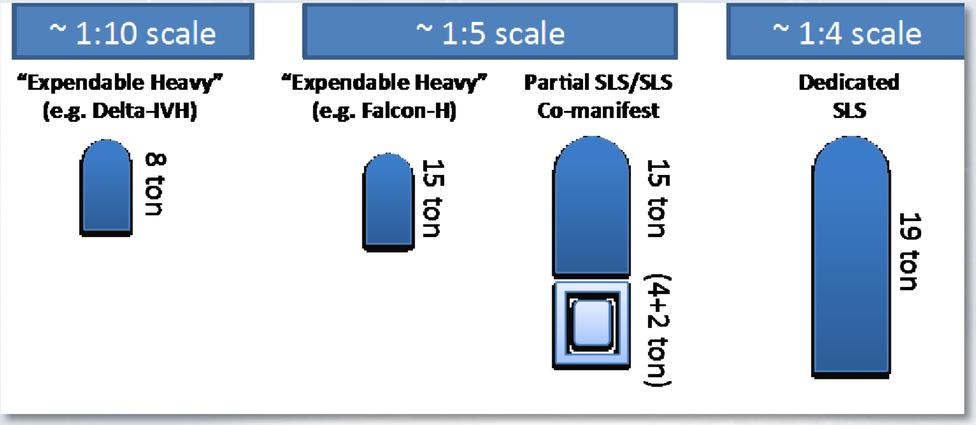
- **Future Mars Sample Return is generally viewed as having the potential to exercise many of the mission elements needed for a human mission**
  - Mars EDL
  - Mars Ascent
  - Potentially Mars in-situ resource utilization



Mars Sample Return Conceptual Design

- **Mars Sub-Scale Precursor Mission Concepts**
  - NASA HEOMD & SMD study
  - Traded three options
    - 1:10 scaling (Delta-IVH)
    - 1:5 scaling (Falcon H)
    - 1:4 scaling (Dedicated SLS)
  - Larger missions better



Precursor Missions Concepts – EDL Risk Reduction

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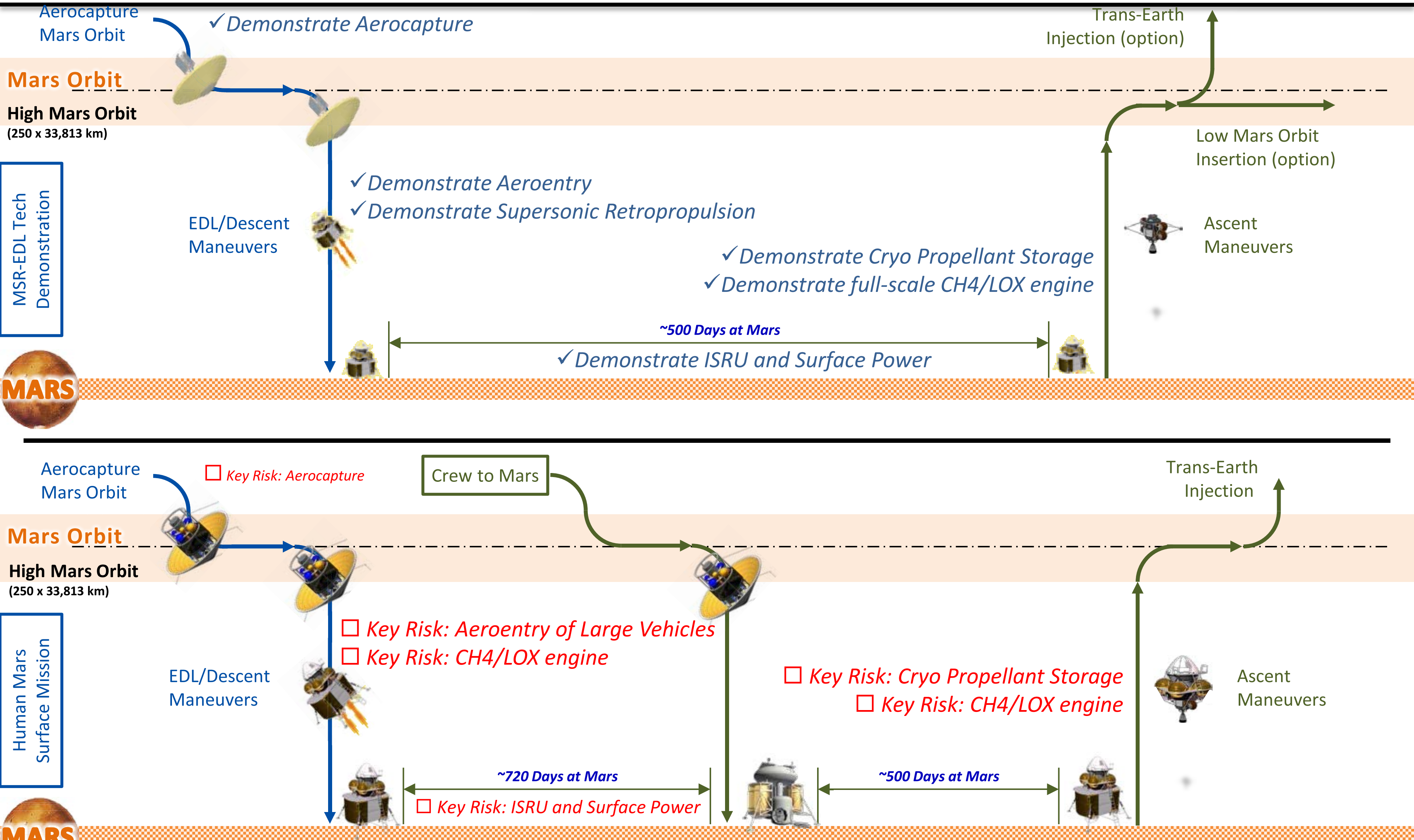

From Charles Whetsel, et al, *Collaborative Study Mars Sub-scale Precursor Mission Concepts*

Landed Mass Capability

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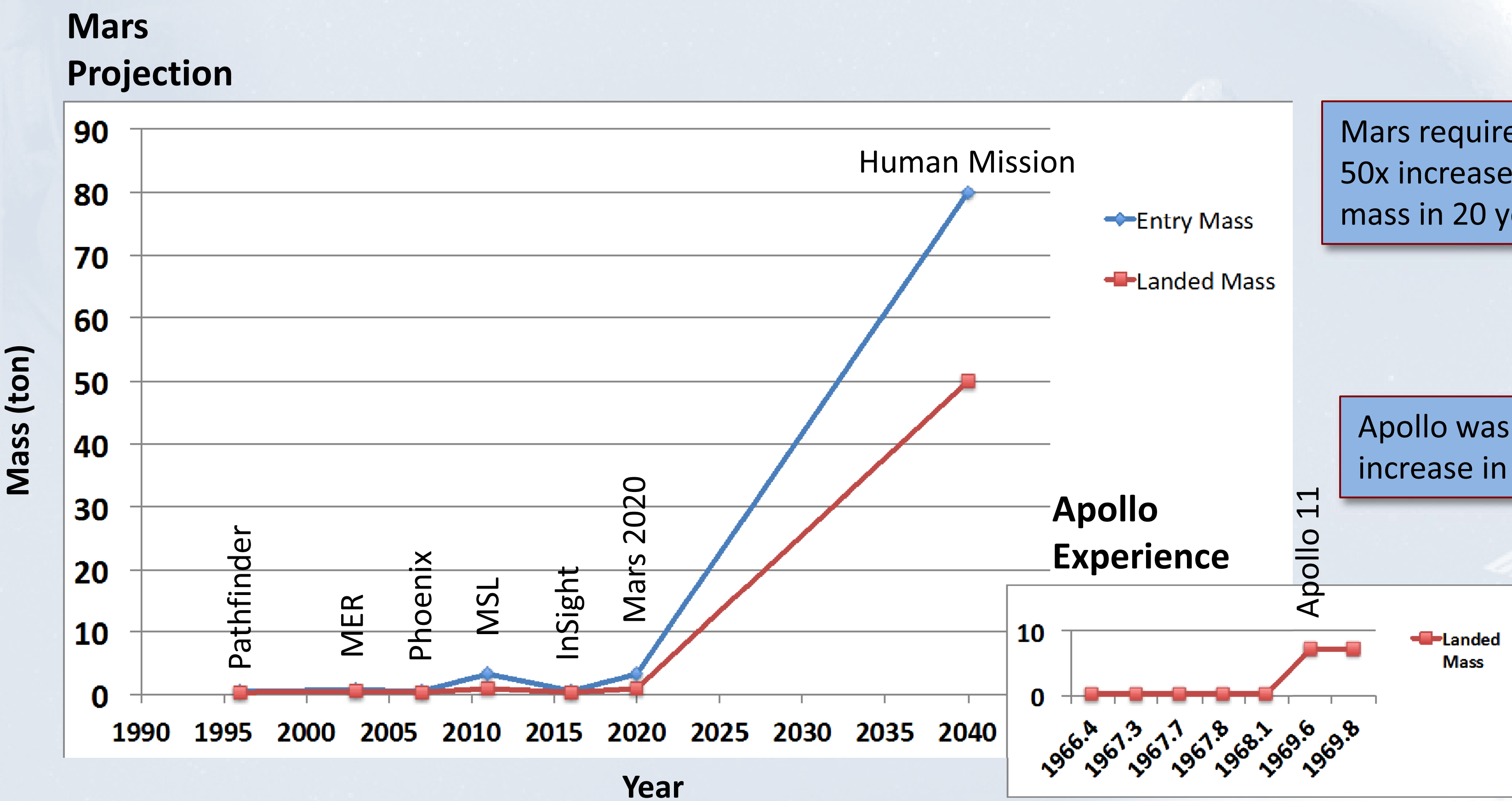
- **A significant increase in landed mass capability over the next 25 years is required for NASA's current human mission architecture**



Mars requires about 50x increase in landed mass in 20 years

Apollo was about a 24x increase in landed mass

Conclusions (Personal Opinion)

- **If we are truly planning to land humans on Mars in 25 years, robotic Mars landers must be the precursor missions**
  - Current NASA budget profile allows for only one path of technology development
  - Continue the current science driven missions and combine with human mission technology development objectives
- **If we are to build off our current capability, the first human Mars landers must be reasonable in size**
  - There are not enough flight opportunities in the next 25 to robustly develop and demonstrate the massive systems envisioned by the current NASA reference architecture
  - Additionally, human Mars landers must have a clear evolutionary path from today's EDL systems
    - Favors blunt body style human mission entry systems

Any viable strategy should be developed in the context of the international space community

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Discussion