Viability of a 2033 Crewed Mars Orbital Mission

The Humans to Mars Summit
May 17, 2023

Hoppy Price
Jet Propulsion Laboratory
California Institute of Technology

Example vehicle rendering courtesy of Boeing

Note: This is a JPL internal study, and does not represent NASA planning

Is There Still Time to Implement a 2033 Mission?

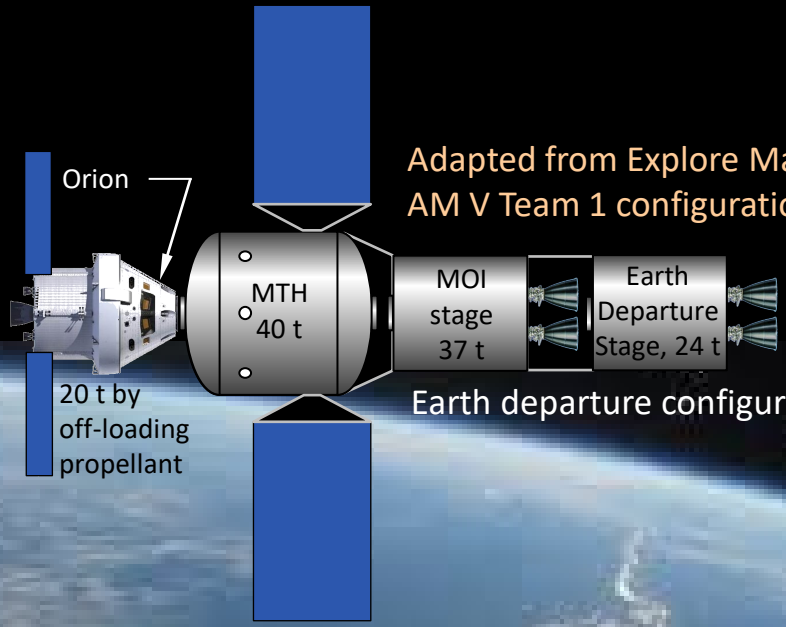
- What vehicles are on track to be available for 2033?
  - SLS Block 2
  - Orion
  - Heavy lift commercial launch vehicles (e.g. Falcon Heavy)
- What else would need to be developed for a minimal mission?
  - Current technology space storable chemical propulsion stages could perform the mission
  - A Mars Transit Habitat (MTH) capable of supporting a crew of 4 for a 1.6 to 2.6 year mission would need to be developed
    - This is probably the driving challenge for the mission
    - The MTH design should be flight tested in Earth orbit or at Gateway
    - Extended crewed missions at Gateway would be needed to characterize galactic cosmic radiation health effects
- The Apollo Program went from zero to Apollo 8 in 9 years
- We would have 9 years to develop a 2033 orbital mission
  - (A lander would come later for follow-on missions)
- The effort would need to start ASAP

Notional Mission Scope with Fallback Options

- As a starting point, the project could be scoped for a 2033 short-stay Mars orbital mission with Venus flyby
  - 1.6 year total duration
  - 13 Falcon Heavy class commercial launches in this example
  - 4 SLS Block 2 launches
- A fallback descope could be to a 2033 long-stay Mars orbital mission (no Venus flyby)
  - 2.6 year total duration
  - 5 Falcon Heavy class commercial launches
  - 3 SLS Block 2 launces
- If schedule ends up not being met, the 2.6 year long-stay mission could gracefully slip to 2035 or 2037 with the same vehicle set
- Another descope could be to a 2033 short duration Mars flyby mission
  - 1.5 year duration (no Venus flyby)
  - 4 Falcon Heavy class commercial launches in this example
  - 3 SLS Block 2 launches
- There is a 2035 short duration backup flyby opportunity available
  - 1.6 year mission includes Venus flyby; requires less ΔV than the 2033 flyby mission
- If there are mass issues, the crew could be descoped to 3

Concept for Humans to Mars Orbit in 2033

- Would minimize development & mission risk with less complex systems
  - Current technology hypergolic chemical propulsion (affordable and reliable)
- Launched in segments by SLS and commercial rockets
- Assembled in high Earth orbit or at Gateway
- Crew would return directly to Earth in Orion capsule
- 2033 offers a unique short-stay orbital mission (~1.6 year total duration)
  - The first crew to travel to both Mars and Venus
  - Not a “one-off”, but a crew transport pathfinder for landing missions to follow



Adapted from Explore Mars AM V Team 1 configuration

Earth departure configuration for crew

- MTH assumptions are based on:
  - “Transit Habitat Design for Mars Exploration”, Polsgrove et al, 2018
  - Masses adjusted for propulsion, EVA support, robotic systems, and leveraging Orion facilities

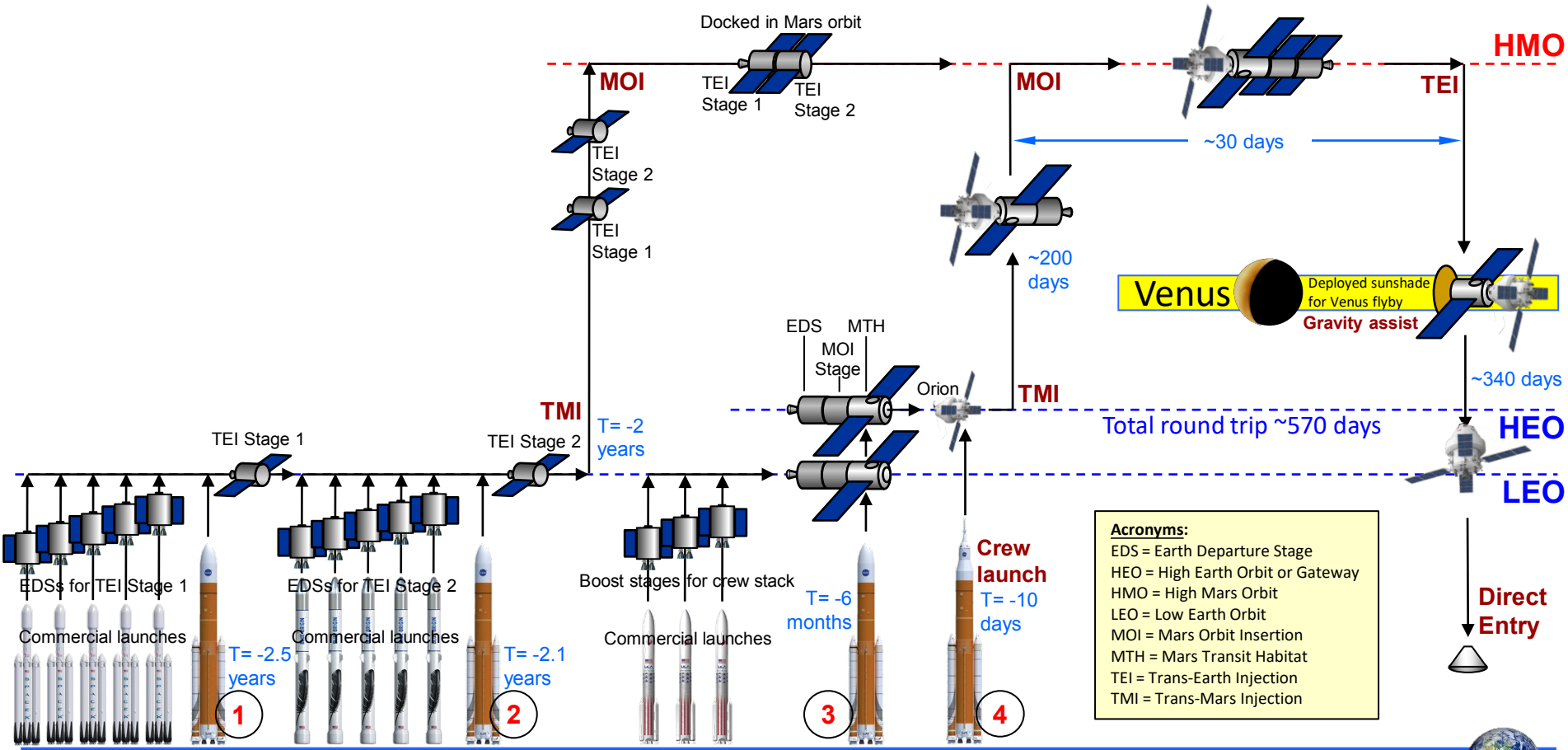
2033 Short-Stay Mars Orbital Mission Concept

Crew of 4; 570 day round trip

4 SLS launches
13 commercial launches

This mission concept example utilizes 17 low-cost conventional hypergolic propulsion stages with a common design (with 3 different tank lengths), possibly using RS-72 or XLR-132 (AR31) engines.

Mars



Earth

Long-Stay Mars Orbital Mission Option

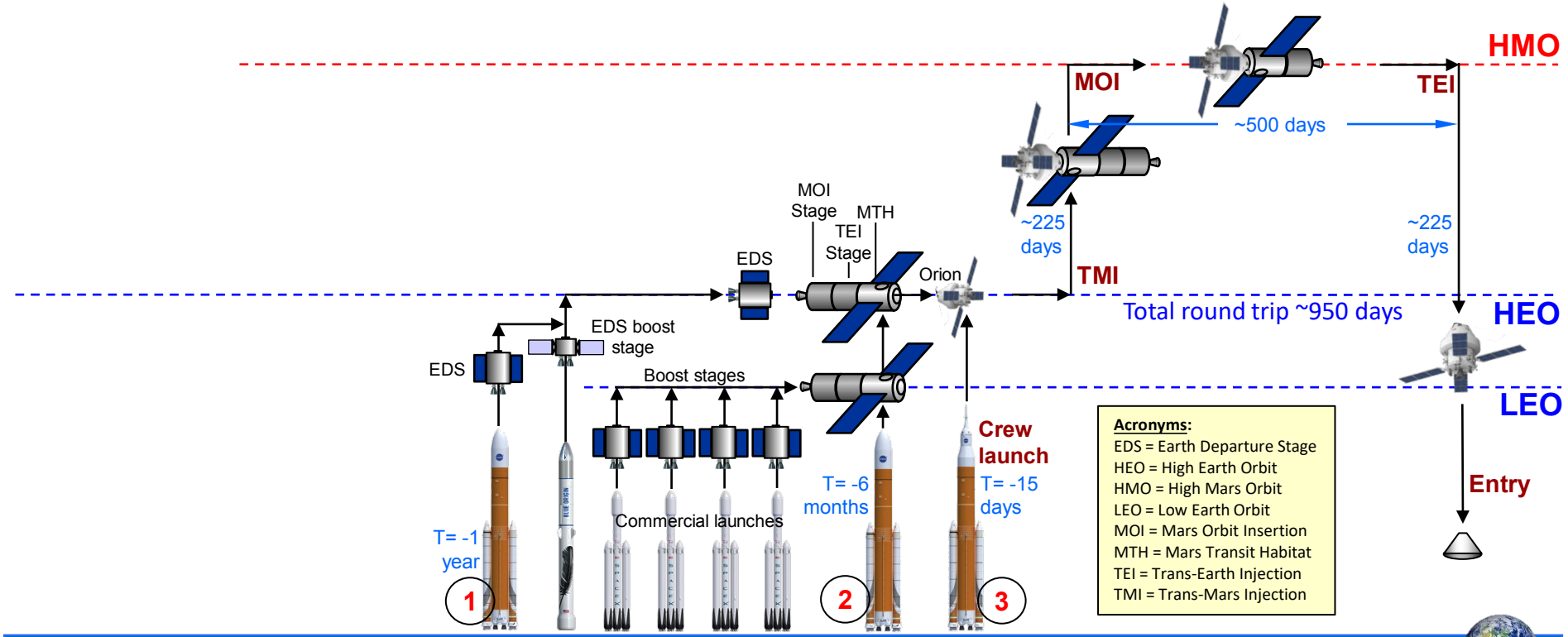
Crew of 4; ~950 day round trip

3 SLS launches
5 commercial launches

This mission concept uses 8 biprop stages of a common design, with 3 different versions of tank lengths.

Mars

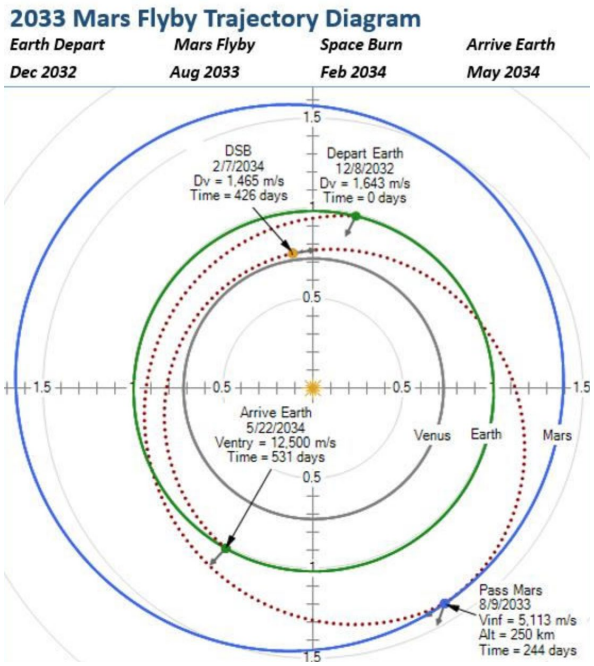
Nothing is pre-positioned in Mars orbit, and no Mars orbit rendezvous would be required for this mission design.

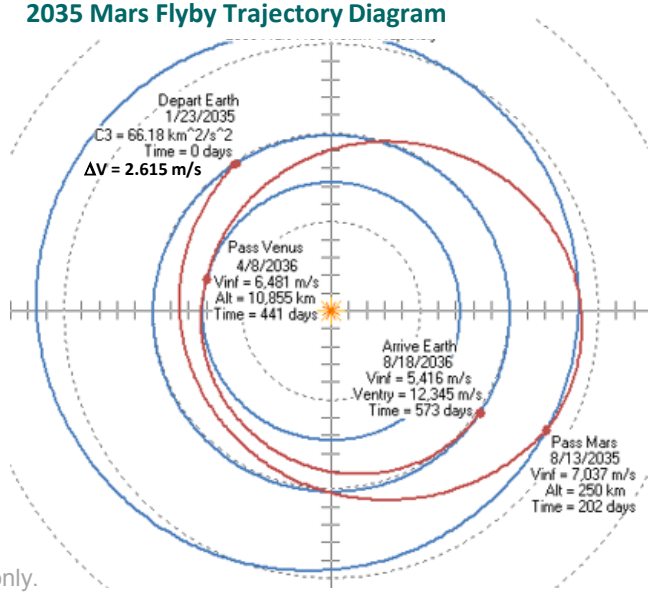


Earth

2033 Short Duration Mars Flyby Mission

- Based on Boeing study for 530 day mission (modified version of their Case 5)
- With conventional space storable chemical propulsion for the Earth Departure Stage (EDS) and the Deep Space Burn (DSB) stage, the following launches would be required in this example:
  - 3 SLS launches (incl. Orion launch with crew)
  - 4 Falcon Heavy class commercial launches
- Should the schedule slip, a 2035 backup short duration Mars flyby mission opportunity is available which includes a Venus flyby

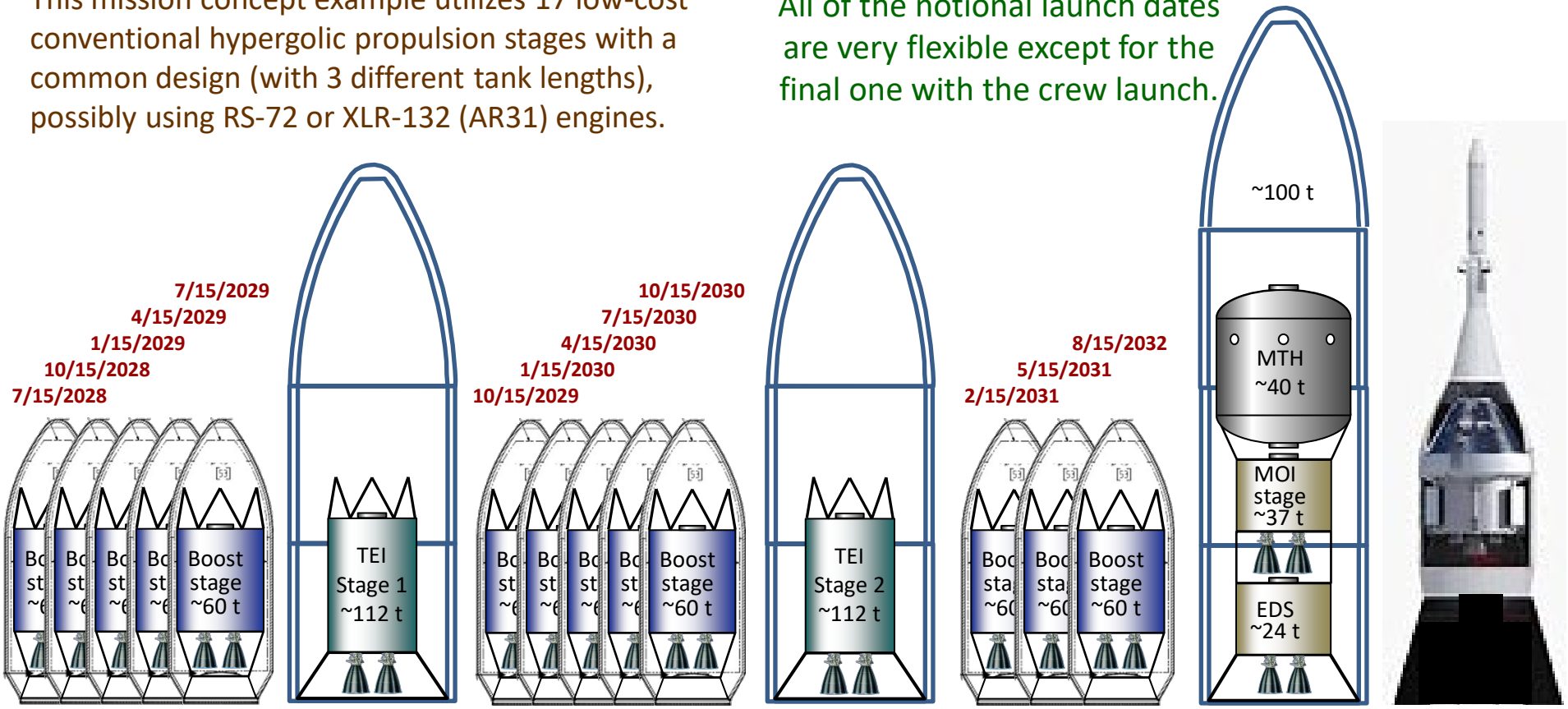




SLS Block 2 and Commercial Launch Concepts for 2033 Mars Orbit 1.6 year Mission

This mission concept example utilizes 17 low-cost conventional hypergolic propulsion stages with a common design (with 3 different tank lengths), possibly using RS-72 or XLR-132 (AR31) engines.

All of the notional launch dates are very flexible except for the final one with the crew launch.



5 commercial launches to LEO of EDS stages for TEI Stage 1

TEI stage 1 to LEO
SLS Launch #1
5/15/2030

5 commercial launches to LEO of EDS stages for TEI Stage 2

TEI stage 2 to LEO
SLS Launch #2
11/15/2030

3 commercial launches to boost crew stack to HEO

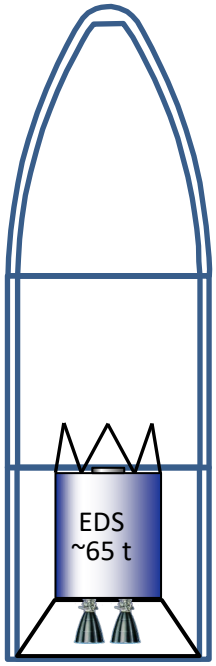
Integrated Mars transit stack to LEO
SLS Launch #3
10/15/2032

Orion with crew for docking with MTH in HEO
SLS Launch #4
4/15/2033

SLS Block 2 and Commercial Launch Concepts for Mars Orbit 2.6 year Mission

This mission concept example utilizes 8 low-cost conventional hypergolic propulsion stages with a common design (with 3 different tank lengths), possibly using RS-72 or XLR-132 (AR31) engines.

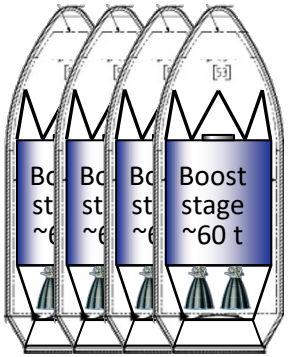
All of the launch dates are very flexible except for the final one with the crew launch.



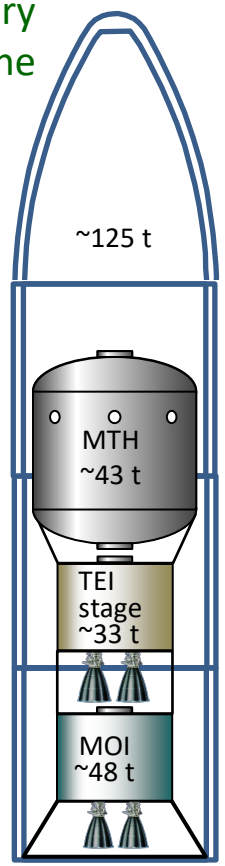
Earth Departure Stage (EDS) to MEO

SLS Launch #1

Commercial launch to MEO of boost stage for EDS



4 commercial launches to LEO of boost stages for transit stack



Integrated Mars transit stack to LEO

SLS Launch #2

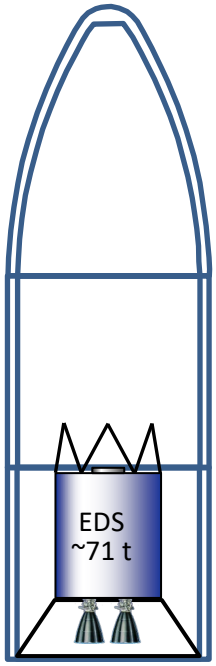
Orion with crew for docking with MTH in HEO

SLS Launch #3

SLS Block 2 and Commercial Launch Concepts for 2033 Mars Flyby 1.5 year Mission

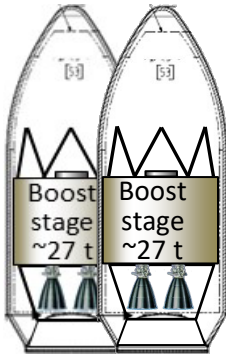
This mission concept example utilizes 6 low-cost conventional hypergolic propulsion stages with a common design (with 2 different tank lengths), possibly using RS-72 or XLR-132 (AR31) engines.

All of the launch dates are very flexible except for the final one with the crew launch.

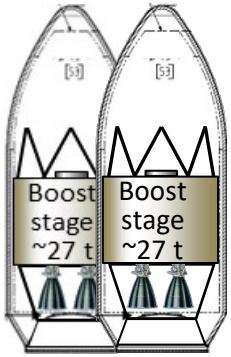


Earth Departure Stage (EDS) to MEO

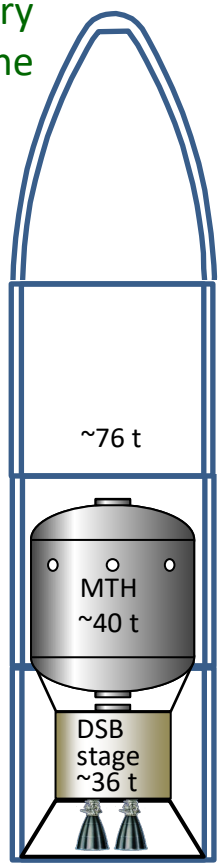
SLS Launch #1



2 commercial launches to MEO of boost stages to position EDS in HEO



2 commercial launches to MEO of boost stages to position transit stack in HEO



Integrated Mars transit stack to MEO

SLS Launch #2

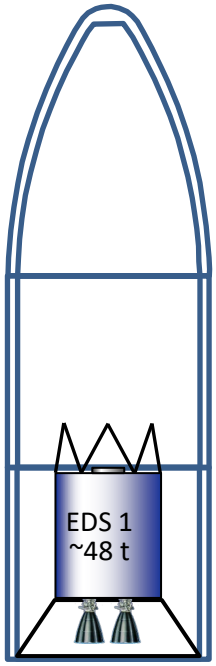
Orion with crew for docking with MTH in HEO

SLS Launch #3

SLS Block 2 and Commercial Launch Concepts for 2035 Mars and Venus Flyby 1.6 year Mission

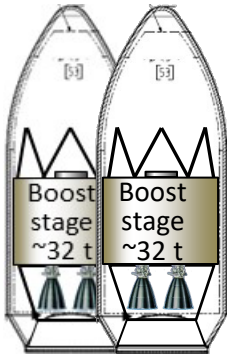
This mission concept example utilizes 4 low-cost conventional hypergolic propulsion stages with a common design (with 2 different tank lengths), possibly using RS-72 or XLR-132 (AR31) engines.

All of the launch dates are very flexible except for the final one with the crew launch.

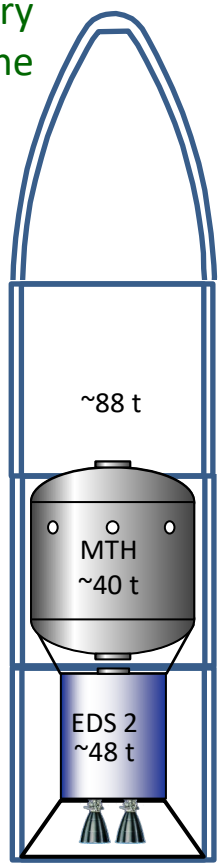


Earth Departure Stage 1 (EDS 1) to HEO

SLS Launch #1



2 commercial launches to MEO of boost stages to position transit stack in HEO



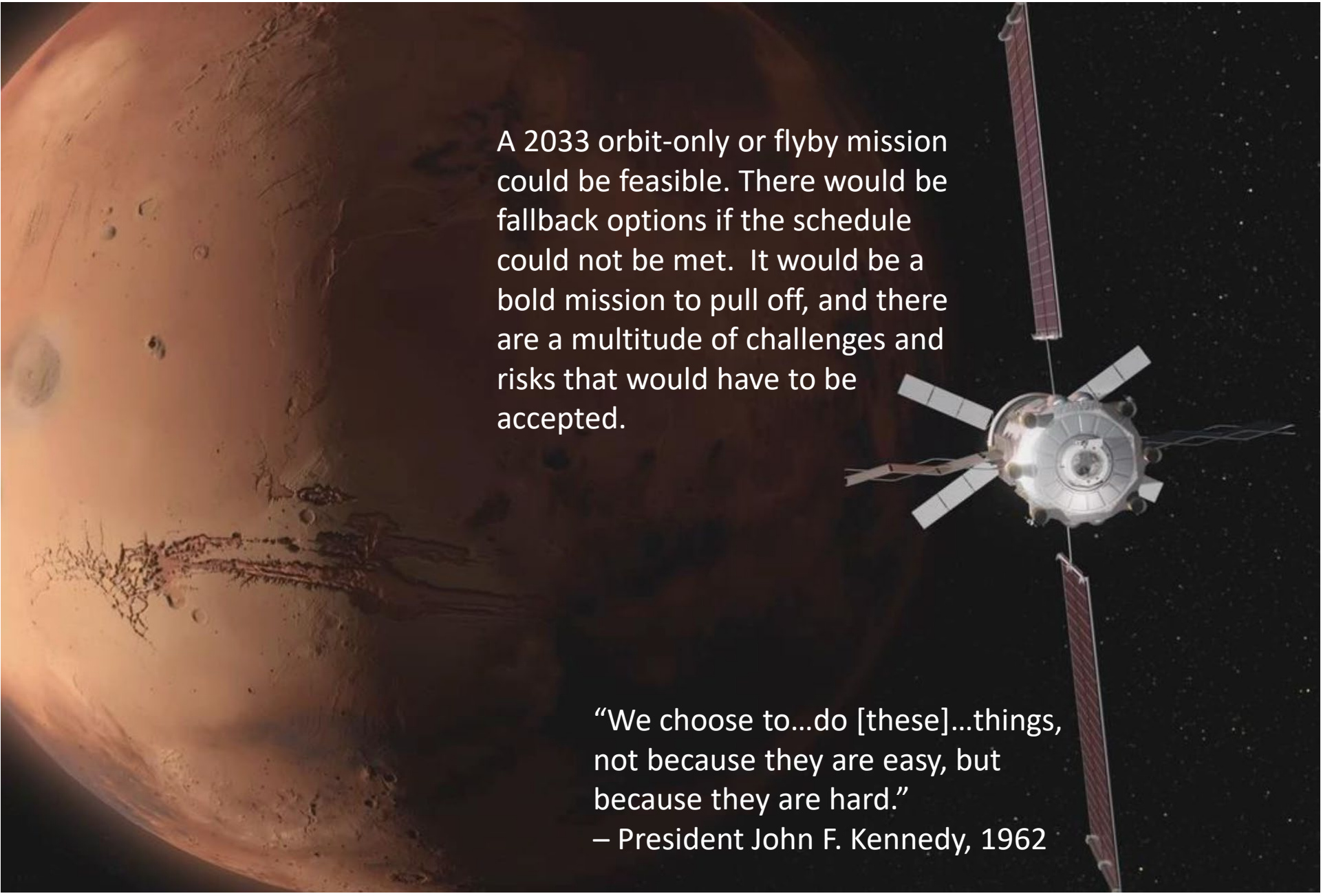
Mars transit stack to MEO

SLS Launch #2

Orion with crew for docking with MTH in HEO

SLS Launch #3

This is probably the most feasible of all of the options.



A 2033 orbit-only or flyby mission could be feasible. There would be fallback options if the schedule could not be met. It would be a bold mission to pull off, and there are a multitude of challenges and risks that would have to be accepted.

"We choose to…do [these]…things, not because they are easy, but because they are hard."
– President John F. Kennedy, 1962

Image courtesy of Boeing