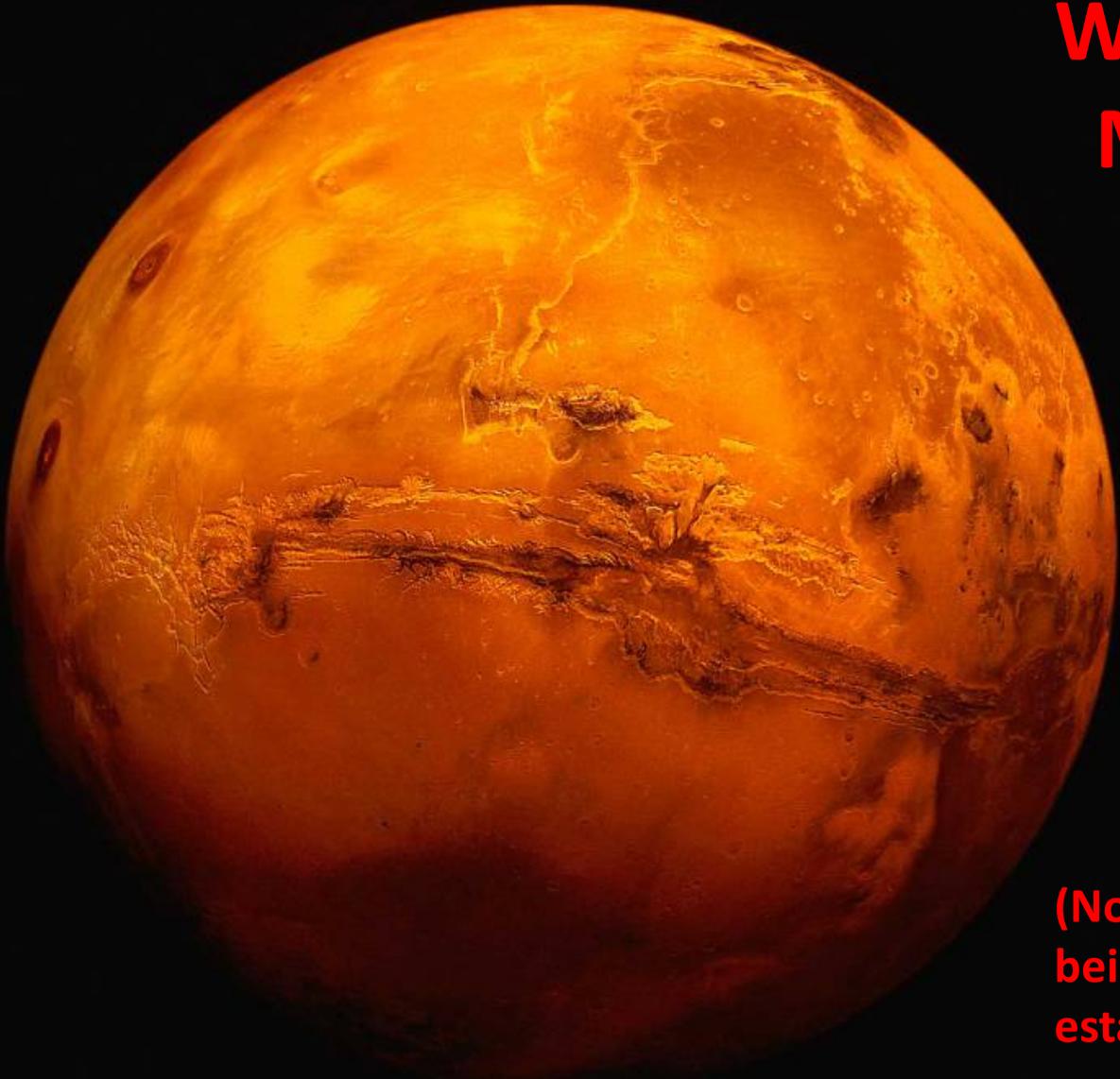




Surprising Advances in the Human Settlement of Mars



Who are planning Manned Missions to Mars?

United States Interests

NASA – US Government / Boeing

SpaceX – Private

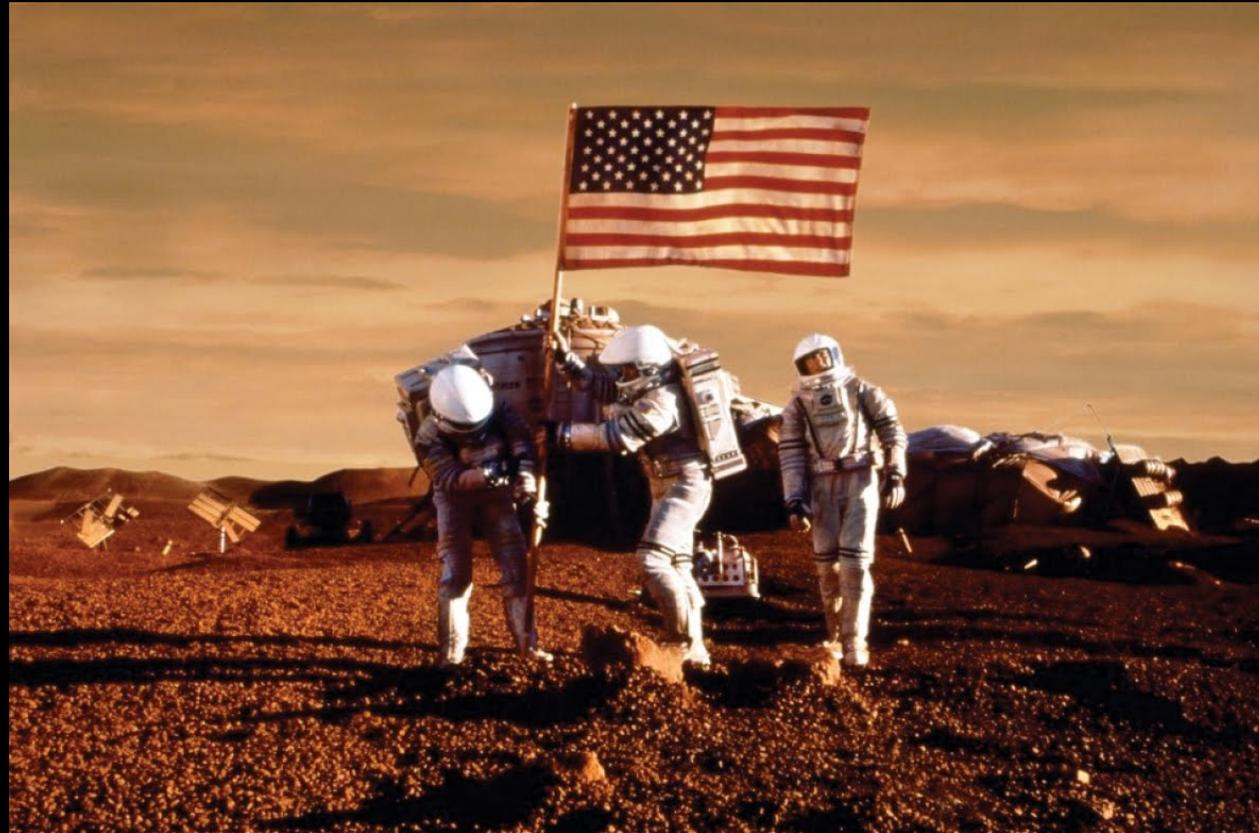
Inspiration Mars – Private Fly-by

Netherlands Entity

Mars One – Private One Way Mission

(No known manned Mars missions are currently being planned by Russia or China. They have established Lunar base plans.)

Who Will Win the Race to Mars?



It will probably be from the United States
SpaceX – substantially leads the pack

Advertised Manned Mission Target Dates



SpaceX – First Manned Mission – 12 Astronauts – 2026 – A Decade Ahead of NASA

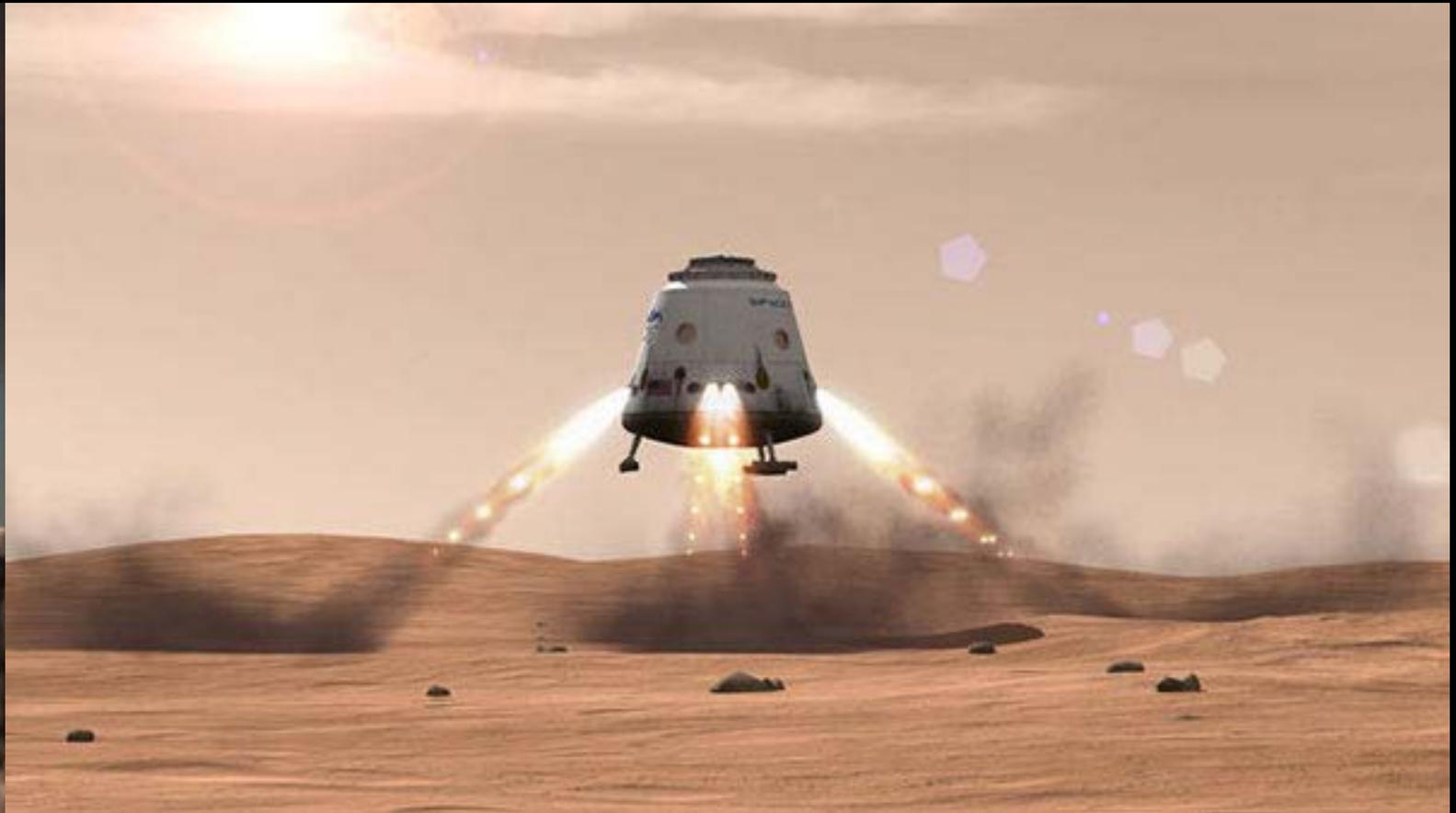
NASA – First Manned Mission – 2037-2045 – Crew Size 4-6

Mars One – One Way Crew of 4 – 2032 Estimated **

Inspiration Mars Fly-by Crew of Two Married Astronauts – 2021 **

(**Very vague estimates based on unsecured funding)

SpaceX Launching First Unmanned Mars Mission - 2018



Primary purpose of mission – to test SpaceX Dragon hardware and landing technologies.

2018 - Hypersonic Thrust Reversal on Mars





What is the Significance of the Unmanned SpaceX Landing on Mars in 2018?

1st Private Landing on Mars*

1st Man Rated Vehicle on Mars

1st In A Series of Human Colony Logistics Flights

Red Dragon Weight on Landing – 20,000 pounds

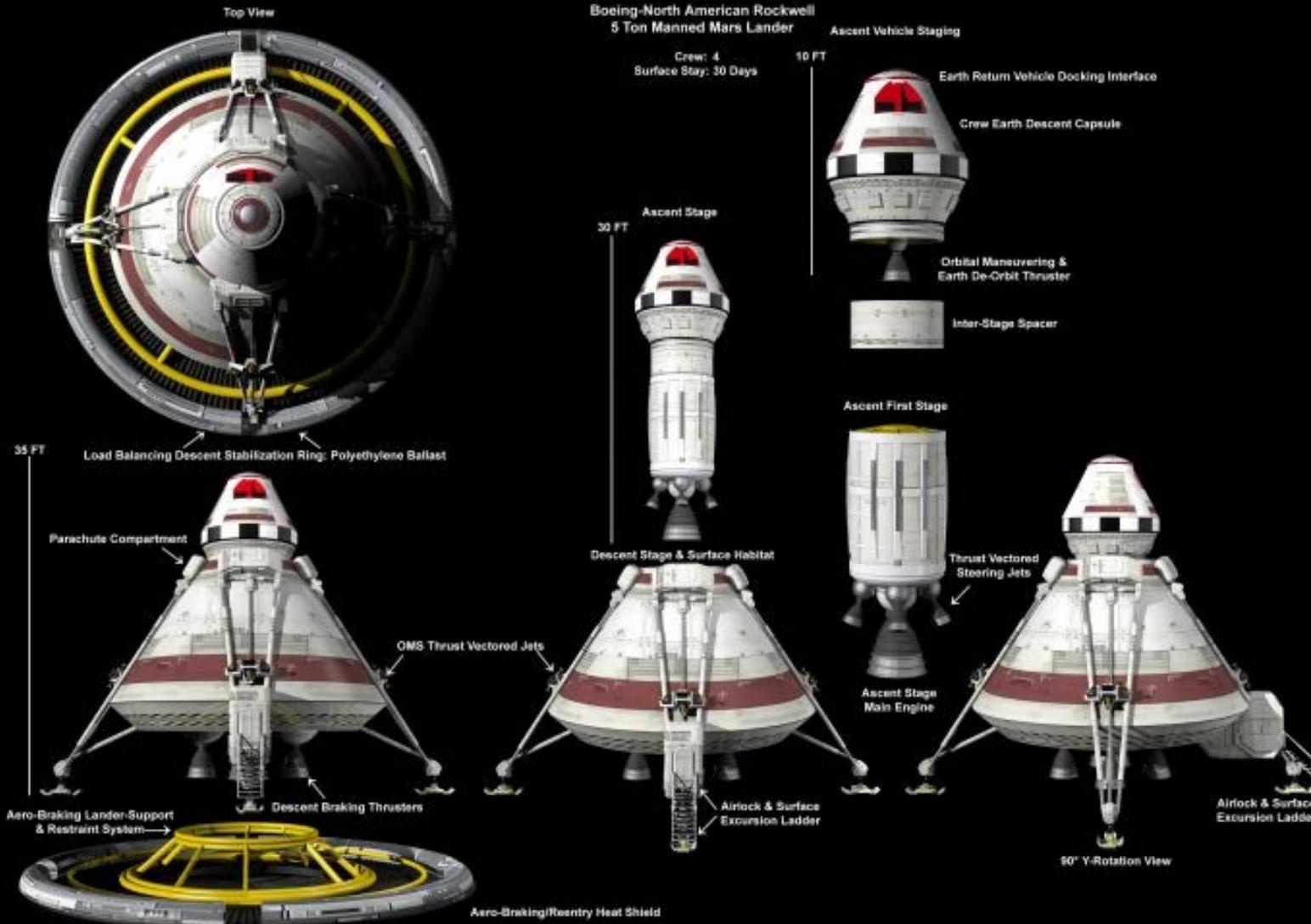
(Mars Curiosity Lander – 2,000 pounds)

Estimated Cost of Red Dragon Mission - \$300 million - \$15,000 / pound

(Curiosity Mission Cost: \$2.5 billion - \$1.25 million / pound)

*NASA offering SpaceX technical assistance only without any direct funding.

Boeing Mars Exploration Planning

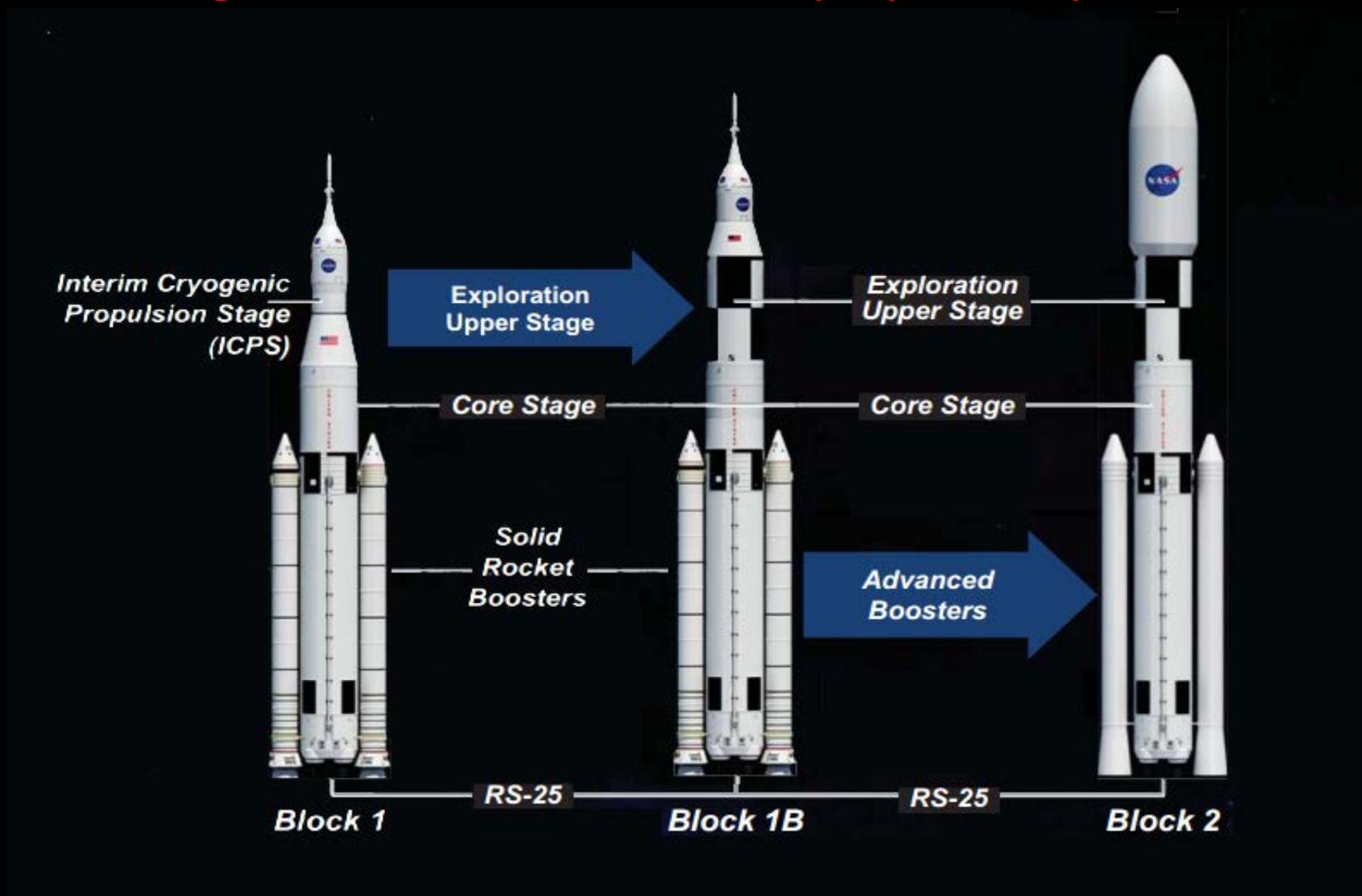


Boeing CEO Dennis Muilenburg says his company plans to beat Musk's SpaceX to the Red Planet.

"I'm convinced that the first person to step foot on Mars will arrive there riding on a Boeing rocket," he told an innovation conference in Chicago.

– October 2016

Boeing Developing NASA's SLS Rocket System Designated for Mars and Deep Space Expeditions



Unanswered Questions

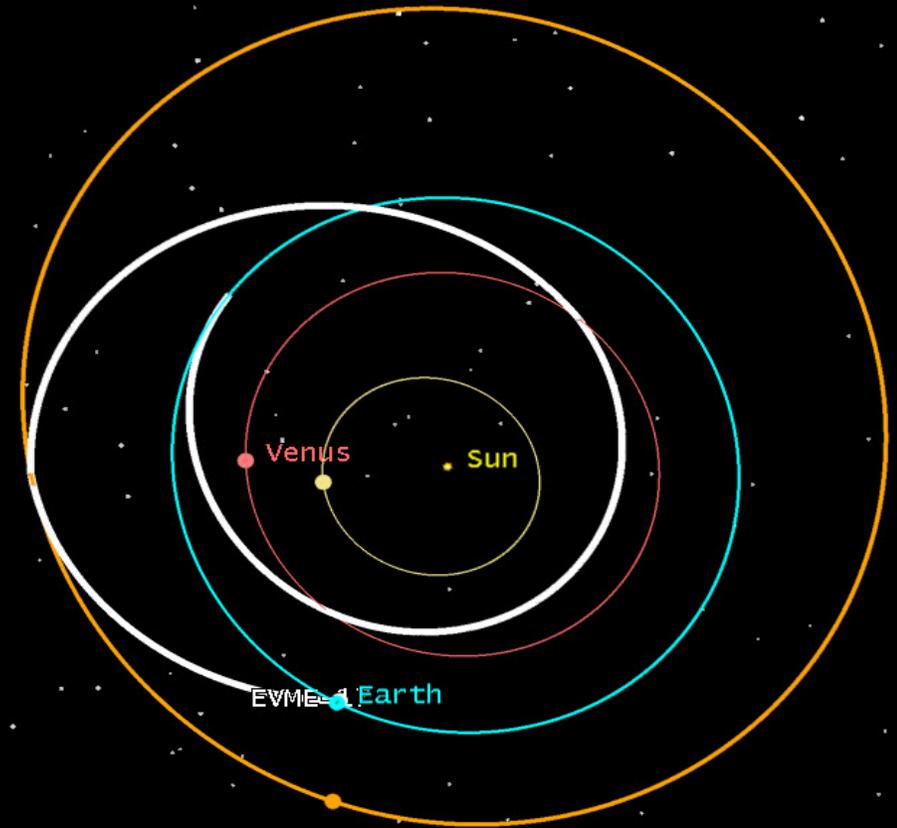
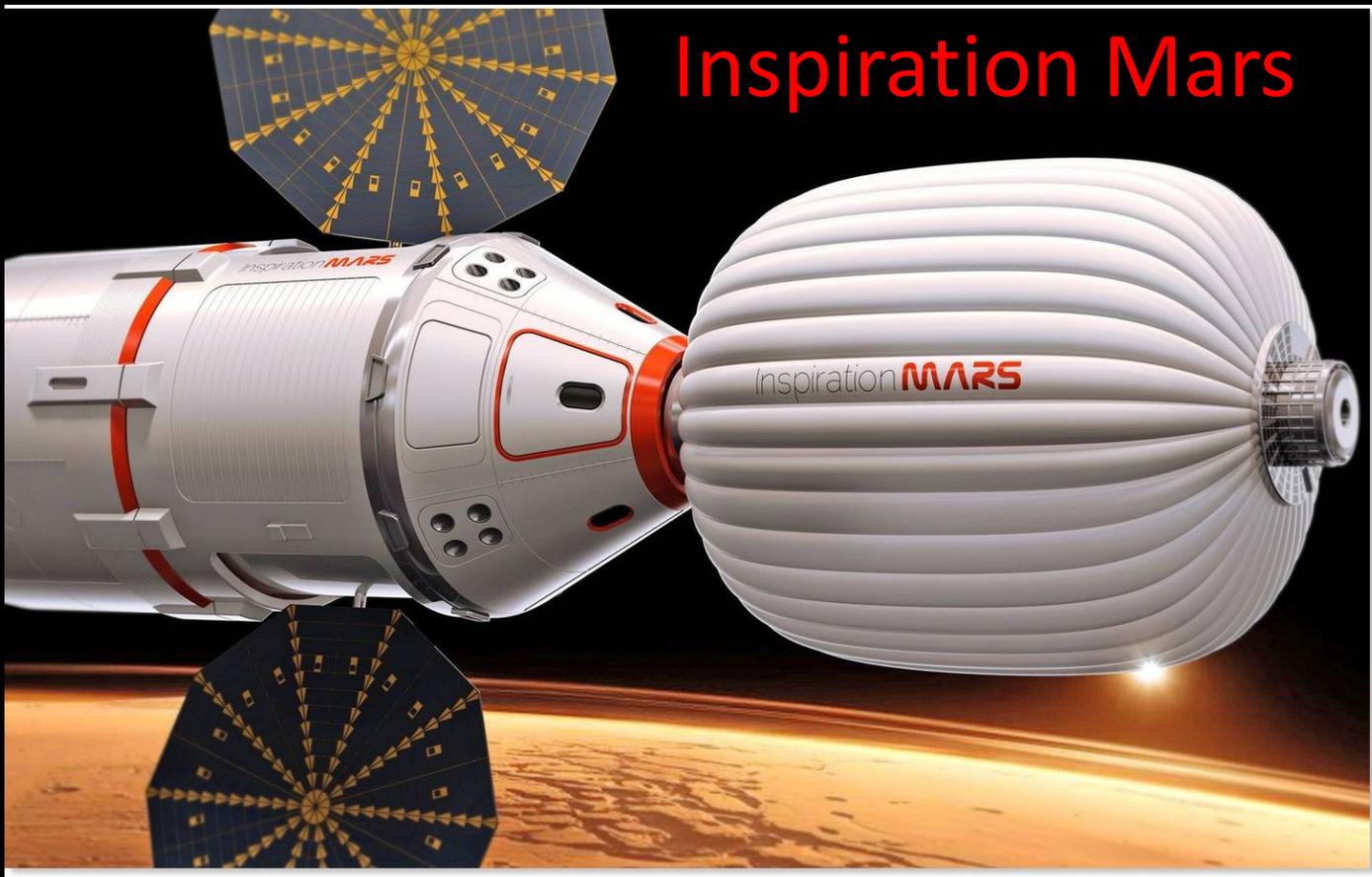
Who pays for the Boeing Mission?

Is the Boeing Mission the same as the NASA Mission?

Will Boeing integrate a booster recovery component?

What are the projected landing dates?

Who pays for development of the Boeing Mars architecture?



Private Mars Fly-By Mission – Scheduled for 2021 – funding not yet realized.
Liftoff with NASA's Space Launch System with a modified Orion capsule on Nov. 22, 2021,
with a Venus flyby in April 2022,
a Mars flyby in October 2022,
and then a return to Earth on June 27, 2023.

582 Days in deep space. (Longest space mission now 438 days in LEO)
(Probability of 2021 launch – very low due to NASA equipment development,
funding and extended mission crew health data.)

Mars One



Led by Dutch Billionaire – Bas Lansdorp

One way crewed missions for permanent colonization

First crewed mission – 2032 – Four Astronauts Flying Exclusively on SpaceX Hardware

Funding sources: Crowd Funding, European Stock Consortium, and Reality TV

Timeline already slipped 10 years

Probability – low due to funding and mission architecture.



NASA Pros: Funding stream; unparalleled proven technology base and experience; world's only proven track record of Mars exploration

NASA Cons: Congressional funding limits; political leverage; expensive space architecture; costly overhead; burdensome processes and procedures (time challenge); and NASA Mars Architecture Hardware is still in planning phase – very little existing hardware.



SpaceX Pros: Very lean organization; very efficient cost and process focus; the entire SpaceX space architecture was designed for Mars missions from the first day

SpaceX Cons: Schedule is very success driven; funding limited and heavy reliance on other space launch business; developing new architecture on the fly is inherently a highly risky business; any corporate mission failure leads to extension of mission plans; and - SpaceX Mars Architecture is still in planning phase – still developing Mars hardware.

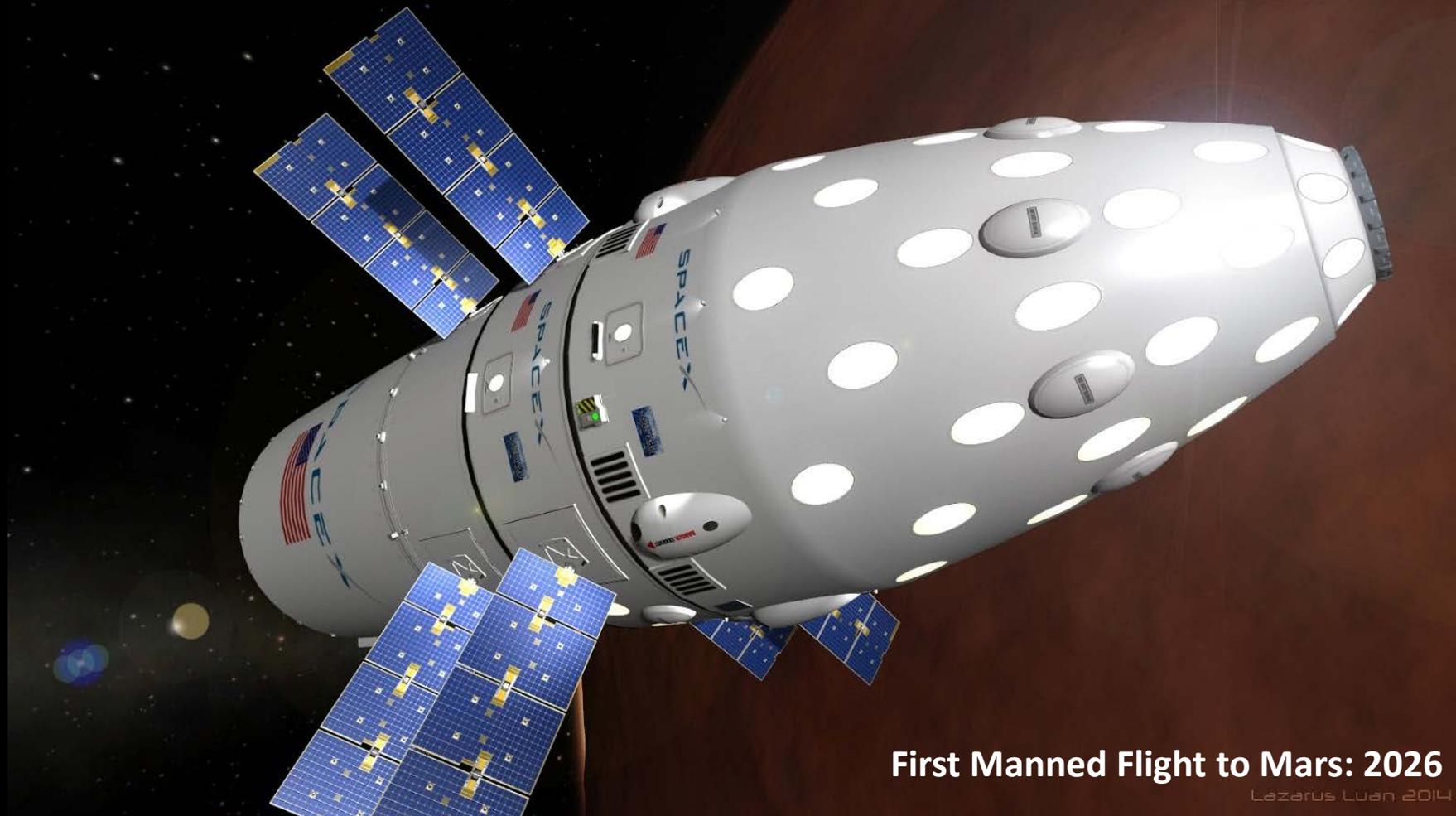
The Great Difference Between SpaceX and NASA Mars Planning

NASA Plans to Build an Outpost

Much Like a Planetary ISS

With Relatively Small Rotating Crews (6-10)

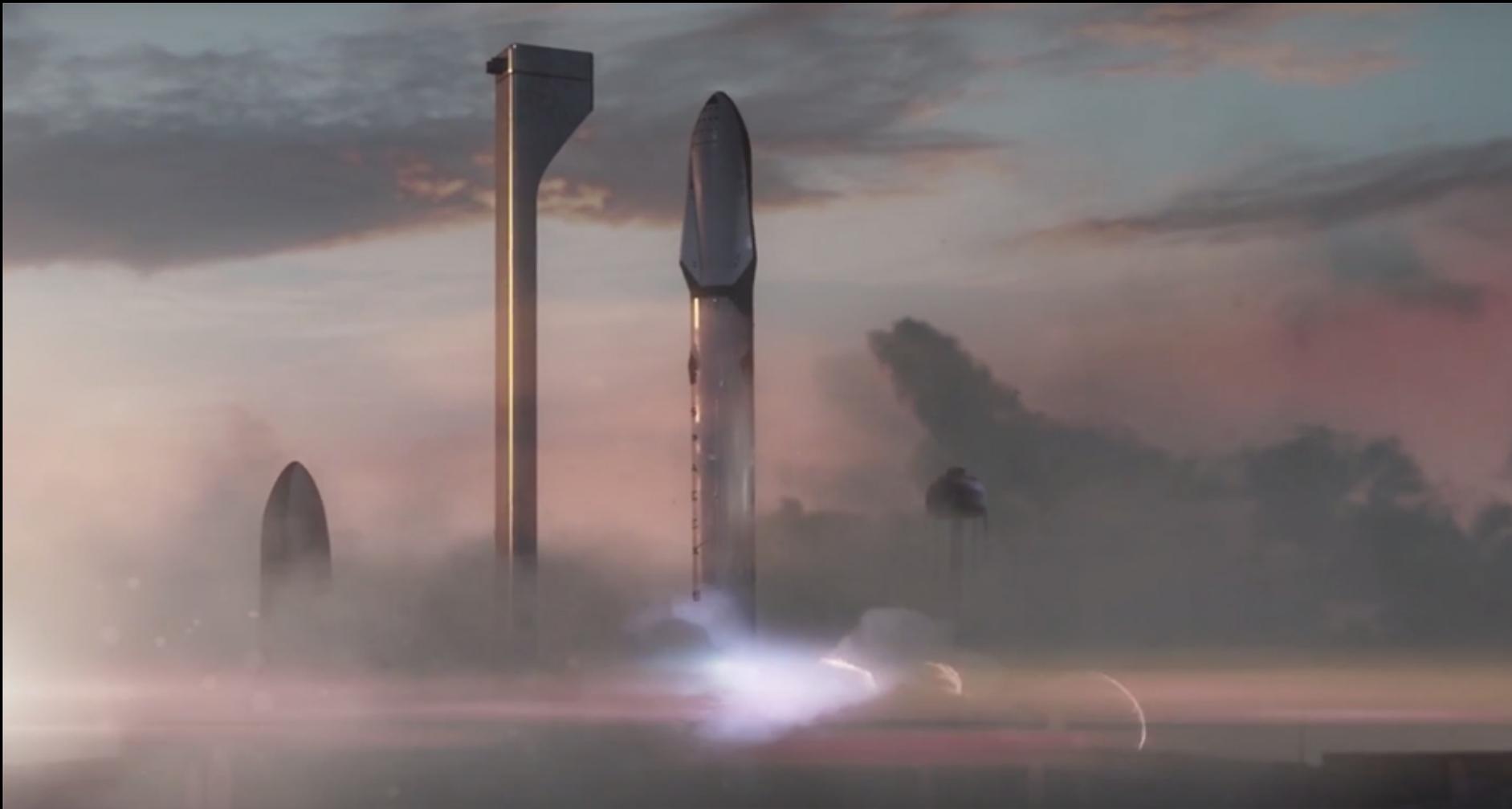




SpaceX Plans to Populate Mars With
1,000,000 Human Settlers in 40 years

Each flight to transport 100 - 200 Permanent Colonists

Ultimately plans transport up to 200,000 human to Mars/year



2017 Estimated Cost Per Seat to Mars: \$10 billion (NASA)

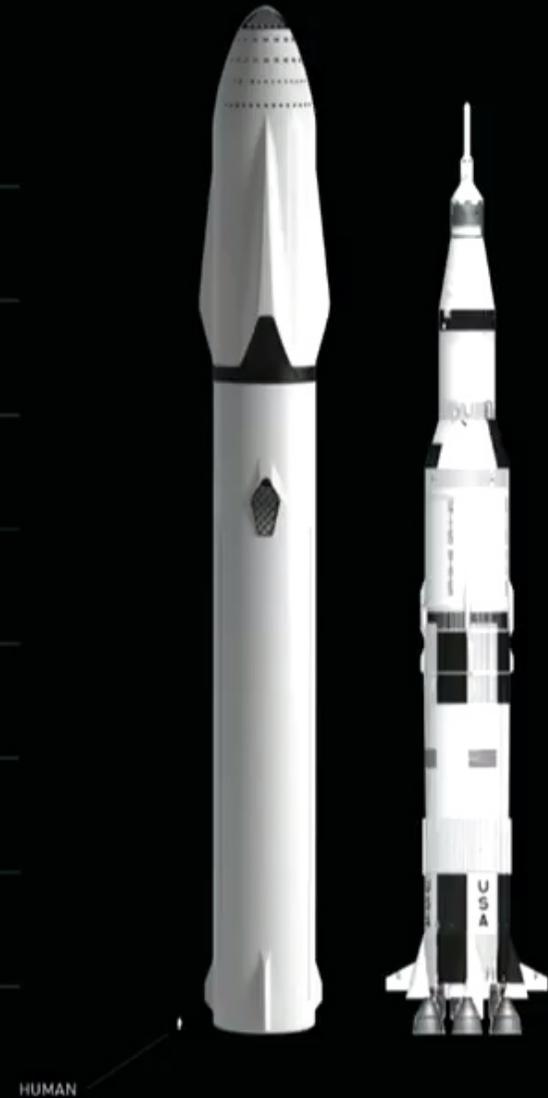
2026 Estimated Cost Per Seat to Mars: \$200,000 (SpaceX)

(Cost reduction factor of 50,000)

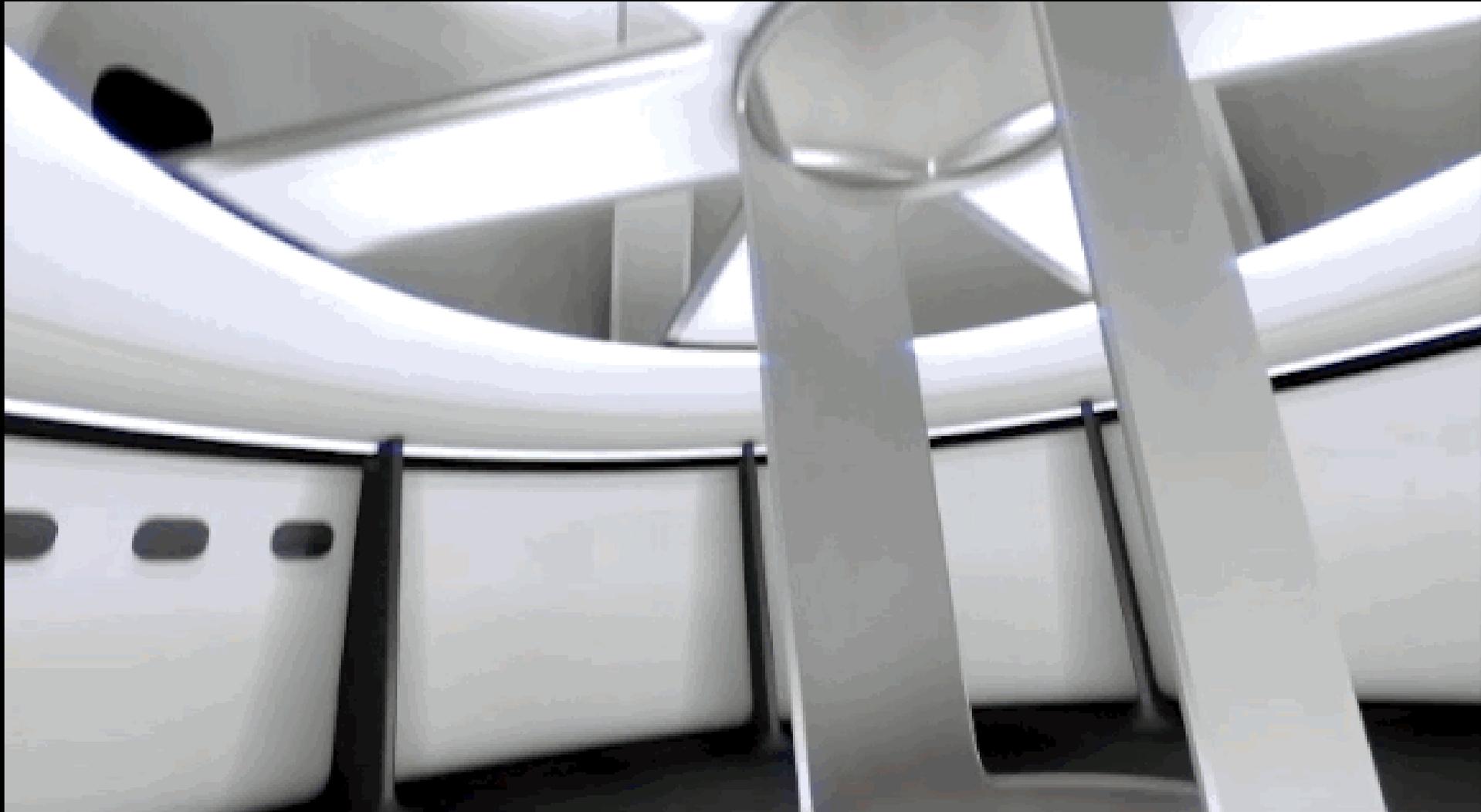
2036 Estimated Cost Per Seat to Mars: \$100,000 (SpaceX)

SpaceX Interplanetary Transport System

| | MARS VEHICLE | SATURN V | RATIO |
|--------------------------------|--------------|----------|-------|
| GROSS LIFT-OFF MASS (t) | 10,500 | 3,039 | 3.5 |
| LIFT-OFF THRUST (MN) | 128 | 35 | 3.6 |
| LIFT-OFF THRUST (t) | 13,033 | 3,579 | 3.6 |
| VEHICLE HEIGHT (m) | 122 | 111 | 1.1 |
| TANK DIAMETER (m) | 12 | 10 | 1.2 |
| EXPENDABLE LEO PAYLOAD (t) | 550 | 135 | 4.1 |
| FULLY REUSABLE LEO PAYLOAD (t) | 300 | - | - |







SpaceX's Mars Colonization Solution – The Raptor Engine



The ITS Raptor Engine uses cryogenic methane and oxygen as a fuel mined directly from the Martian atmosphere.

ITS Raptor is 130% more powerful than the Space Shuttle Main Engines (Space Shuttles use 3 engines plus two solid rockets on liftoff)

The ITS rocket booster will launch with 42 Raptor Engines Firing Simultaneously

Same physical size as current SpaceX Merlin Engine – but 3.5 times more powerful

Successfully Tested 25 September 2016



The SpaceX Interplanetary Transport - Raptor System will speed up the Mars voyage from the current 270 days to 80 days – and eventually 30 days

The Space Shuttle Transportation System launched 7 astronauts to low earth orbit per launch. Mission cost: \$455 billion

But the SpaceX ITS is designed to transport up to 200 passengers each launch to Mars per mission. Mission cost: not announced

The SpaceX Mars Colonization plan is fully two-way, round trip capable with launches to and from Mars every two years

The Permanent Earth – Mars Colony Logistics System Begins May 2018

The first Martian Colony will require pre-staged equipment, atmospheric processing stations, food, water, fuel processing and excavation equipment before the first colonists arrive.

**These Mars Colony logistics supply missions begin in 2018
and will continue every 26 months through the 21st Century**

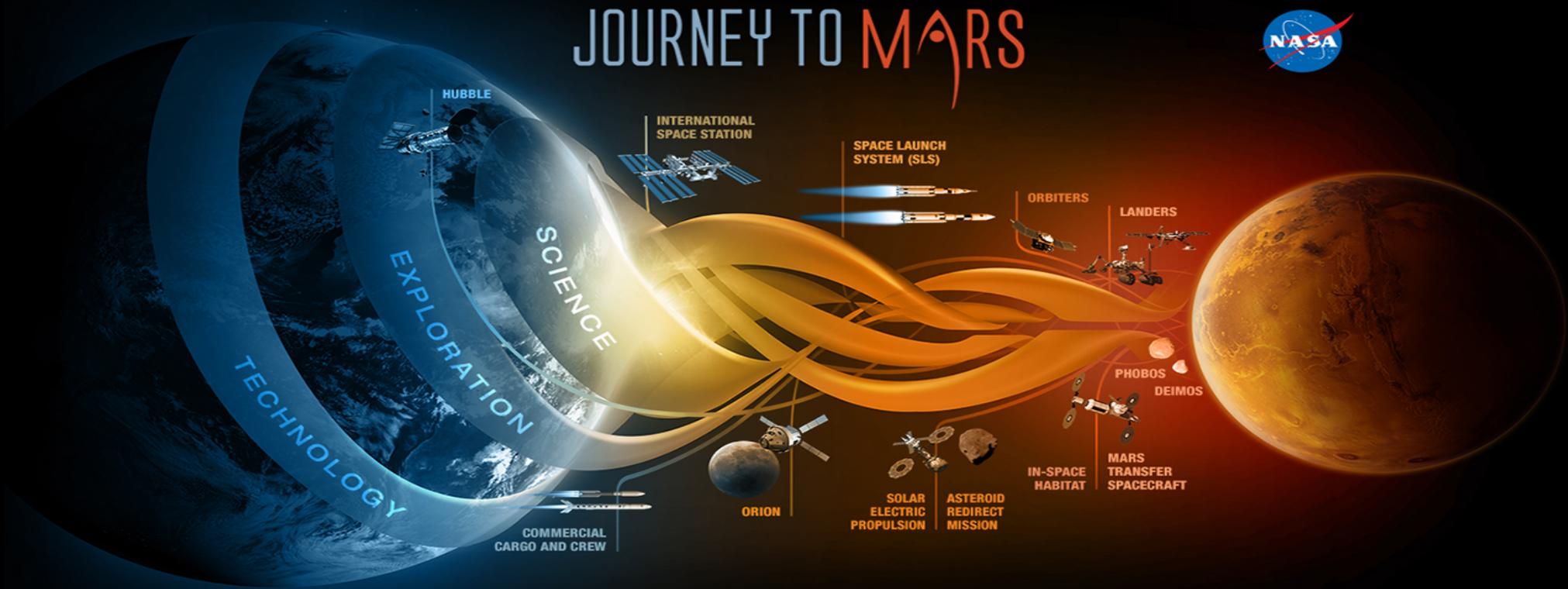




SpaceX Status Today

BRYAN VERSTEEG / SPACEX

- Return to flight launch scheduled Monday 9 January
- Falcon Heavy being prepared for first KSC launch spring 2017
- Red Dragon Mission remains on schedule for 2018
- While busy launching earth orbiting satellites - SpaceX's primary goal is colonizing Mars



“NASA is developing the capabilities needed to send humans to an asteroid by 2025 and Mars in the 2030s – goals outlined in the bipartisan NASA Authorization Act of 2010 and in the U.S. National Space Policy, also issued in 2010.... Engineers and scientists around the country are working hard to develop the technologies astronauts will use to one day live and work on Mars, and safely return home from the next giant leap for humanity. NASA also is a leader in a Global Exploration Roadmap, working with international partners and the U.S. commercial space industry on a coordinated expansion of human presence into the solar system, **with human missions to the surface of Mars as the driving goal.**”

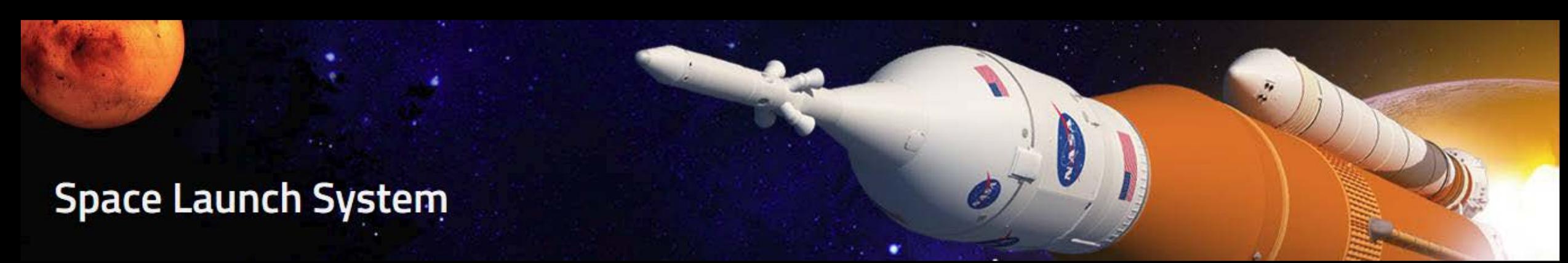


NASA is committed to sending a manned mission to Mars – details are limited.

NASA has a very wide and diverse focus: unmanned earth orbital space exploration; unmanned deep space exploration; manned space exploration; cutting edge aeronautics.

NASA Space Launch System (SLS) is designed for MANY possible deep space exploration initiatives: lunar orbit; asteroid; Mars.

Human Mars exploration must take its proper place in the Agency's mission and budget.

A digital rendering of the Space Launch System (SLS) rocket in space. The rocket is white with orange boosters and is shown from a low angle, pointing towards the top right. The background is a dark blue space with stars and a large orange planet (Mars) in the top left corner. The text "Space Launch System" is written in white on the left side.

Space Launch System



Maiden Launch scheduled for

November 2018

NASA Manned Mars Mission Status Today



NASA Mars Exploration Plan and Progress

December 2014 – First Orion Unmanned Test Flight - 4.5 hours

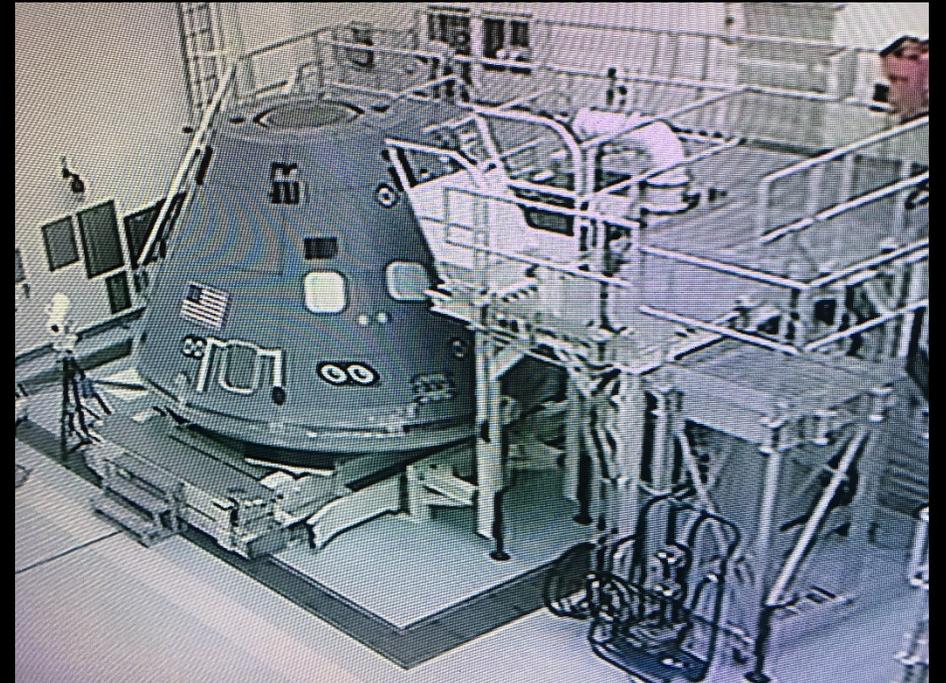
2018 Launch of Orion Capsule (2nd Flight) – Unmanned Trajectory Around the Moon
Exploration Mission 1 - Scheduled for 30 September 2018

3 Weeks in space – 6 days in orbit around the moon

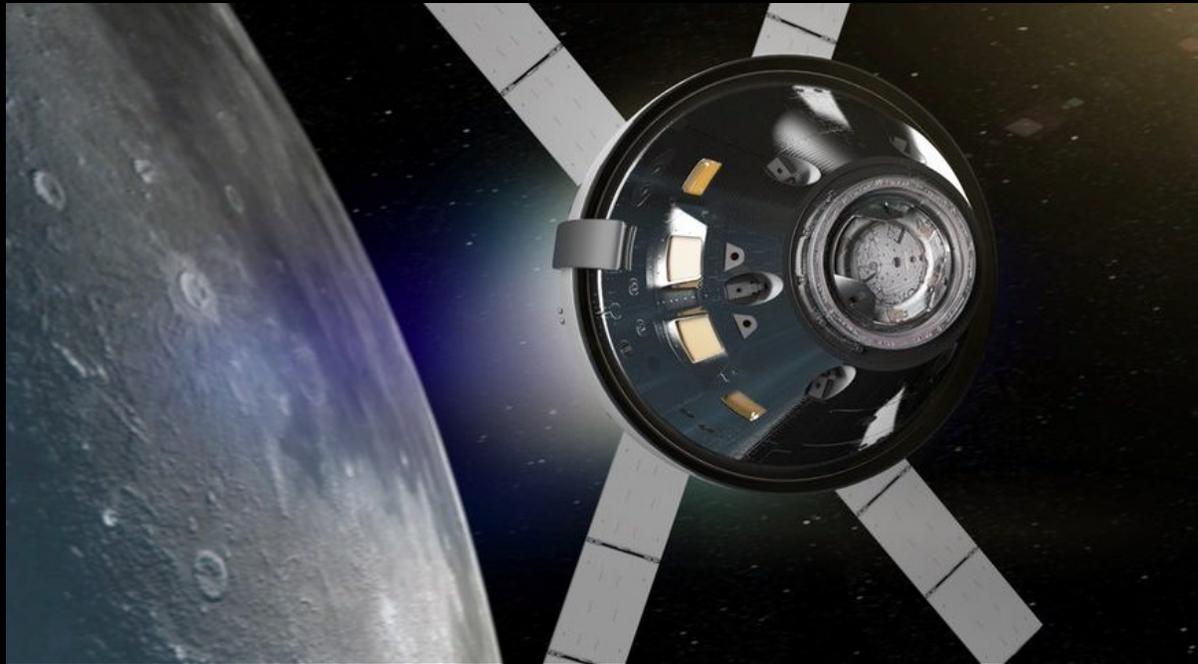
(Orion capsule shown below on Thursday, 5 January 2017, in KSC processing bay.)



Can support a crew of four for
21 days in deep space.



NASA Mars Exploration Plan and Progress



Orion Exploration Mission 2 – First Manned Orion Mission

Launch Scheduled 2021-2023

Crew of Four Astronauts – Four days in Lunar Orbit

Orion successful test Launch December 2014

Scheduled Orion Missions

| | | |
|-------------|----------------|-----------------------------|
| EM-1 | 2018 | Unmanned test - lunar orbit |
| EM-2 | 2021-23 | Manned lunar orbit |
| EM-3 | No Date | Manned Lunar Orbit |
| EM-4 | No Date | Manned Lunar Orbit |
| EM-5 | No Date | Manned Lunar Orbit |

Proposed Mars Mission With No Fixed Date

2037-2045

Possible human Mars mission with 4-6 Astronauts. 540 days on the surface of Mars in 2037 or 2045.

No funding yet allocated by Congress for design or construction of Mars hardware or manned Mars Mission

Questions?

