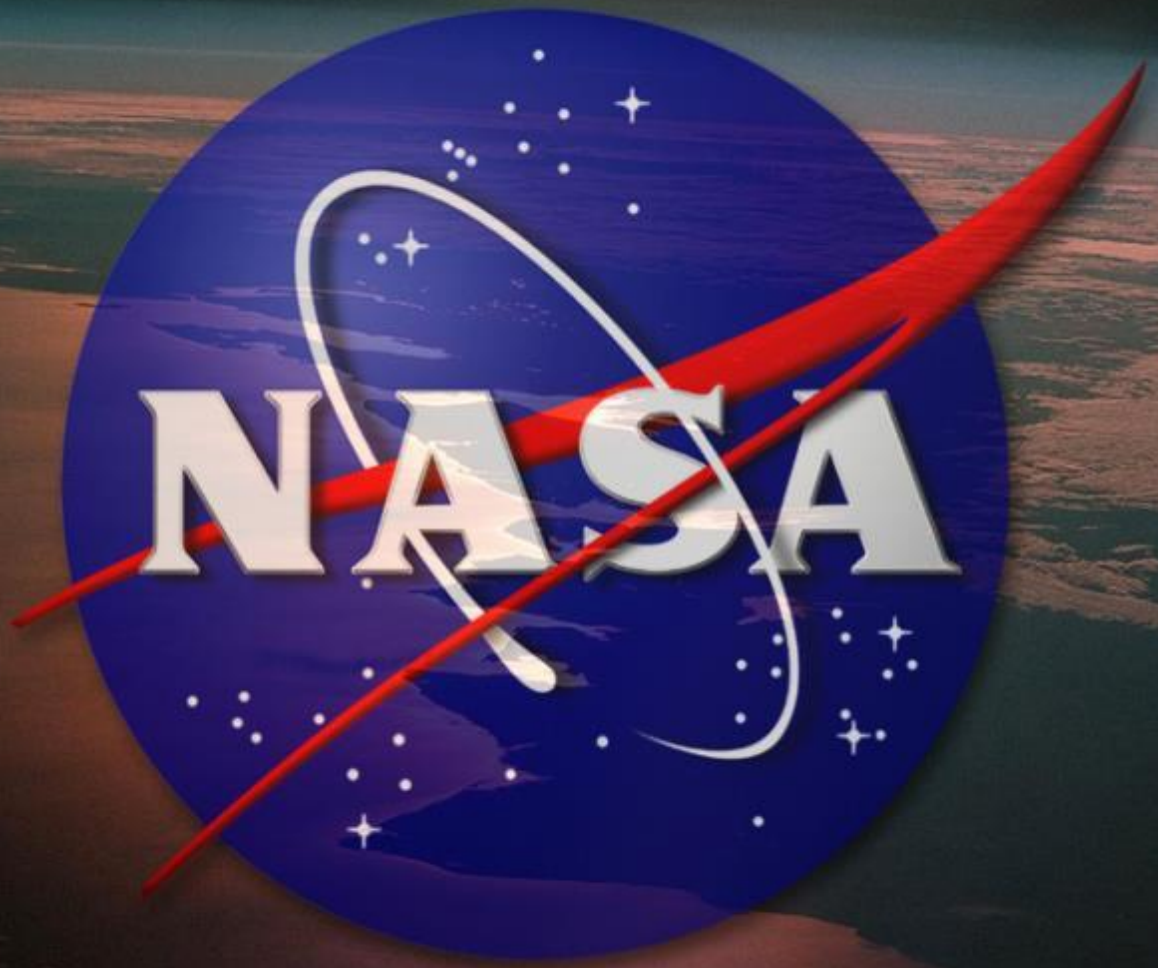
# Welcome to JSC




Liftoff Summer Institute July 2017 Presentation V2

# Where Do We Go From Here?

**Tim Hall**
**NASA Johnson Space Center**
**June 2017**

National Aeronautics and Space Administration

# First, What's Going On Now At NASA Today?

# *Human Spaceflight….*

JAXA HTV

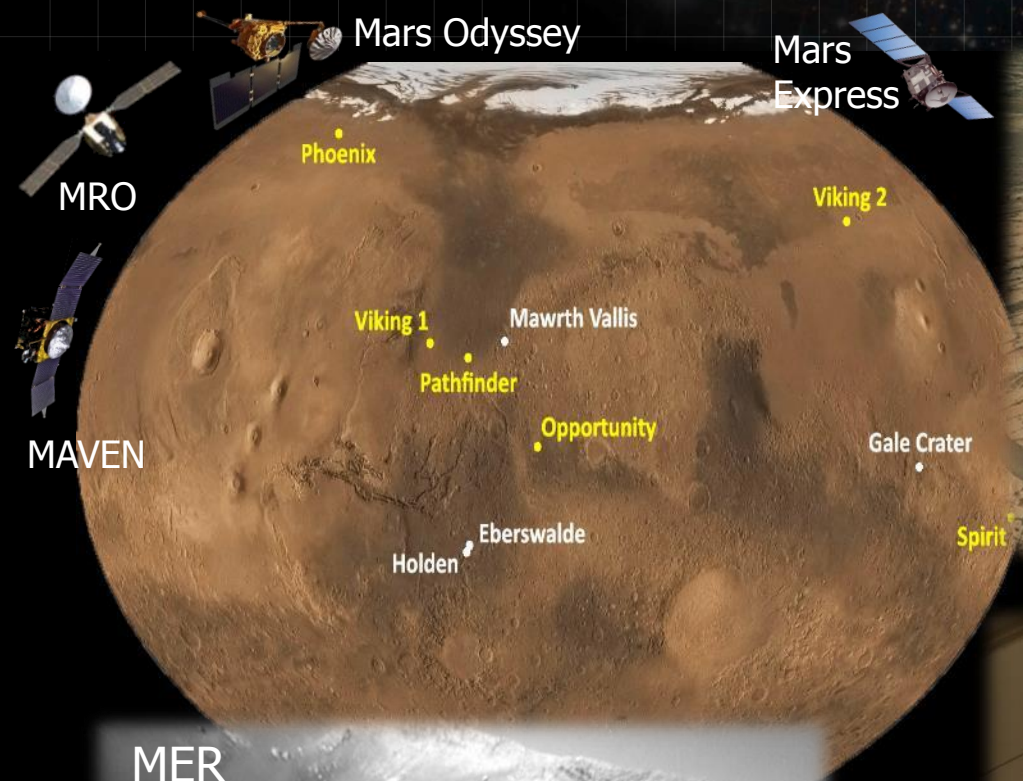
SpaceX Dragon

Orbital Sciences ATK Cygnus

Expedition 52

Expedition 53

# Planetary Missions, Mars is busy!…







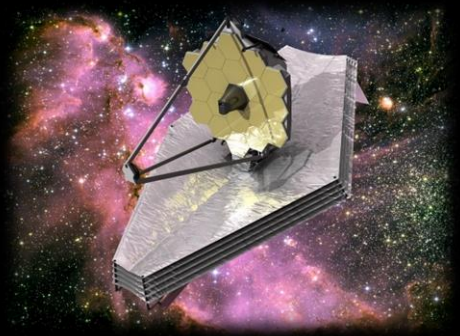
http://www.space.com/16874-where-did-nasa-spacecraft-land-on-mars-video.html

# Many, many other cool missions…

Just a few to mention…

## Cyclone Global Navigation Satellite System (CYGNSS)

is a space-based multi satellite system developed to improve hurricane forecasting

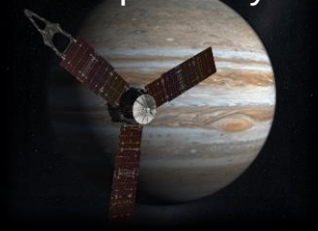


## James Webb Telescope

Launch in 2019

## Juno

Arrived at Jupiter July 2016



## Hubble

Still researching origins of the universe

## Eyes on the Solar System

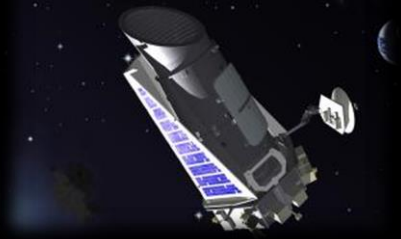
http://eyes.nasa.gov/

## Kepler

Planet Count

Confirmed Planets: 977

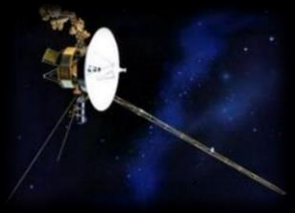
Planet Candidates: 4,234



## Voyager 1

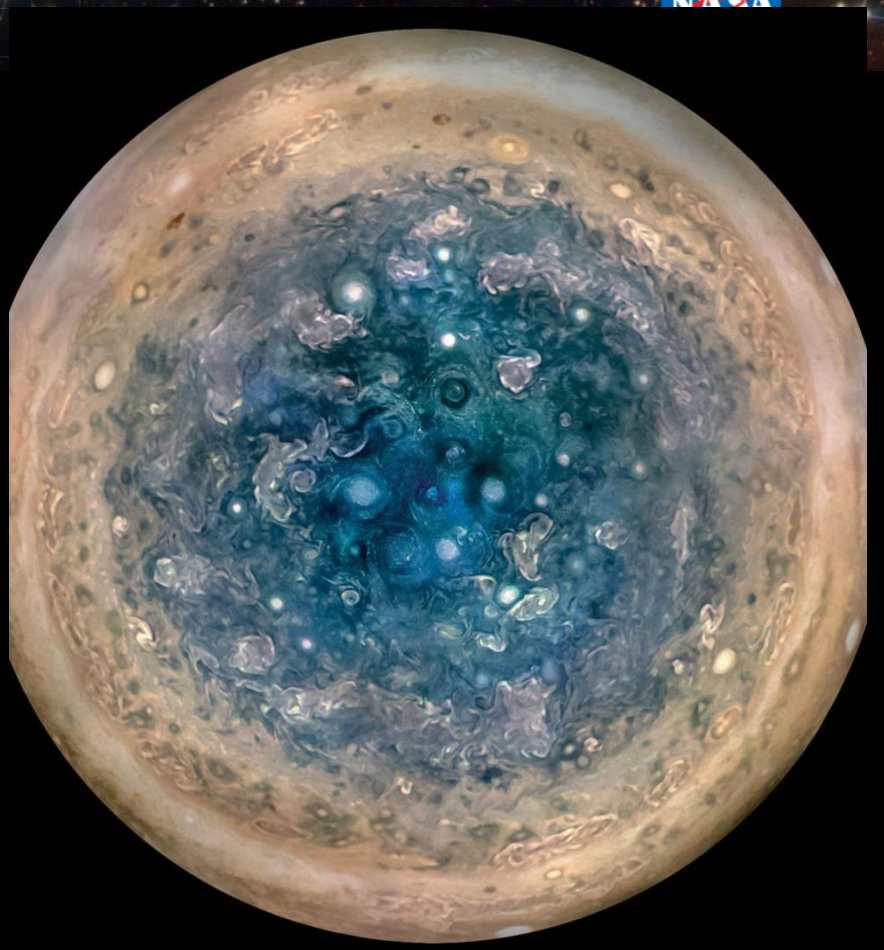
Has left the building…

Traveling interstellar space



# Jupiter – JUNO

- Juno is a NASA space probe orbiting the planet Jupiter.
  - It is operated by NASA's Jet Propulsion Laboratory. The spacecraft was launched from Cape Canaveral Air Force Station on August 5, 2011,
  - Juno entered a polar orbit of Jupiter on July 5, 2016 to begin a scientific investigation of the planet.
  - After completing its mission, Juno will be intentionally deorbited into Jupiter's atmosphere.[8]
- Juno's mission is to measure Jupiter's composition, gravity field, magnetic field, and polar magnetosphere.
  - It will also search for clues about how the planet formed, including whether it has a rocky core, the amount of water present within the deep atmosphere, mass distribution, and its deep winds, which can reach speeds of 618 kilometers per hour (384 mph)



"It's snowing on Jupiter, and we're seeing how it works," Juno principal investigator Scott Bolton, of the Southwest Research Institute in San Antonio
Zoomed-in view of a photo taken by NASA's Juno probe on May 19, 2017, showing clouds of water ice and/or ammonia ice high up in Jupiter's atmosphere in the south tropical zone.

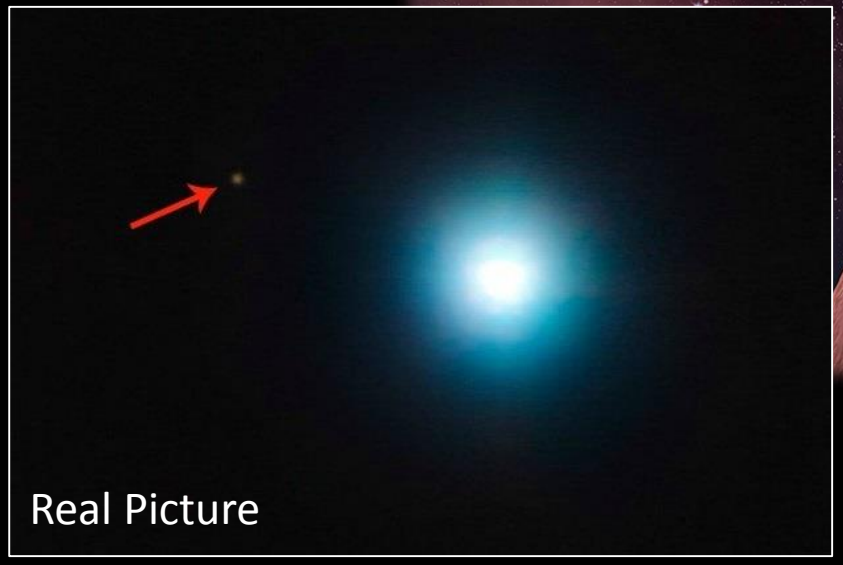
# Jupiter – Juno

- This enhanced-color image of Jupiter's bands of light and dark clouds was created by citizen scientists Gerald Eichstädt and Seán Doran using data from the JunoCam imager on NASA's Juno spacecraft.
- Three of the white oval storms known as the "String of Pearls" are visible near the top of the image. Each of the alternating light and dark atmospheric bands in this image is wider than Earth, and each rages around Jupiter at hundreds of miles (kilometers) per hour. The lighter areas are regions where gas is rising, and the darker bands are regions where gas is sinking.
- Juno acquired the image on May 19, 2017, at 11:30 a.m. PST (2:30 p.m. EST) from an altitude of about 20,800 miles (33,400 kilometers) above Jupiter's cloud tops.

# Exoplanets

## NASA Finds 219 Possible Planets, Including 10 'Earths'

NASA’s Kepler space telescope team has released a mission catalog of planet candidates that introduces 219 new candidates, 10 of which are near-Earth size and orbiting in their star's habitable zone, which is the range of distance from a star where liquid water could pool on the surface of a rocky planet.?

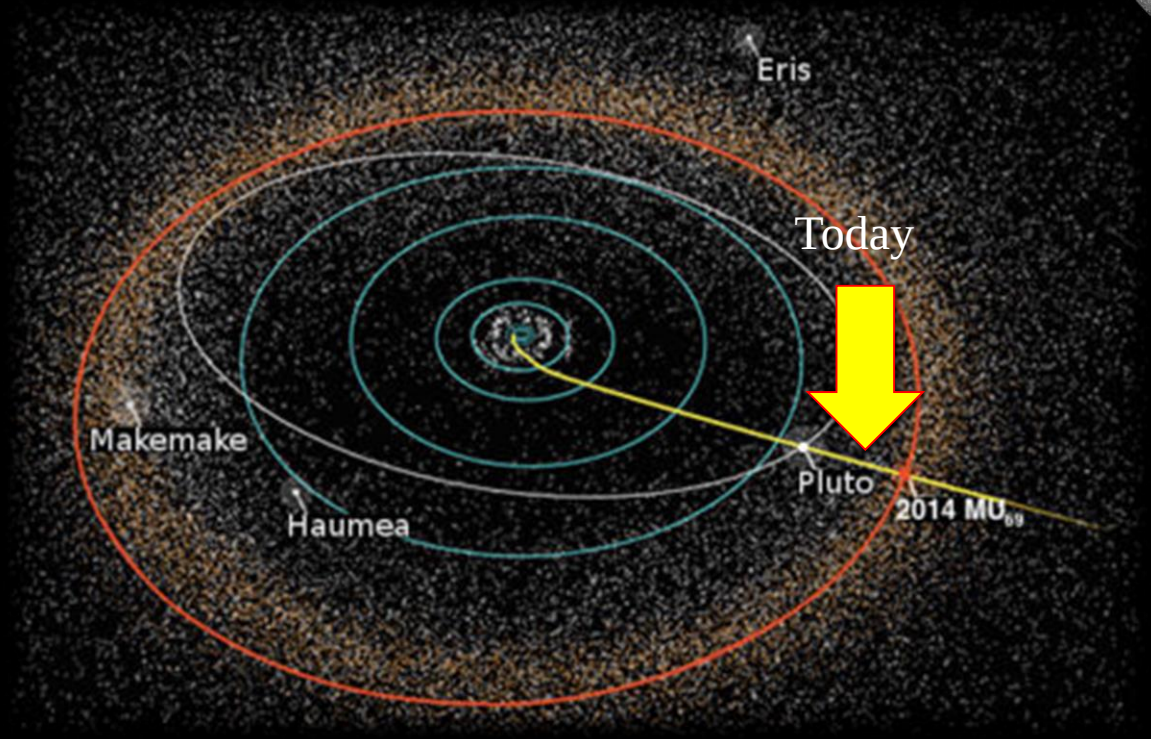



Astronomers have managed to capture an amazingly clear image of CVSO 30c - a potential exoplanet orbiting a distant star named CVSO 30, that lies some 1,200 light-years away.

# New Horizons @ Pluto!

- **New from NASA's New Horizons:**
  - **The Spacecraft just passed half way to its next target MU69 in January of 2019**

NASA's New Horizons spacecraft passed Pluto in July 2015



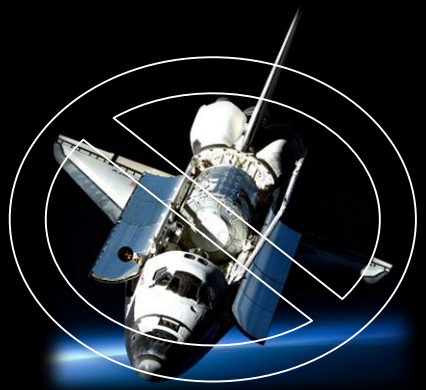
National Aeronautics and Space Administration

# Human Space Flight Vehicles and Plans for Exploration

www.nasa.gov/exploration

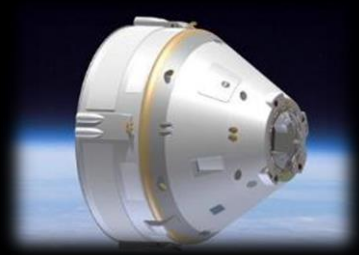
# Human Space Flight "Vehicles" for ISS

Russian Soyuz



US Space Shuttle

Future US Commercial Crew Capsules



Boeing CST-100 Starliner

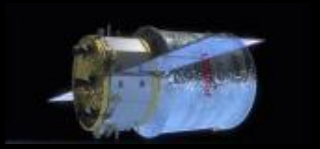
SpaceX Dragon Capsule

- NOTE: ISS Also has Cargo Vehicles for ISS (no human rating)

## Commercial Resupply Vehicles

SpaceX Dragon Cargo

Orbital Sciences ATK Cygnus



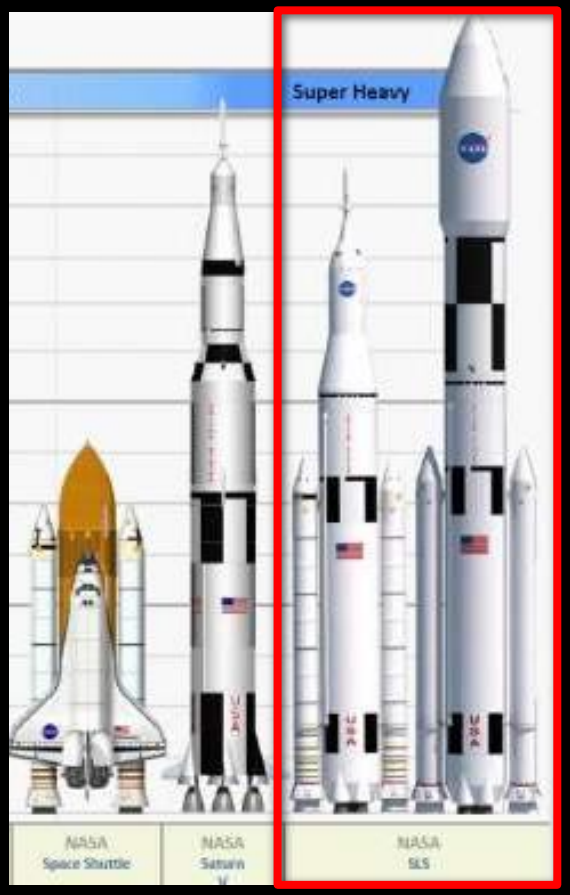
Sierra Nevada Dream Chaser Cargo (2019)

## International Partner Vehicles

JAXA Space Agency HTV

# Human Space Flight "Vehicles" for Exploration

- Exploration




SLS – Space Launch System
Heavy Lift Vehicle

Orion & Service Module

Possible Deep Space
Gateway
(Habitat and Propulsion
Module and Airlock)

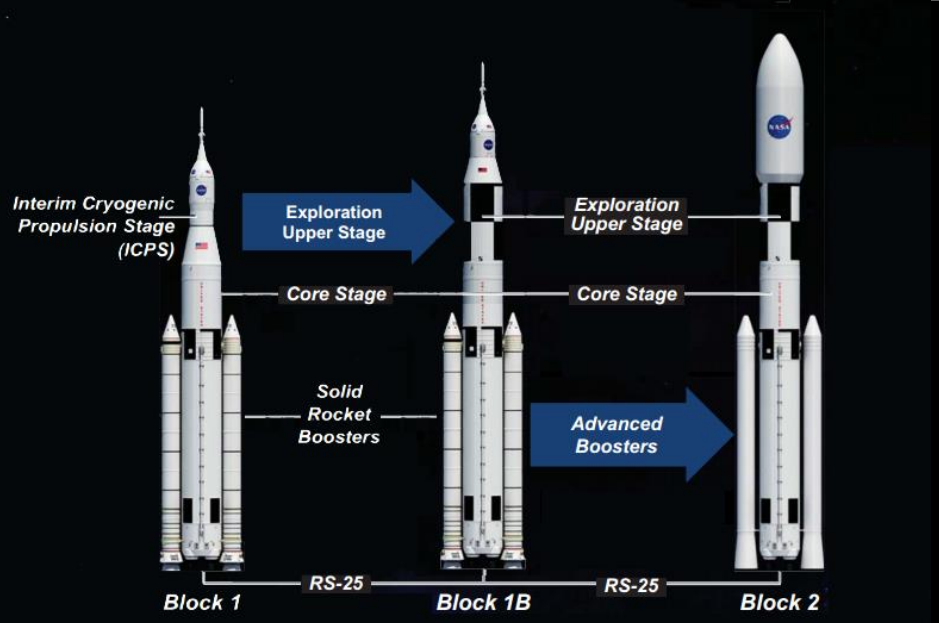
# NASA Plans to use ISS as Test Bed for Exploration

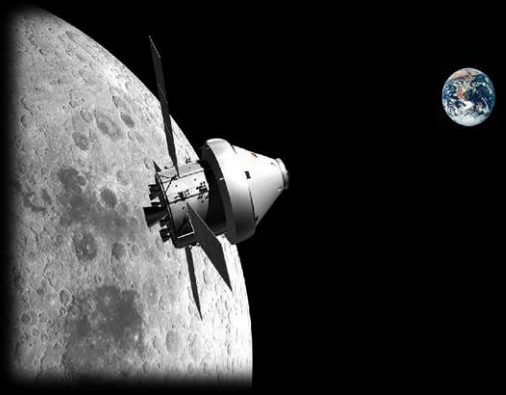
- Utilize ISS to test out exploration technologies
- These include:
  - Closed Loop Environmental Systems
  - Power Systems
  - Materials for use in deep space environments
  - Human long duration mission mitigations
  - Exploration Space Suit technologies

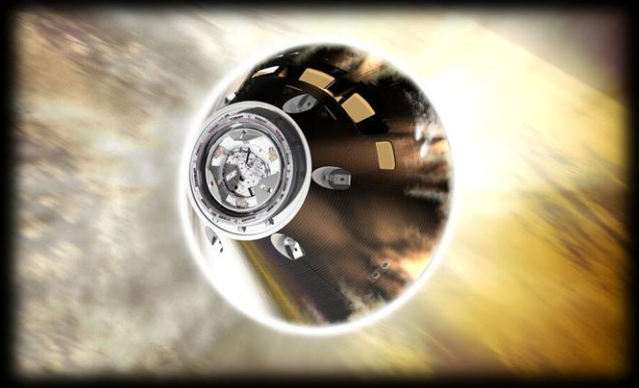
# Orion & SLS Plans

Orion Program mission schedule

| Mission | Acronym | Launch date |
|---|---|---|
| Exploration Flight Test 1 | EFT-1 | December 5, 2014 |
| Exploration Mission 1 | EM-1 | November 2019 |
| Pad Abort 2 | PA-2 | December 2018 |
| Exploration Mission 2 | EM-2 | August 2021 |





National Aeronautics and Space Administration

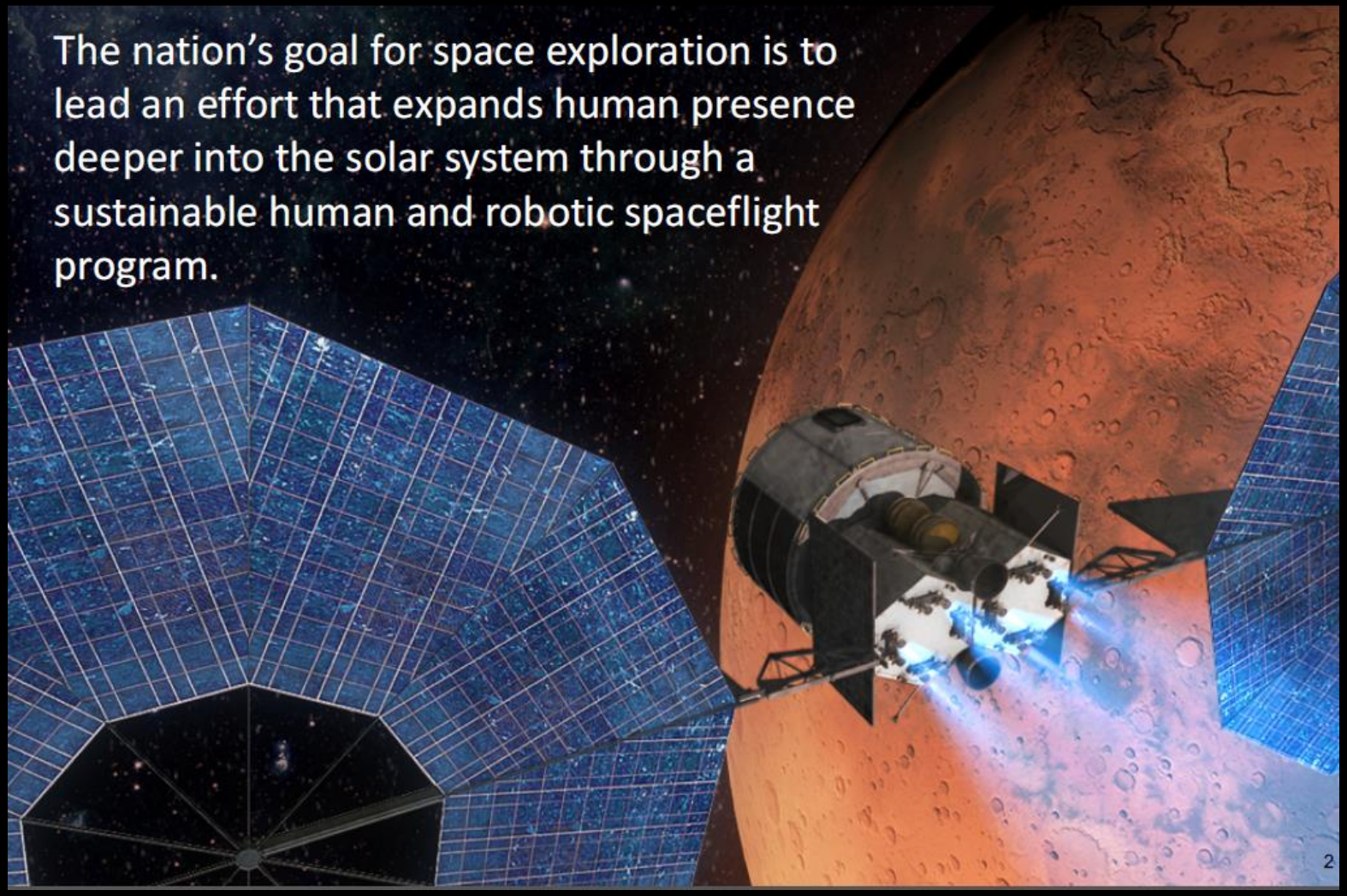
# NASAs Exploration Strategy

**As of March 2017**

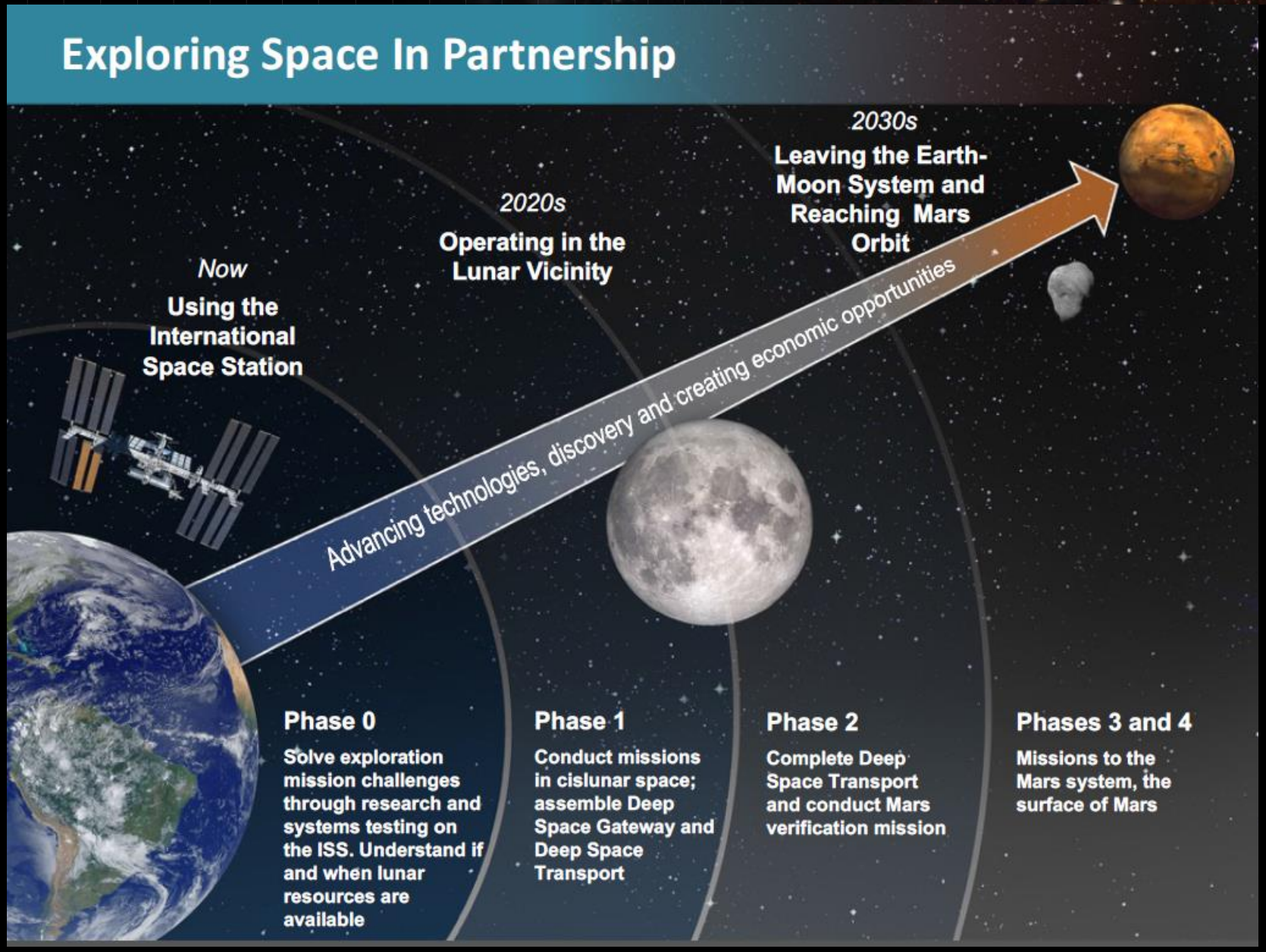
www.nasa.gov/exploration

# Exploration

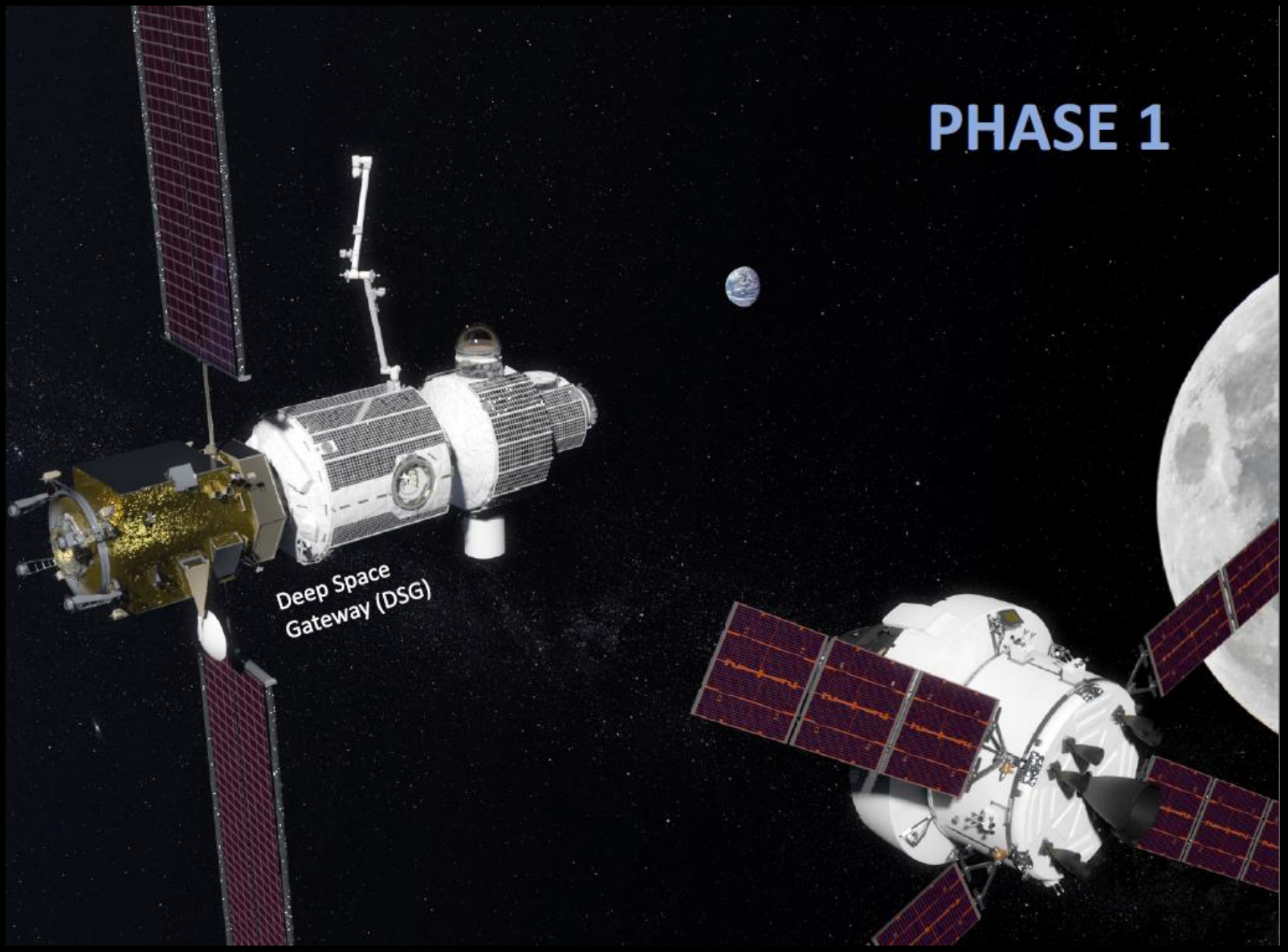
## Our Goal



# Exploration Plans



# Deep Space Gateway Functionality



# Deep Space Gateway Cise Lunar Missions

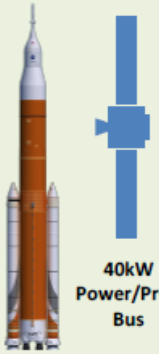
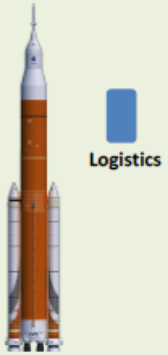
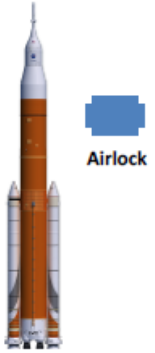
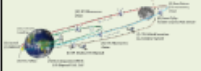
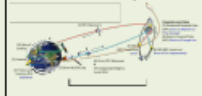
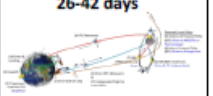
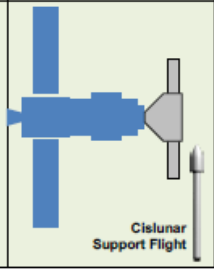
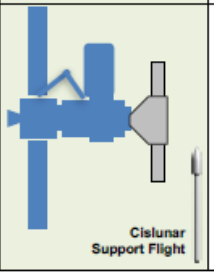
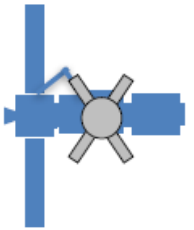
- Lunar orbiting outpost
  - Possible use of L2 (Lagrange point)
  - Science collection from deep space
  - Exploration System Technology Demonstration

- Lunar Base????
  - Science collection
  - Exploration Systems Technology Demonstration
  - Surface Habitat, Lander and Walking suit test bed for Mars

# SLS Capability and Potential Manifest

## Phase 1 Plan

**Establishing deep-space leadership and preparing for Deep Space Transport development**

| | | Deep Space Gateway Buildup | | | |
|---|---|---|---|---|---|
| **EM-1** | **Europa Clipper** | **EM-2** | **EM-3** | **EM-4** | **EM-5** |
| **2018 - 2025** | | | | | **2026** |
| SLS Block 1<br>Crew: 0 | SLS Block 1B Cargo | SLS Block 1B<br>Crew: 4<br>CMP Capability: 8-9T | SLS Block 1B<br>Crew: 4<br>CMP Capability: 10mT | SLS Block 1B<br>Crew: 4<br>CMP Capability: 10mT | SLS Block 1B<br>Crew: 4<br>CPL Capability: 10mT |
|  |  Europa Clipper (subject to approval) |  40kW Power/Prop Bus |  Habitation |  Logistics |  Airlock |
| Distant Retrograde Orbit (DRO)<br>26-40 days | Jupiter Direct | Multi-TLI Lunar Free Return<br>8-21 days | Near Rectilinear Halo Orbit (NRHO)<br>16-26 days | NRHO, w/ ability to translate to/from other cislunar orbits<br>26-42 days | NRHO, w/ ability to translate to/from other cislunar orbits<br>26-42 days |
|  |  |  |  |  |  |
| **Gateway (blue) Configuration (Orion in grey)** | |  |  Cislunar Support Flight |  Cislunar Support Flight |  |

These essential Gateway elements can support multiple U.S. and international partner objectives in Phase 1 and beyond

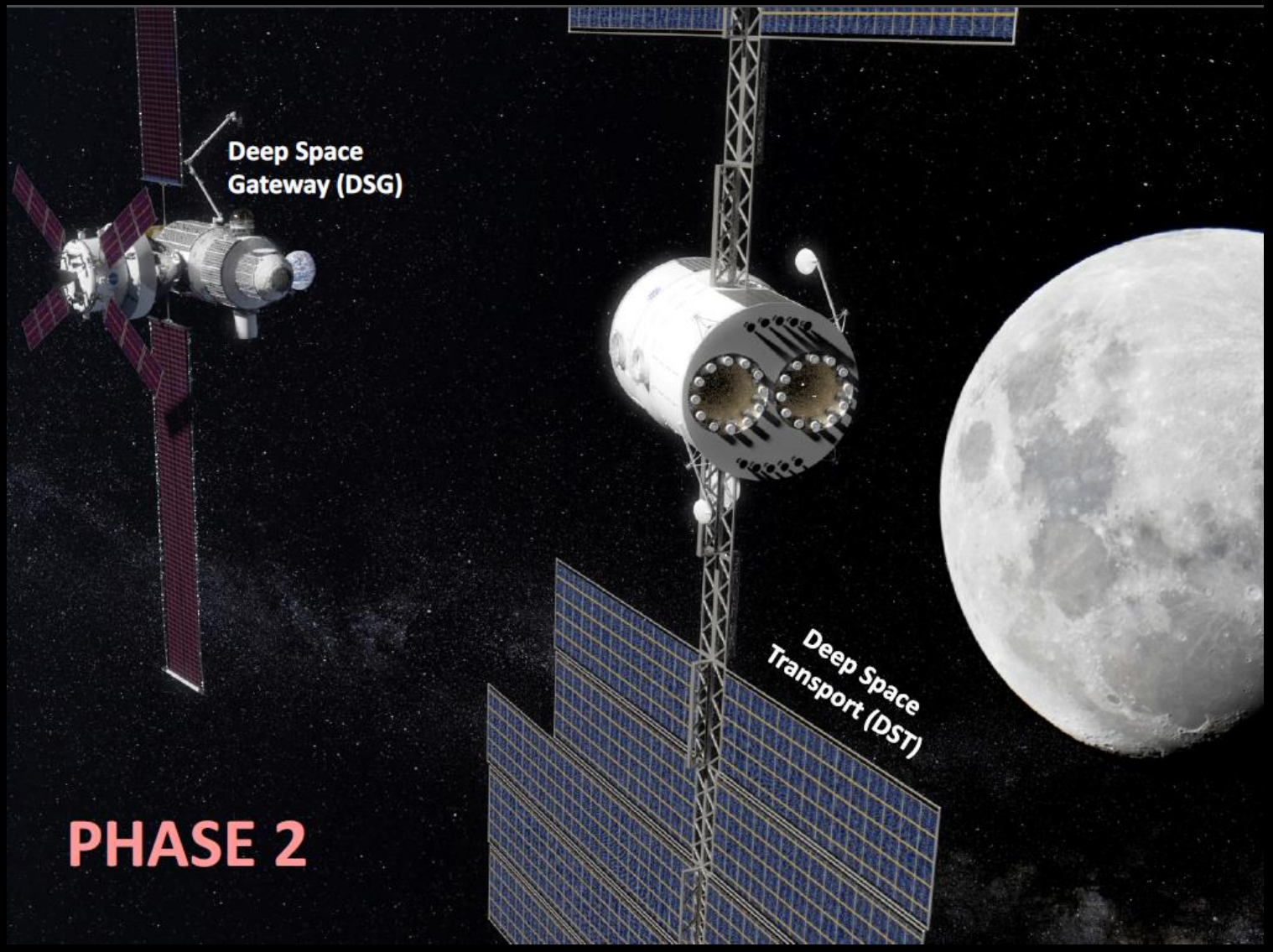
**Known Parameters:**

- Gateway to architecture supports Phase 2 and beyond activities
- International and U.S. commercial development of elements and systems
- Gateway will translate uncrewed between cislunar orbits
- Ability to support science objectives in cislunar space

**Open Opportunities:**

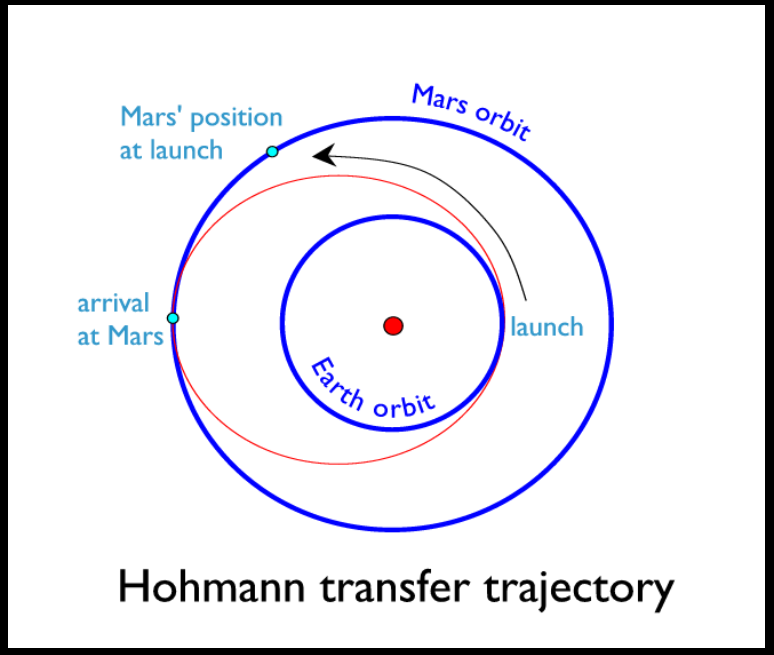
- Order of logistics flights and logistics providers
- Use of logistics modules for available volume
- Ability to support lunar surface missions

# Exploration Next Pahse

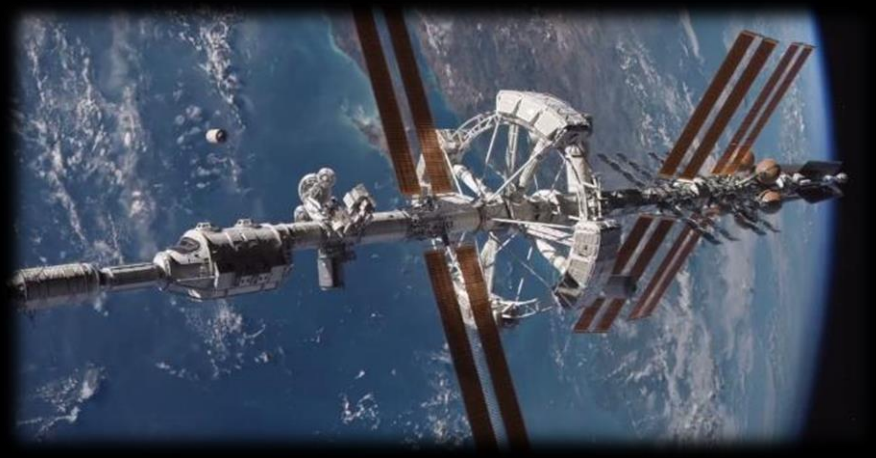


# Human Mars Mission

- Extend Mission Durations
- Test out Deep Space Propulsion and cargo systems
- Continue to shrink technology gap for exploration outside Earth/Moon region
- Last Phase would be a Mars transit from Deep Space Gateway



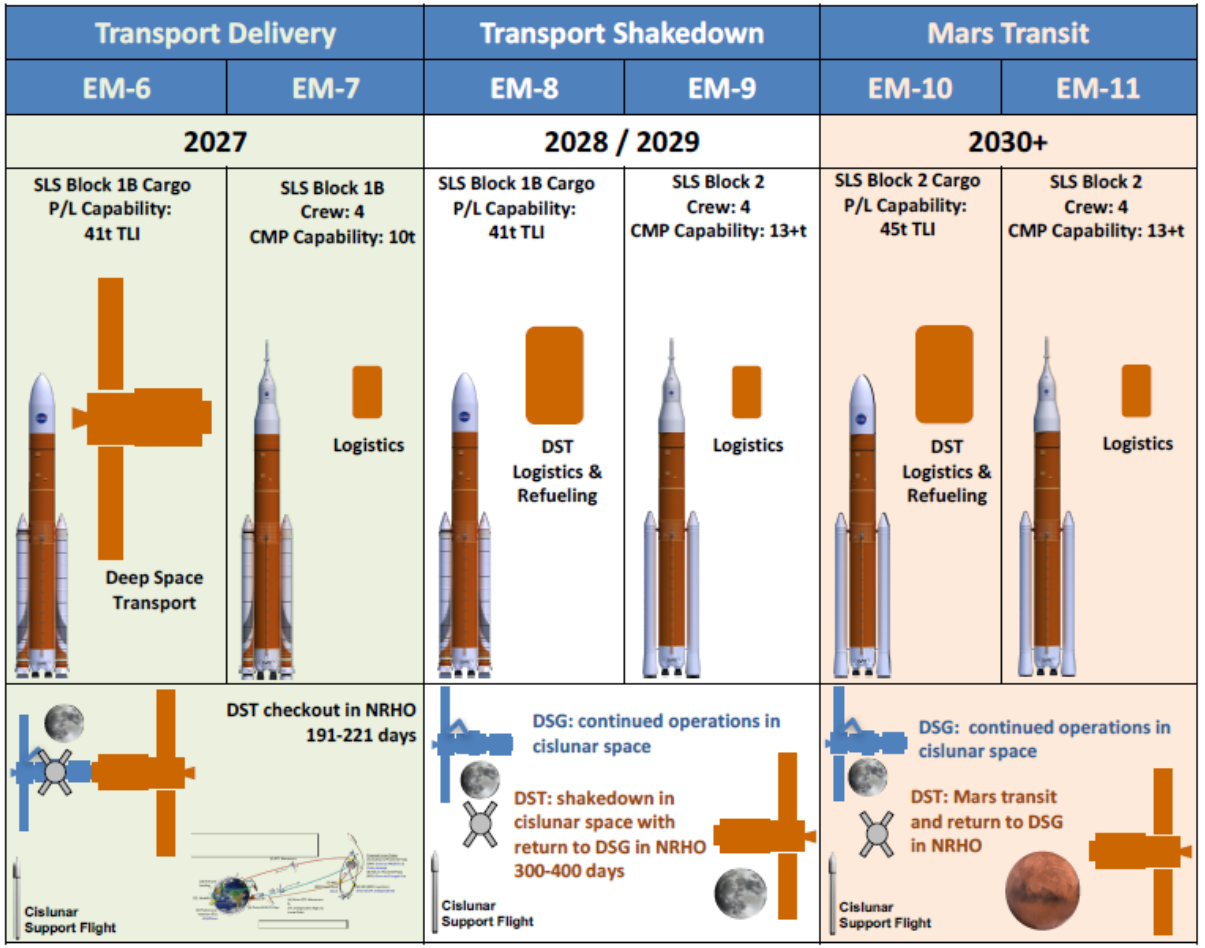
Hohmann transfer trajectory



Images Credit: The Martian/20th Century Fox

# (PLANNING REFERENCE) Phase 2 and Phase 3

## Looking ahead to the shakedown cruise and the first crewed missions to Mars



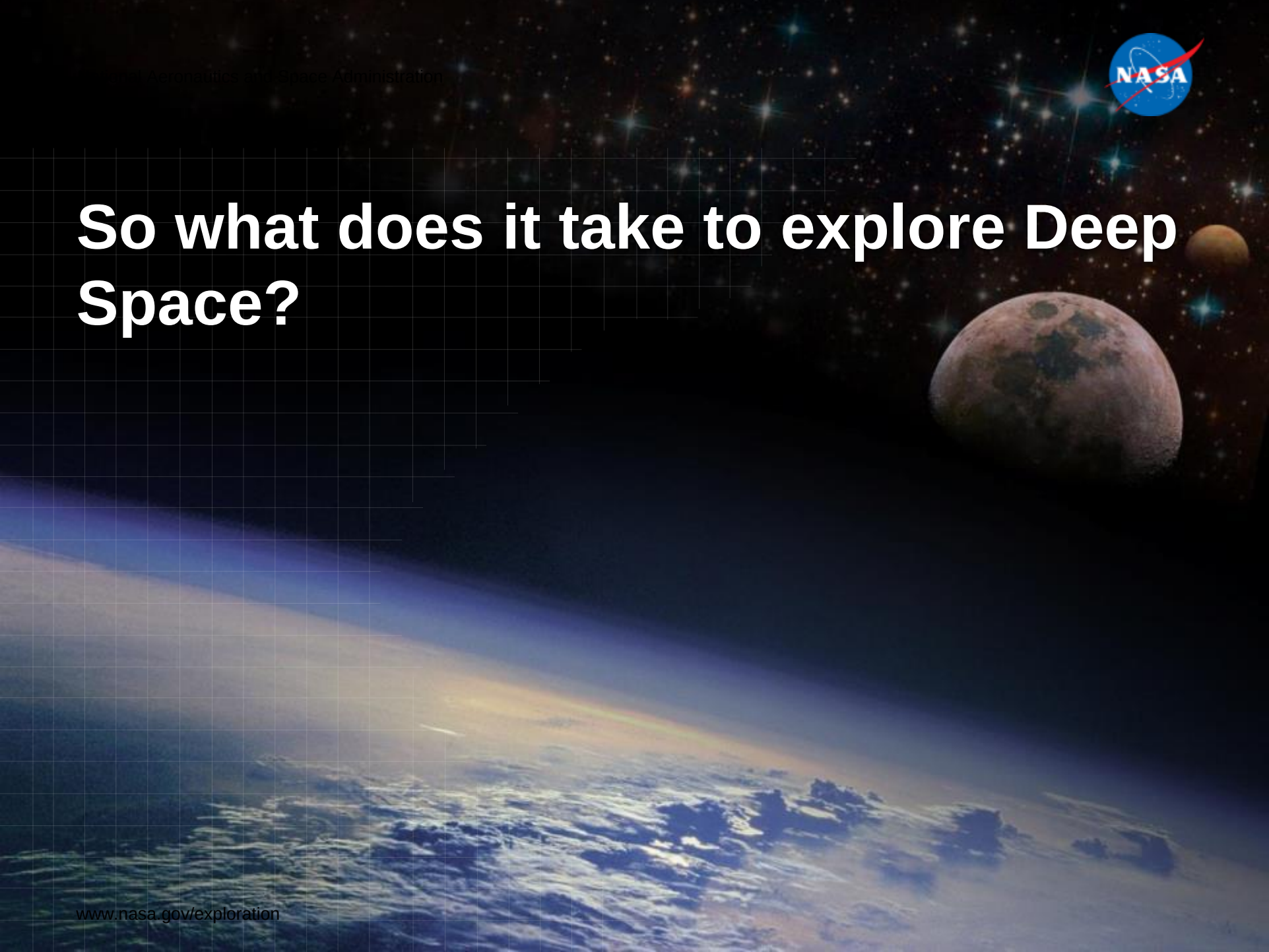

**Reusable Deep Space Transport supports repeated crewed missions to the Mars vicinity**

**Known Parameters:**

- DST launch on one SLS cargo flight
- DST shakedown cruise by 2029
- DST supported by a mix of logistics flights for both shakedown and transit
- Ability to support science objectives in cislunar space

**Open Opportunities:**

- Order of logistics flights and logistics providers
- Shakedown cruise vehicle configuration and destination/s
- Ability to support lunar surface missions



# So what does it take to explore Deep Space?

# Space Exploration Challenges…

- Who would you need on a deep space mission?

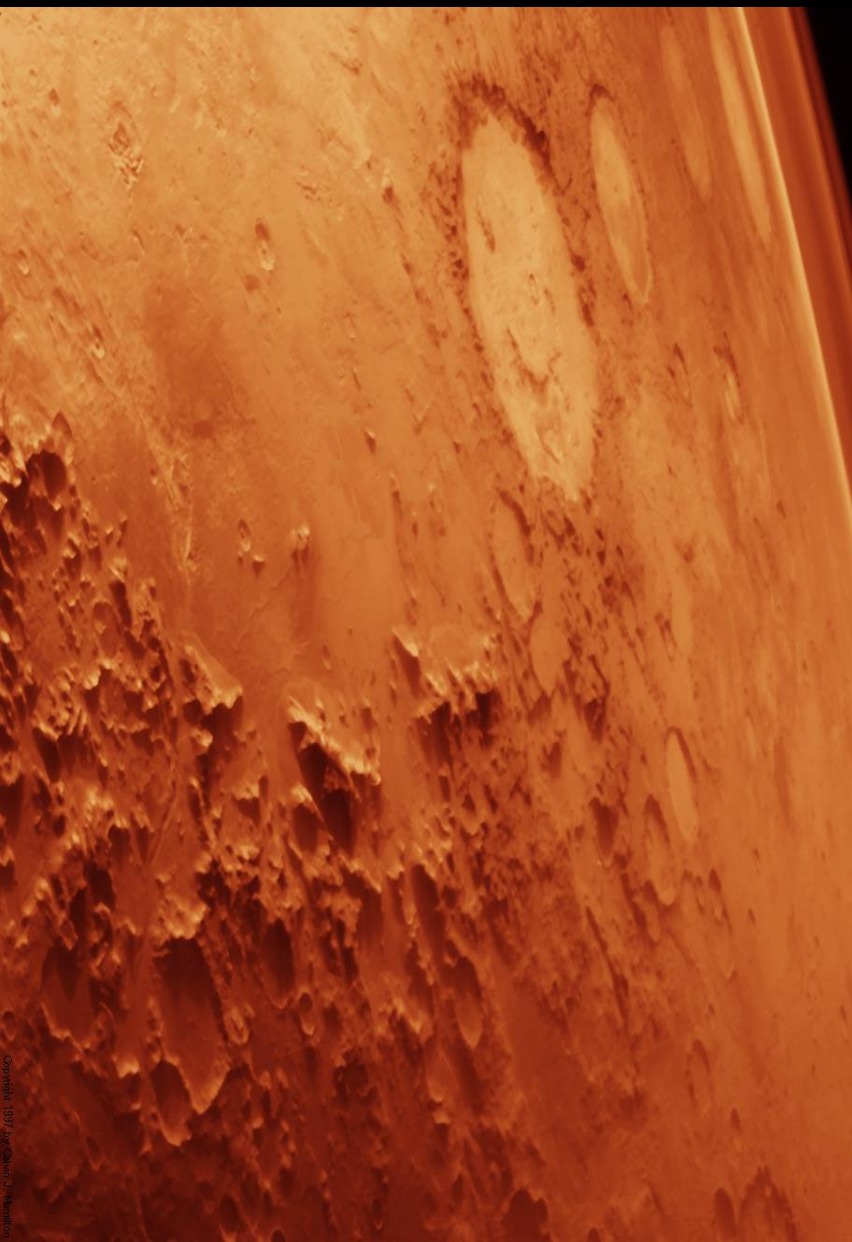
Standard for LEO today
- Pilot
- Scientist
- Engineer

- Other crew, required?
  - Doctor
  - Dentist
  - Psychologist
  - Geologist
  - IT/Computer
  - Machinist
  - Handyman
  - Sheriff
  - Judge/Lawyer

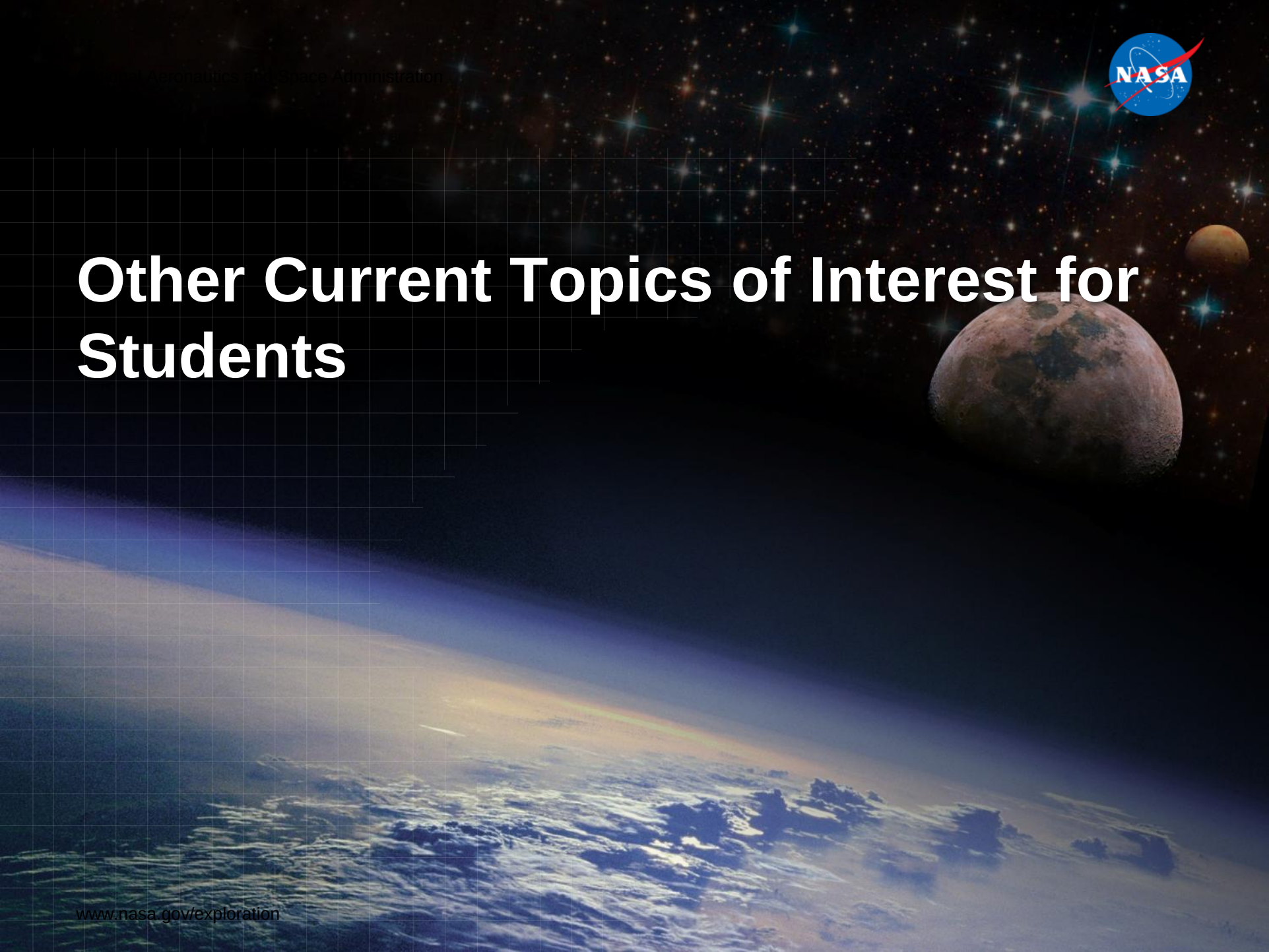
**20+ People???**

Required Systems Experts for Exploration Missions
- Propulsion
- Navigation
- Communication
- Environmental (Plumber, AC, Heat)
- Power
- Stowage/Inventory

# Space Exploration Challenges…



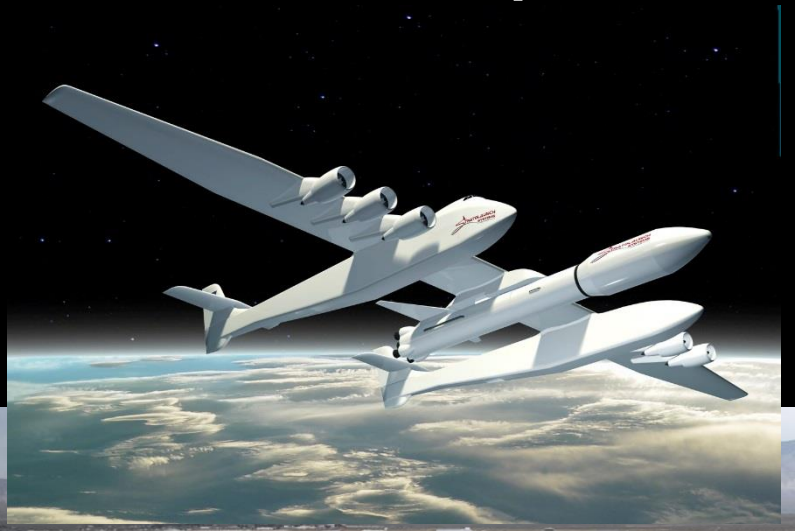
- Up mass
  - Exploration Vehicle – est. 100 tons of material and supplies (ISS 420 tons)
- Propulsion
  - Chemical, Ion, Solar Electric
- Environmental Systems
  - Closed loop, Reliability, Redundancy
- Automation
  - Self maintaining systems
- Radiation Shielding
  - Crew and systems health
- Communication
  - Comm delays increase
- Long Range Human Health Affects
  - Bone health, eye damage, long term radiation exposure
- Stowage/Logistics



# Other Current Topics of Interest for Students

# Stratolaunch - Microsoft co-founder built the world's largest plane to launch rockets into space

It's called the Stratolaunch aircraft, and it's massive. The plane has a 385-foot wingspan, which makes it the largest in the world by that metric. It weighs about 500,000 pounds dry, but that can swell to a maximum takeoff weight of 1.3 million pounds. Stratolaunch moves all that weight across the ground on 28 wheels, and eventually will carry its cargo through the air thanks to six 747 aircraft engines.



https://www.theverge.com/2017/5/31/15721480/stratolaunch-paul-allen-rockets-space-satellites

# First Private Moon Landing Gears Up for Launch by Year's End

Moon Express and Rocket Lab are poised to make history.

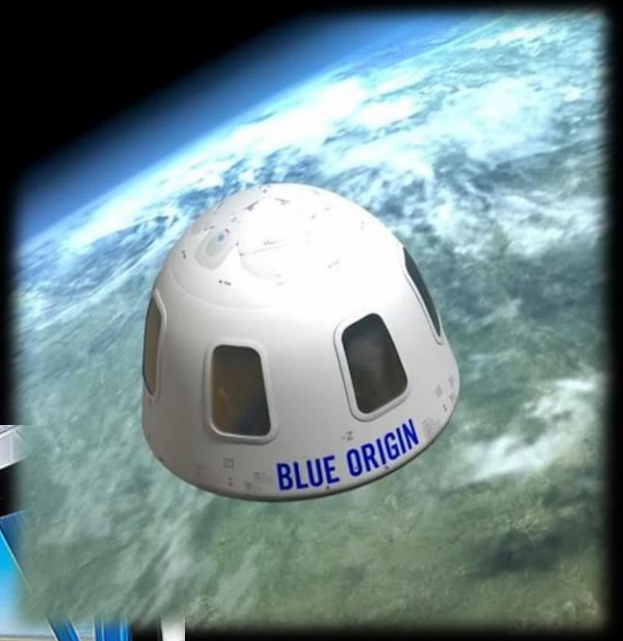
Moon Express (or MoonEx), a space exploration company powered by industry engineers and Silicon Valley money, is making the final adjustments to its lunar lander in its facilities at Cape Canaveral. Its goal is to achieve something that has only been accomplished by the three largest superpowers in the world: a soft landing on the moon.

"It will be the space equivalent of the four-minute mile. I think we're going to redefine the possible," MoonEx co-founder and CEO Bob Richards tells *Popular Mechanics*. "We've seen this throughout history—everybody thinks something is impossible until they see it done."

http://www.popularmechanics.com/space/moon-mars/a26702/moon-express-lunar-landing-launch-years-end/

# Blue Origin Rides into Space

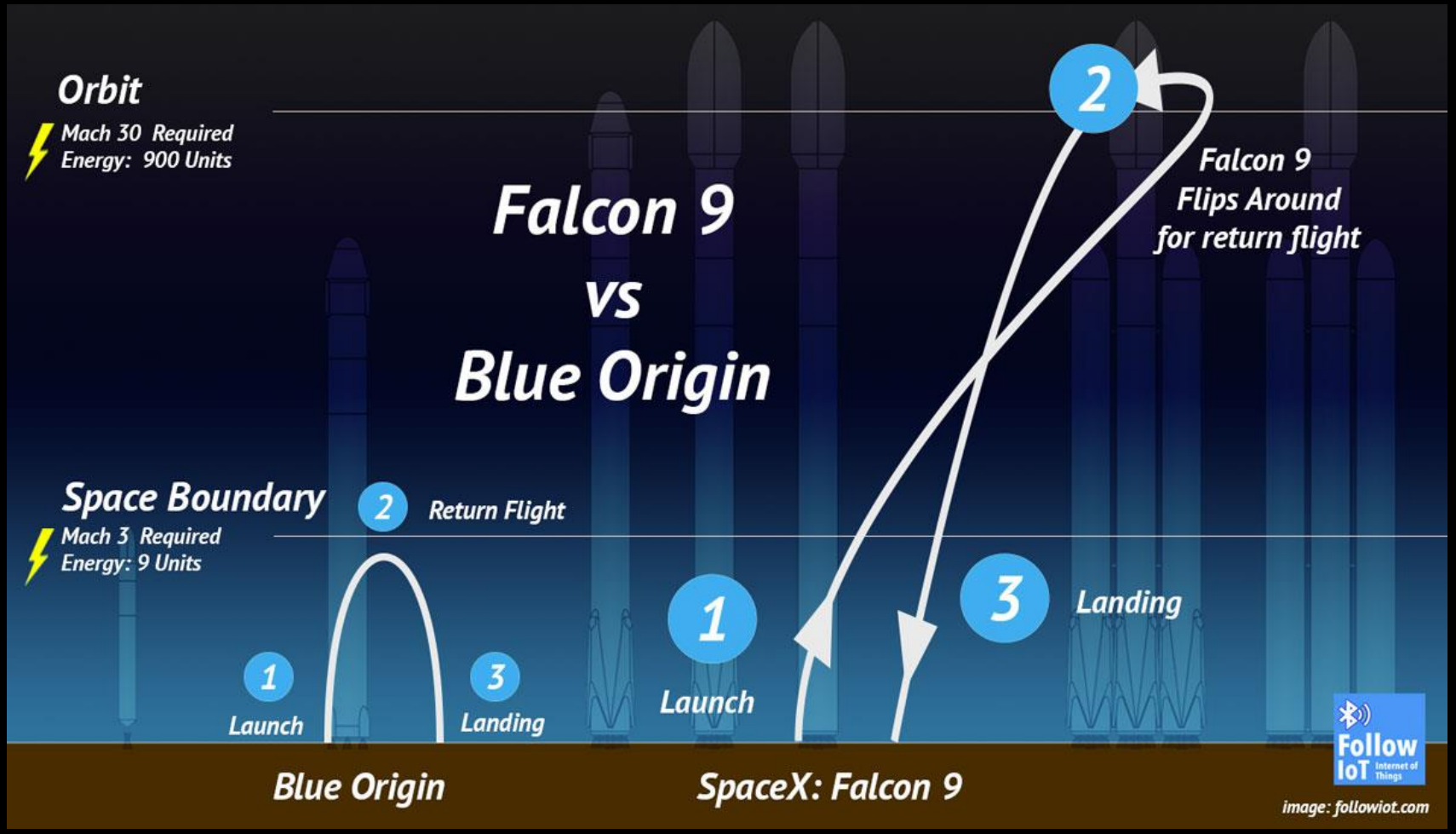
Blue Origin released new images today (March 29) of the interior of its New Shepard passenger capsule, which the company says will be used to send paying customers on brief trips into space.





https://www.space.com/36267-blue-origin-space-capsule-interior-sneak-peek.html

# Interesting Look at Blue Origin vs SpaceX




# Questions?

## Thank You!

# My favorites…

# My favorite sites and links…

- Heavens Above
  - http://heavens-above.com/
- NASA Spinoffs
  - http://spinoff.nasa.gov/
- Eyes on the Solar System
  - http://eyes.nasa.gov/
  - Youtube NASA Television
  - http://www.youtube.com/user/NASAtelevision
  - Youtube Earth Video
  - http://www.youtube.com/watch?v=Ip2ZGND1I9Q
  - ISS Tour by CDR/Suni Williams
  - http://www.youtube.com/watch?v=doN4t5NKW-k
  - Why Mars is Hard Stan Love
  - http://www.youtube.com/watch?v=fturU0u5KJo
- Perspectives

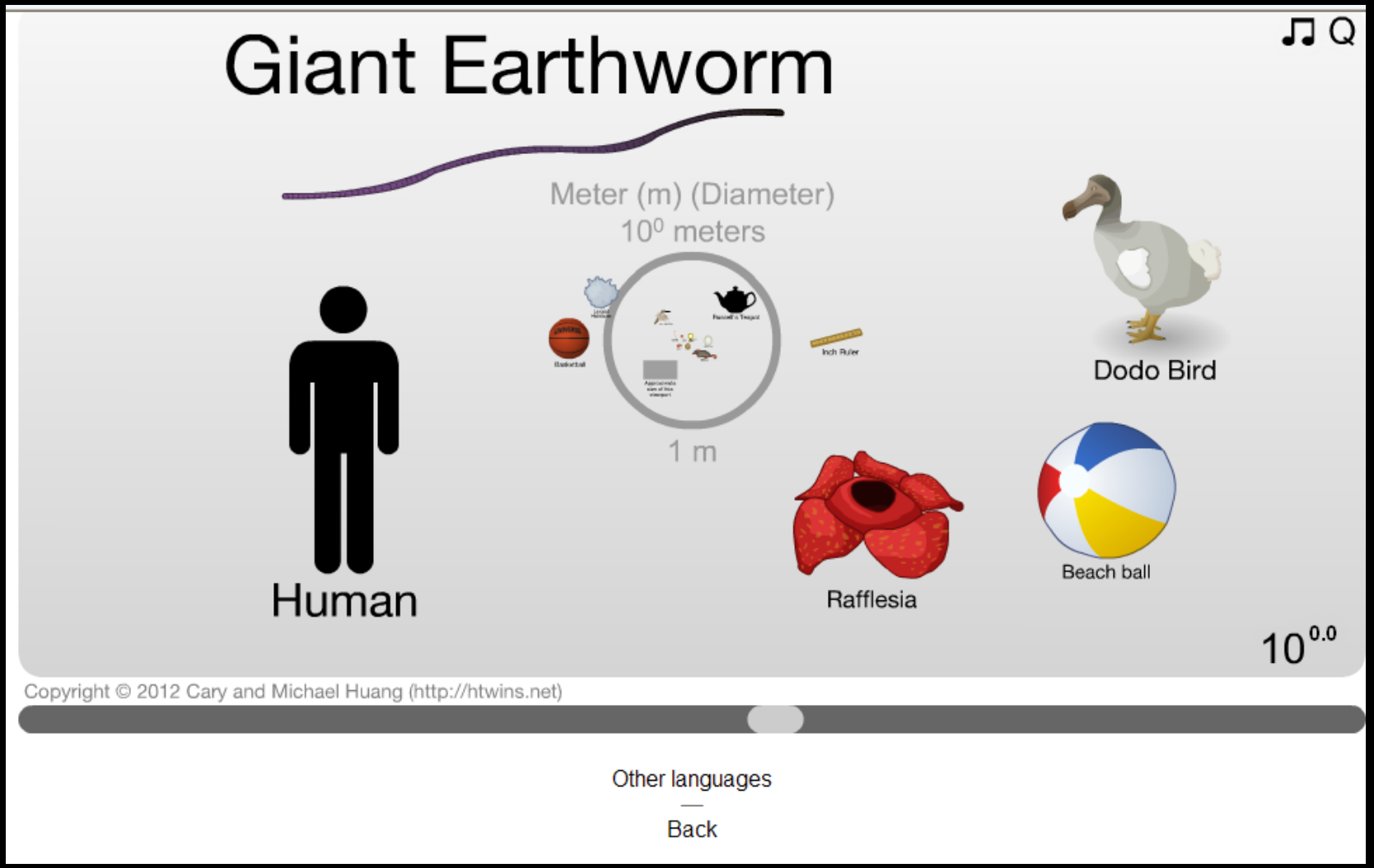
  http://htwins.net/scale2/?bordercolor=white
- ISSLive
  - http://spacestationlive.jsc.nasa.gov/
- Distance Learning Network
  - NASA DLN Website: http://www.nasa.gov/offices/education/programs/national/dln/index.html
  - Toolkit with Material and Templates: http://communications.nasa.gov/OCP/Communications%20Tool%20Kit/Presentation%20Templa

# JPL – Eyes on the Solar System


Eyes on the Solar System
http://eyes.nasa.gov/

# Perspective -

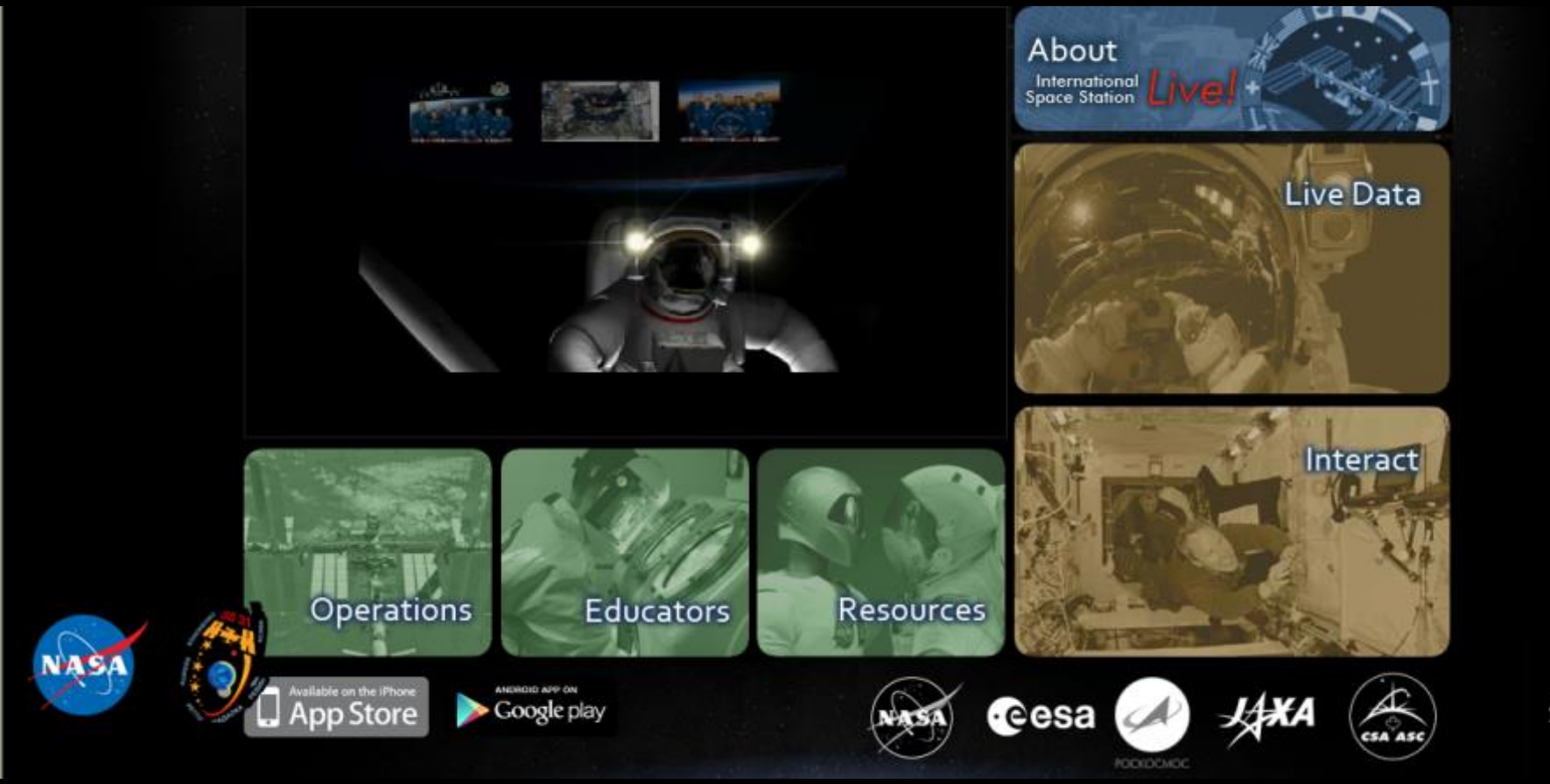
http://htwins.net/scale2/?bordercolor=white



# ISS*Live*

ISSLive

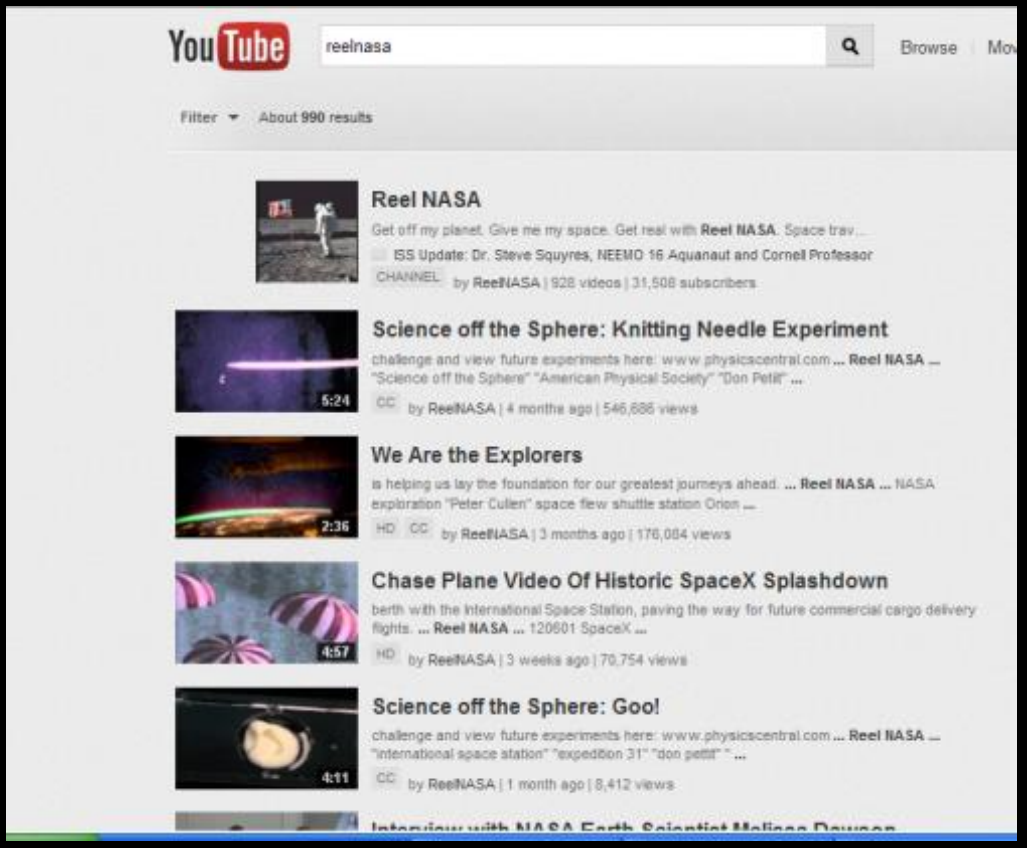
http://isslive.com/



# Youtube – REELNASA

ReelNASA

http://www.youtube.com/results?search_query=reelnasa&sa=X&spell=1&search=Search&oi=spell



# NASA Spinoffs

http://spinoff.nasa.gov/

# Heavens Above

http://heavens-above.com/

# NASA Distance Learning

NASA DLN Website: http://www.nasa.gov/offices/education/programs/national/dln/index.html

## See the Space Station fly over YOUR home!

Use “Skywatch” program or go to “sightings by city”

- **spaceflight.nasa.gov/realdata/sightings**

| SATELLITE | LOCAL DATE/TIME | DURATION (MIN) | MAX ELEV (DEG) | APPROACH (DEG-DIR) | DEPARTURE (DEG-DIR) |
|---|---|---|---|---|---|
| ISS | Tue Nov 14/06:22 AM | 4 | 66 | 10 above WSW | 31 above NE |