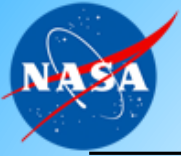


Human Space Exploration in Our Solar System

Antony Jeevarajan, Ph.D.
Johnson Space Center

National Aeronautics and Space Administration
Houston, TX 77058

Email: antony.s.jeevarajan@nasa.gov



DEDICATED TO THE TEACHERS



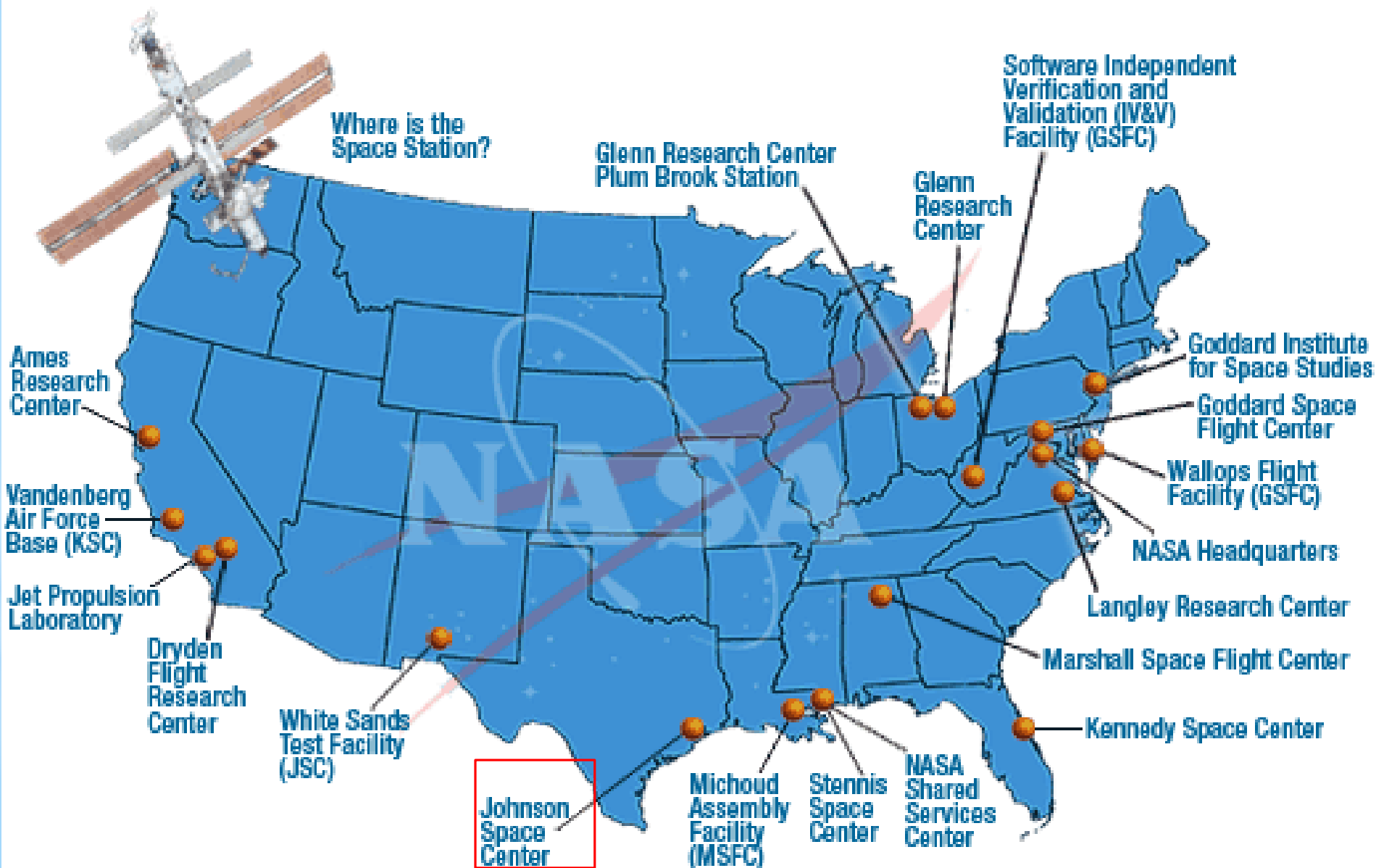
Objectives



- ❖ **Where are we in the Universe?**
- ❖ **Solar System – A glance**
- ❖ **Hubble and Webb Telescopes**
- ❖ **More importantly, an attempt to answer all of your questions**

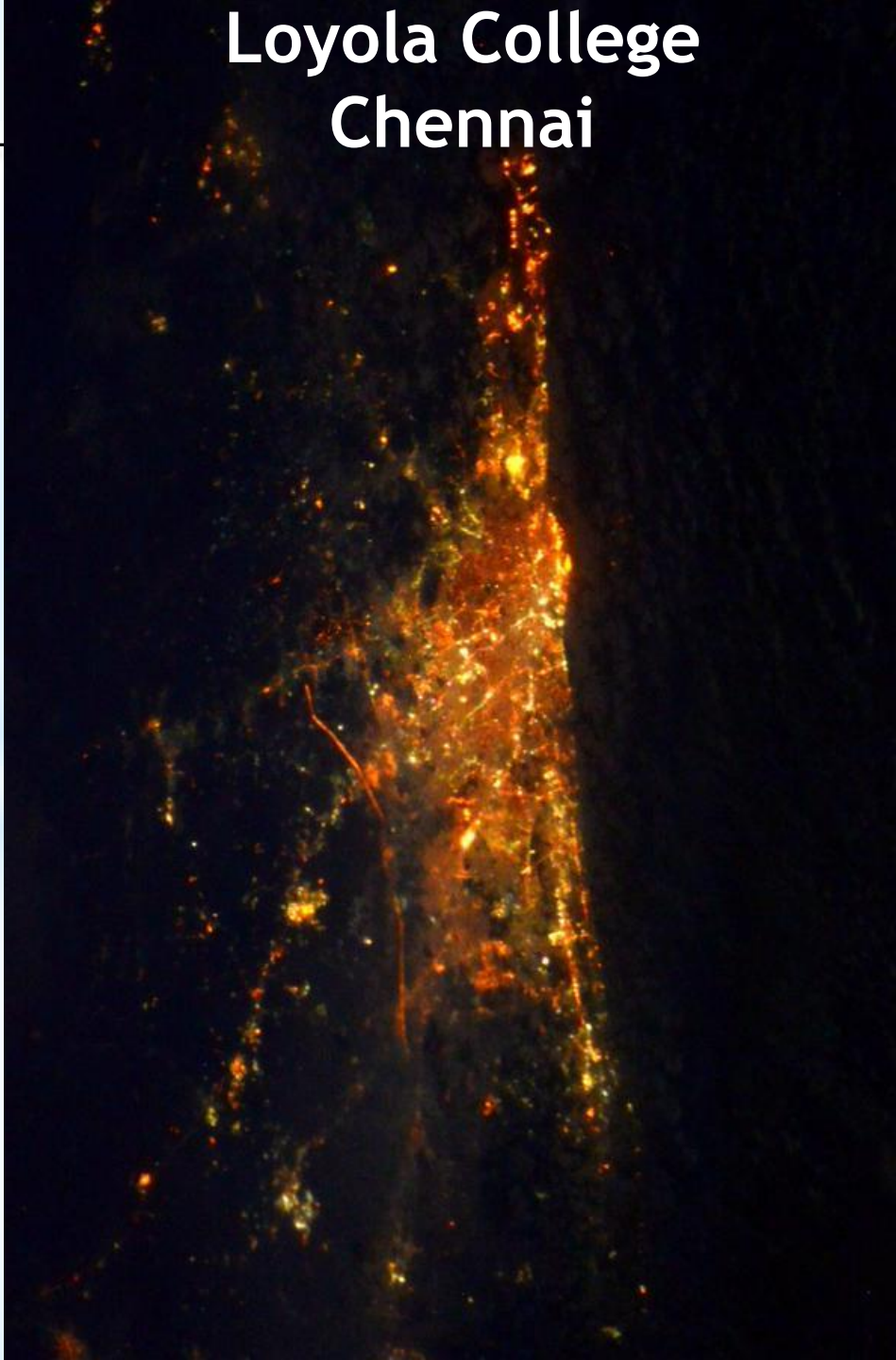


NASA Centers





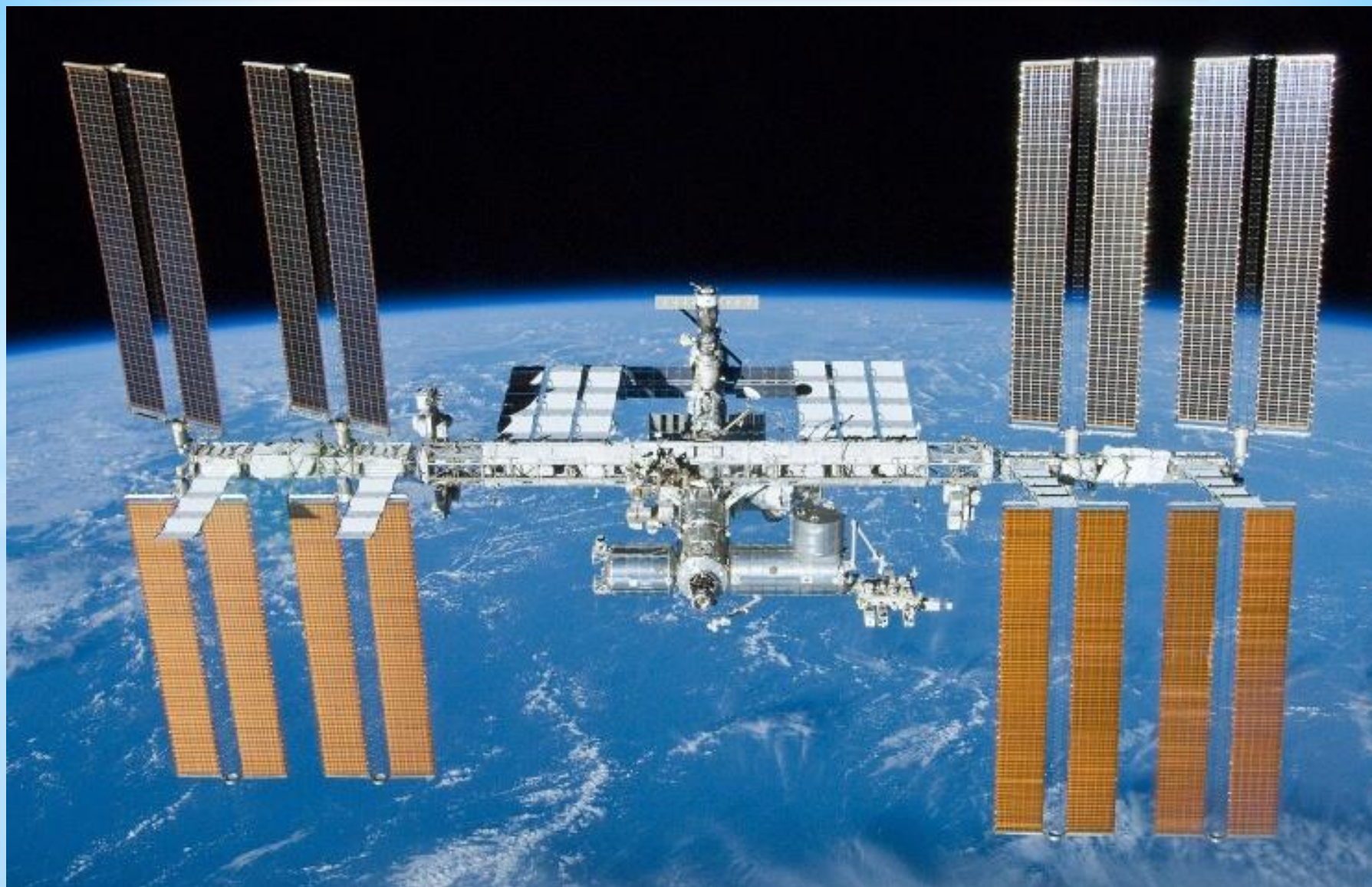
Loyola College Chennai

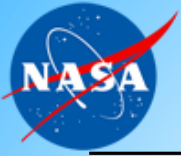


Our Habitation at Night



Our Planet from ISS (~250 miles)





Beautiful Fragile Blue Planet (~250,000 miles)

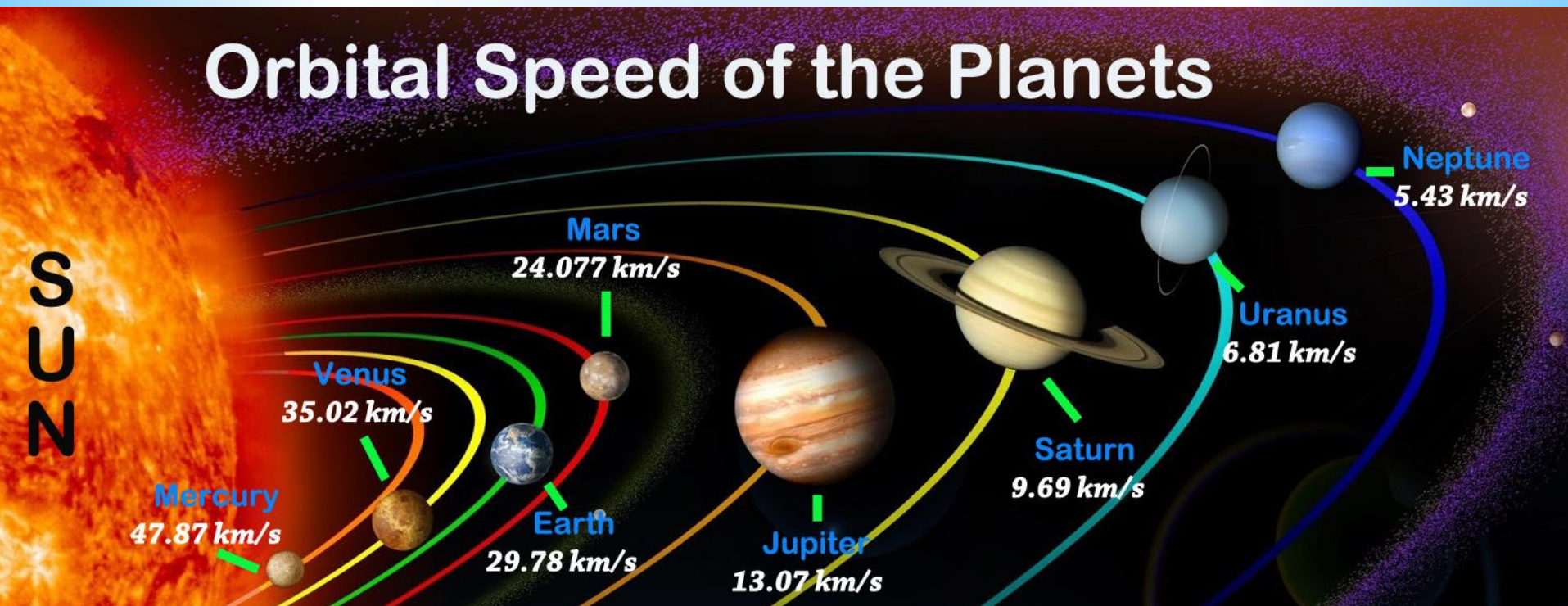




Mars - Earth Mutual View (~250,000,000 miles)

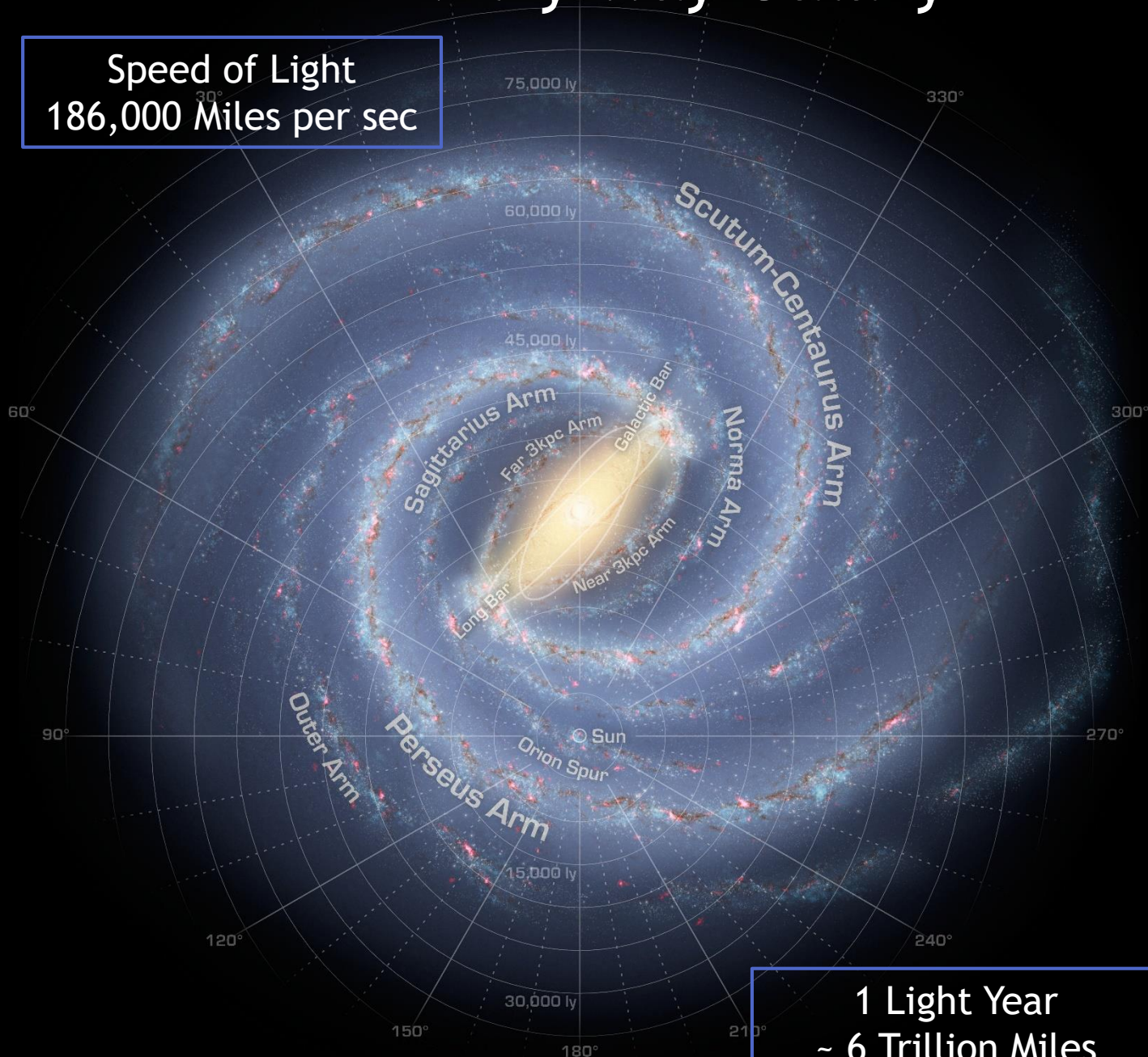


Orbital Speed of the Planets



Milky Way Galaxy

Speed of Light
186,000 Miles per sec



1 Light Year
~ 6 Trillion Miles

Milky Way from Earth

Top from Lebanon and Bottom from Chile





Hubble Telescope Repair Mission Crew (STS-125)



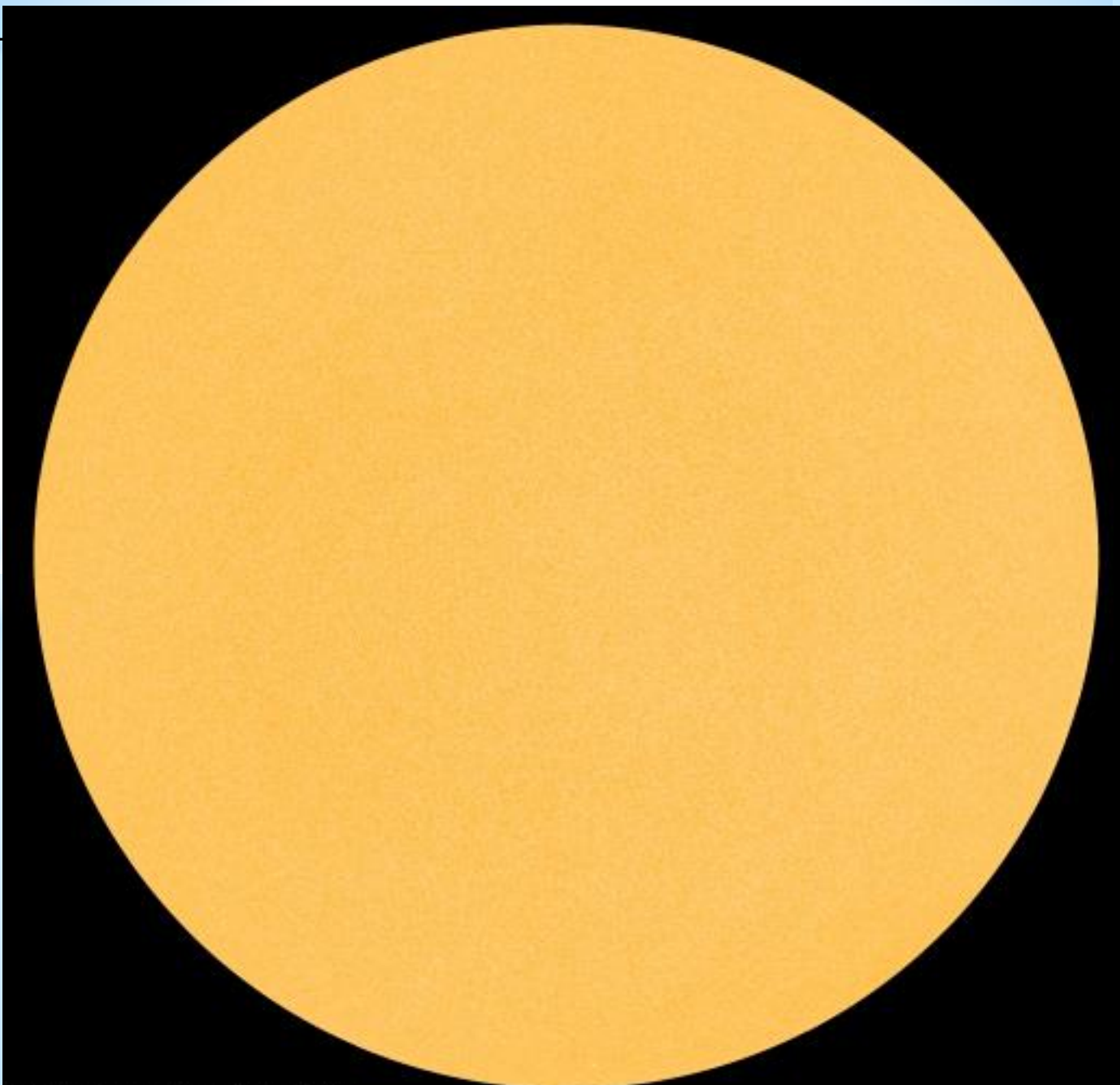
Webb Telescope





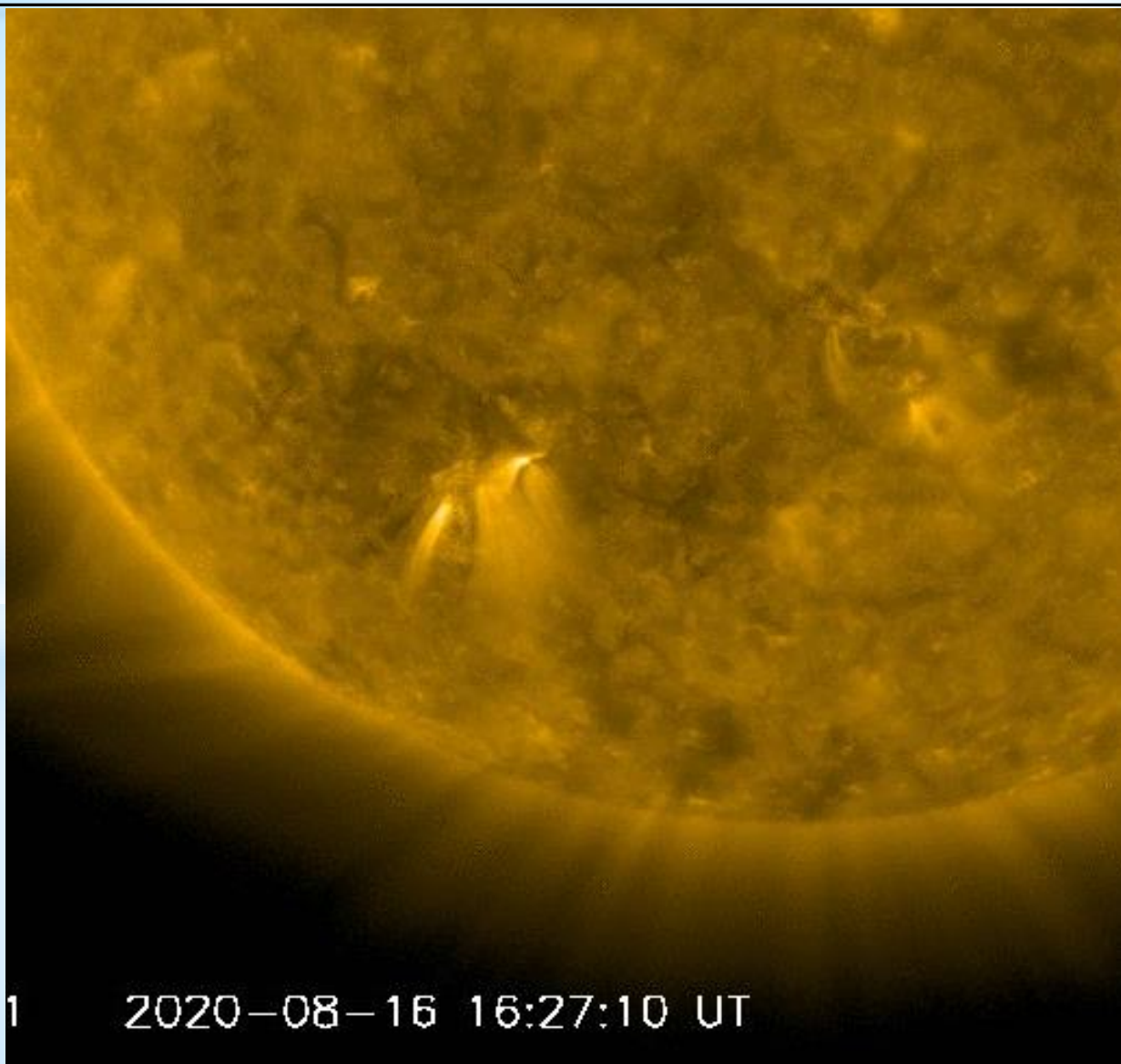


Spotless Sun 2019

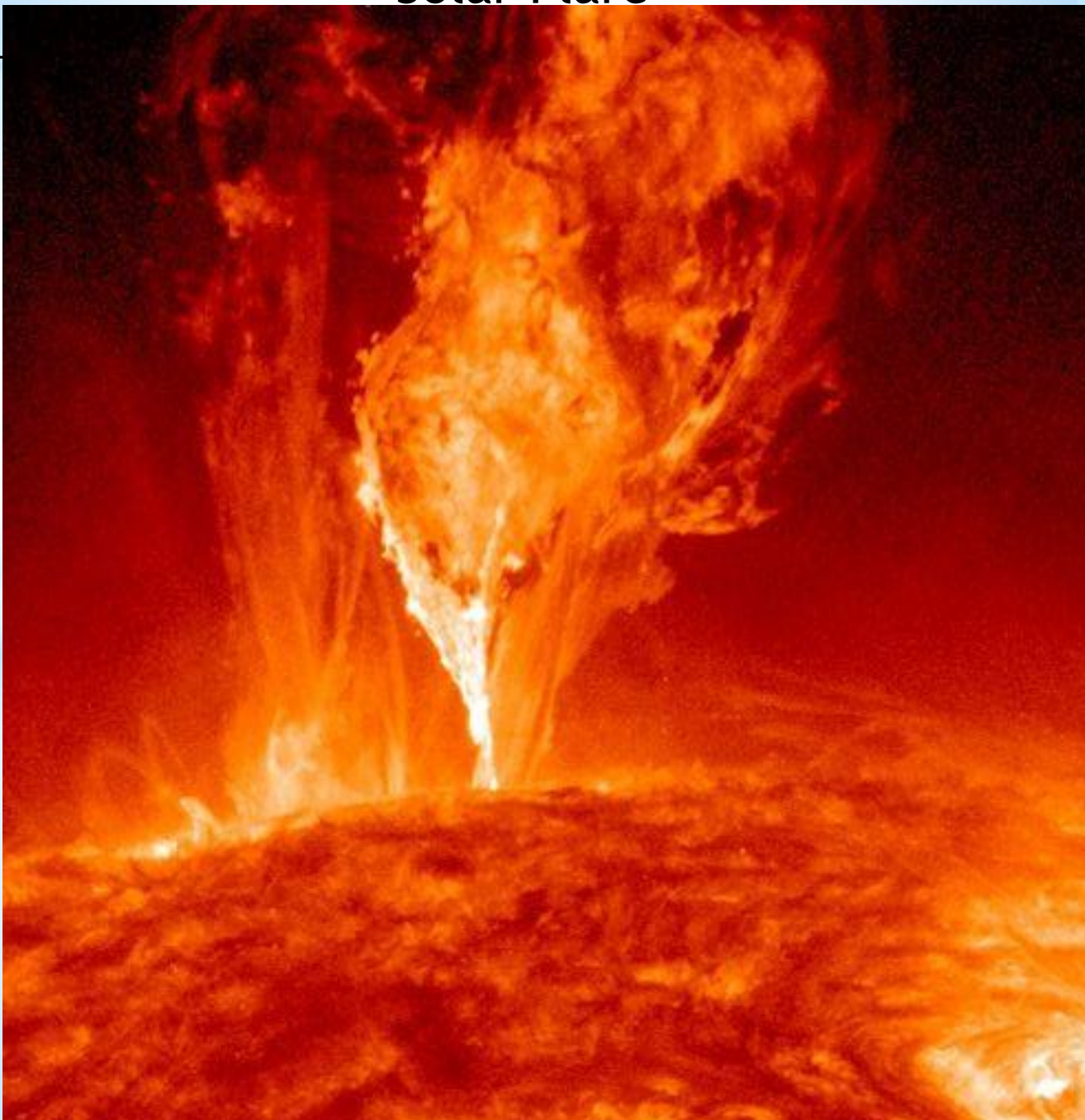




Solar Flare Aug 16, 2020



Solar Flare



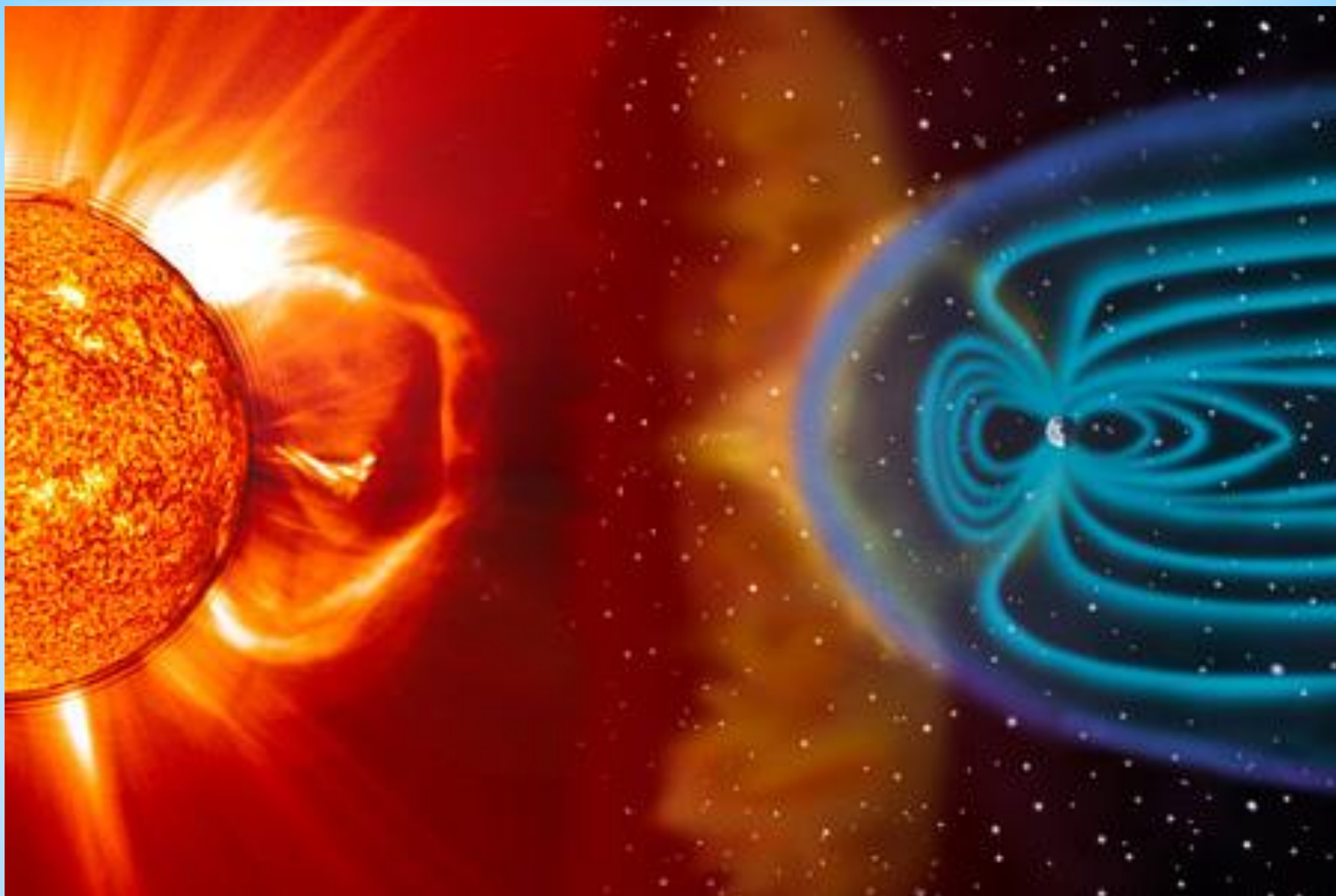


Solar Flare and Earth (Size Comparison)





Solar Flare and Earth's Magnetic Field



Aurora from Northern Hemisphere

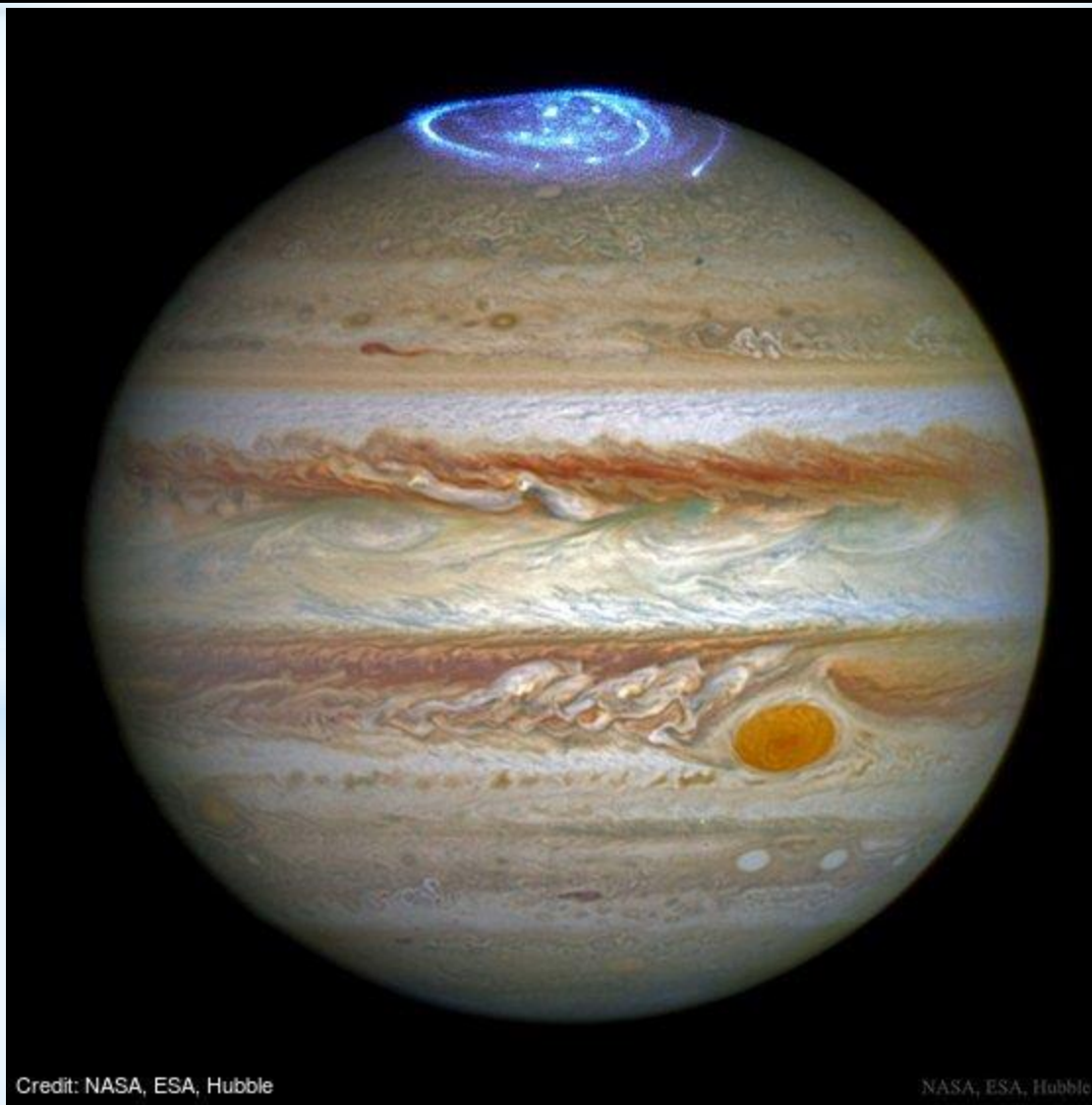




Auroras from ISS

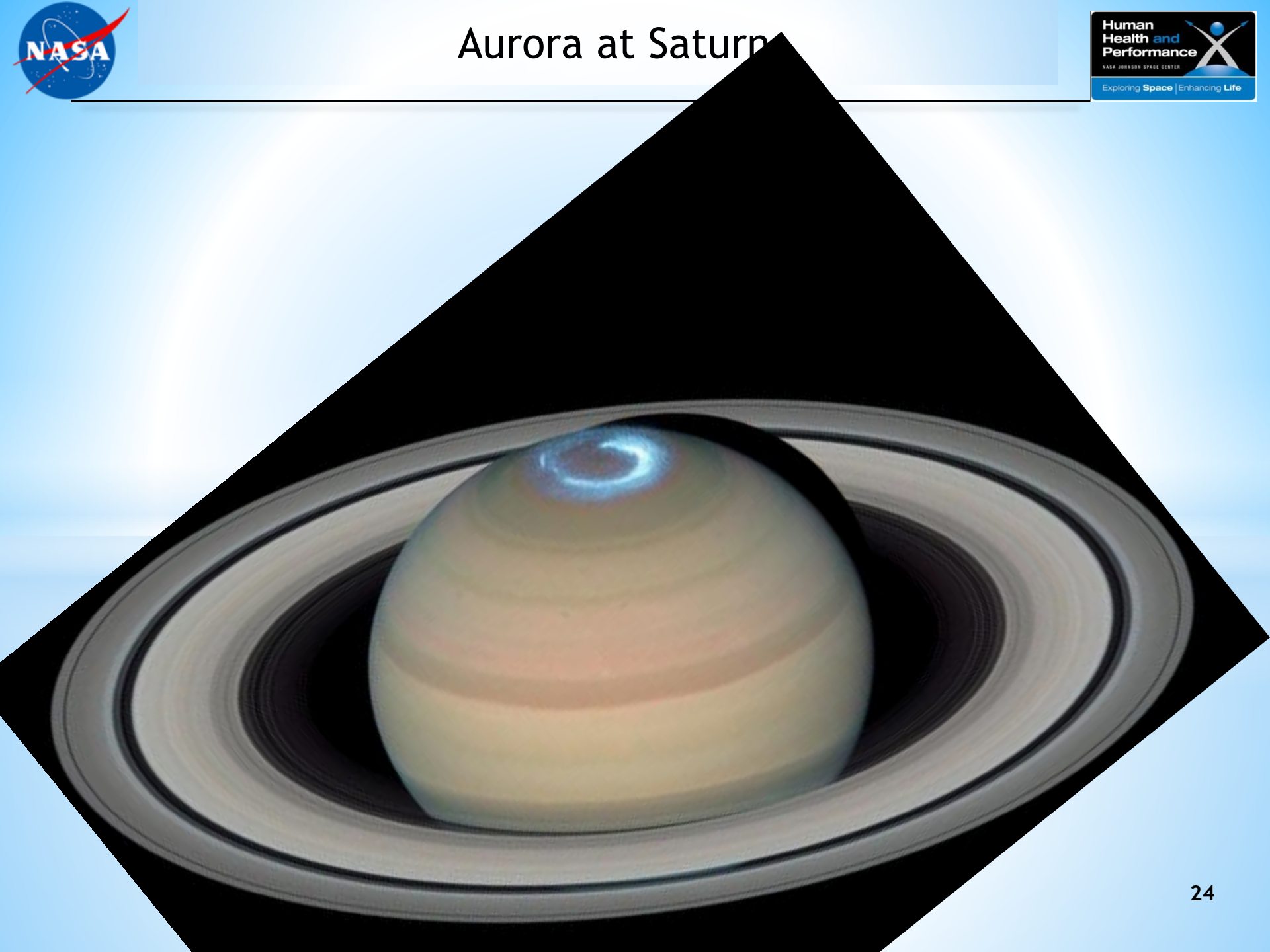


Aurora at Jupiter



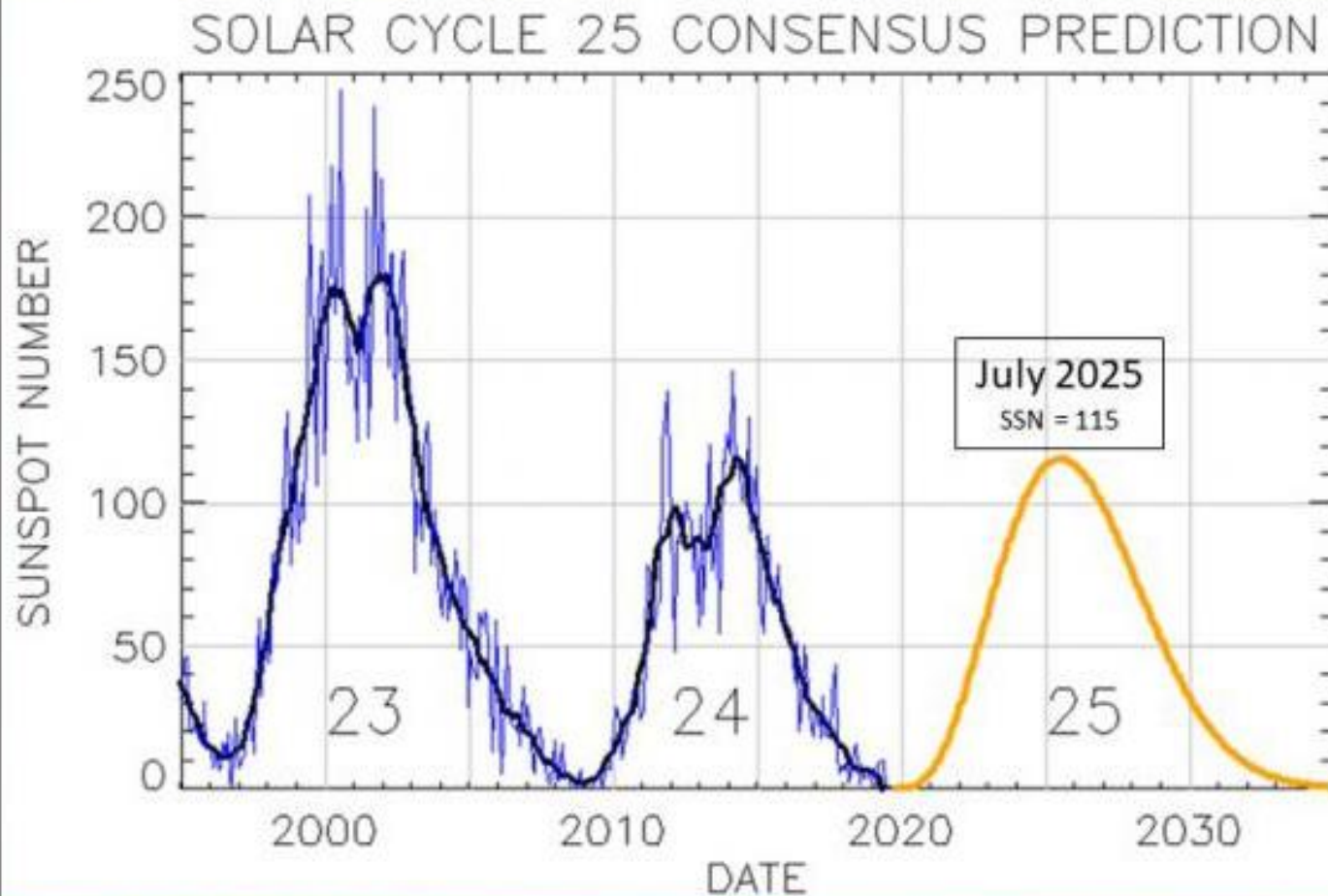


Aurora at Saturn



Solar Cycle 25 Forecast Update

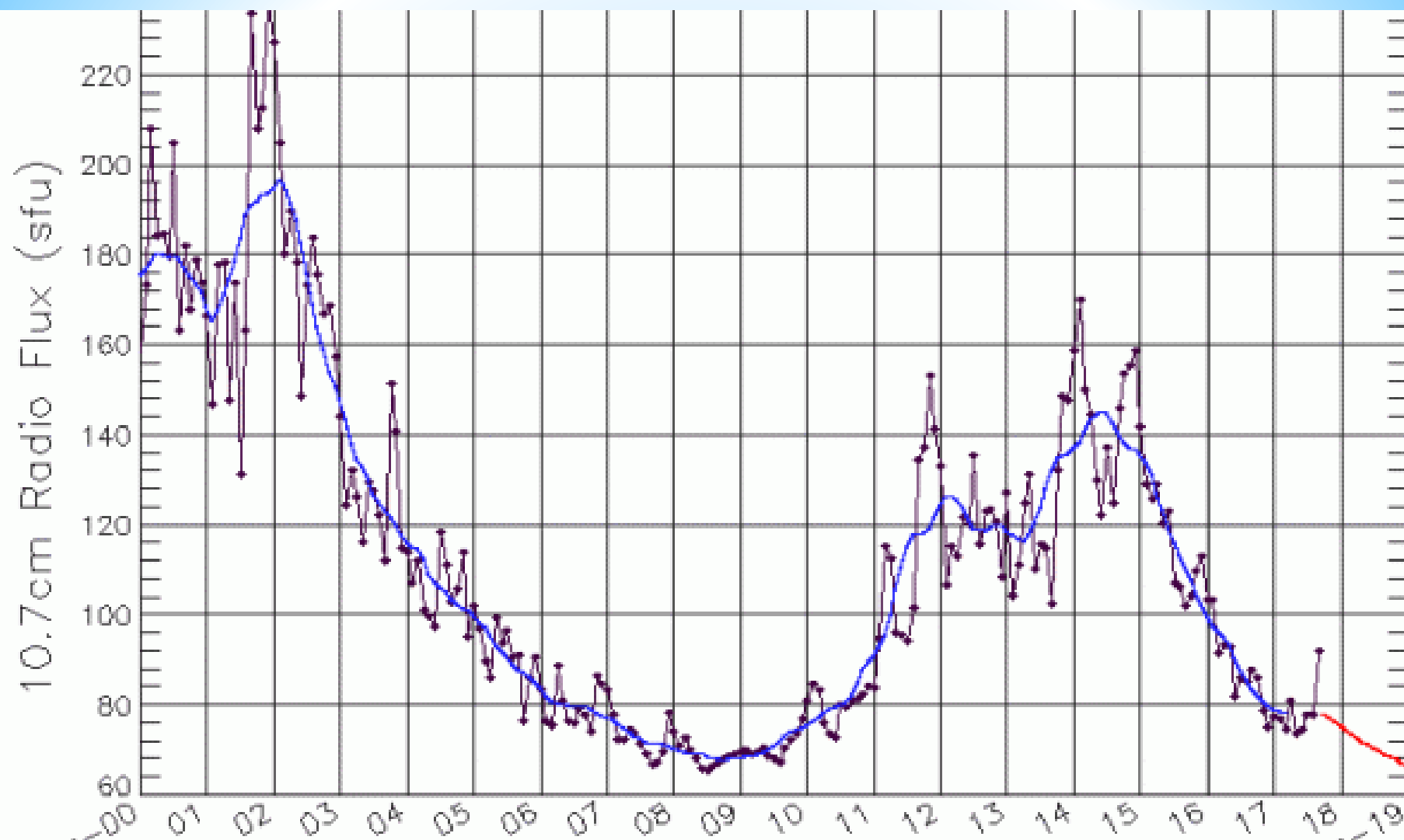
- Released December 9th, 2019 -



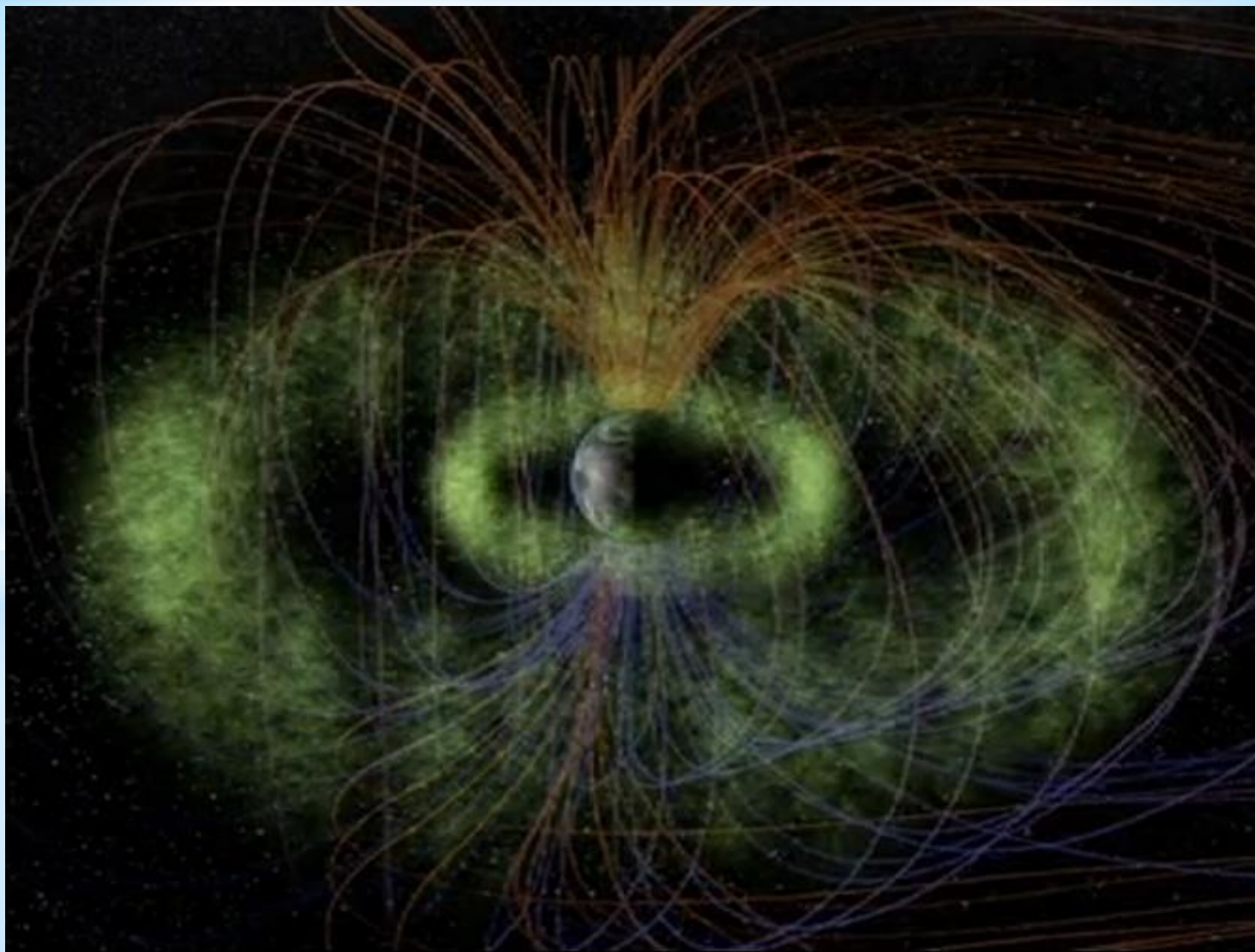
Solar Cycle 25 will have a peak SSN of 115 (± 10) in July 2025

Solar Cycle 24/25 minimum will occur in April, 2020 (± 6 months)

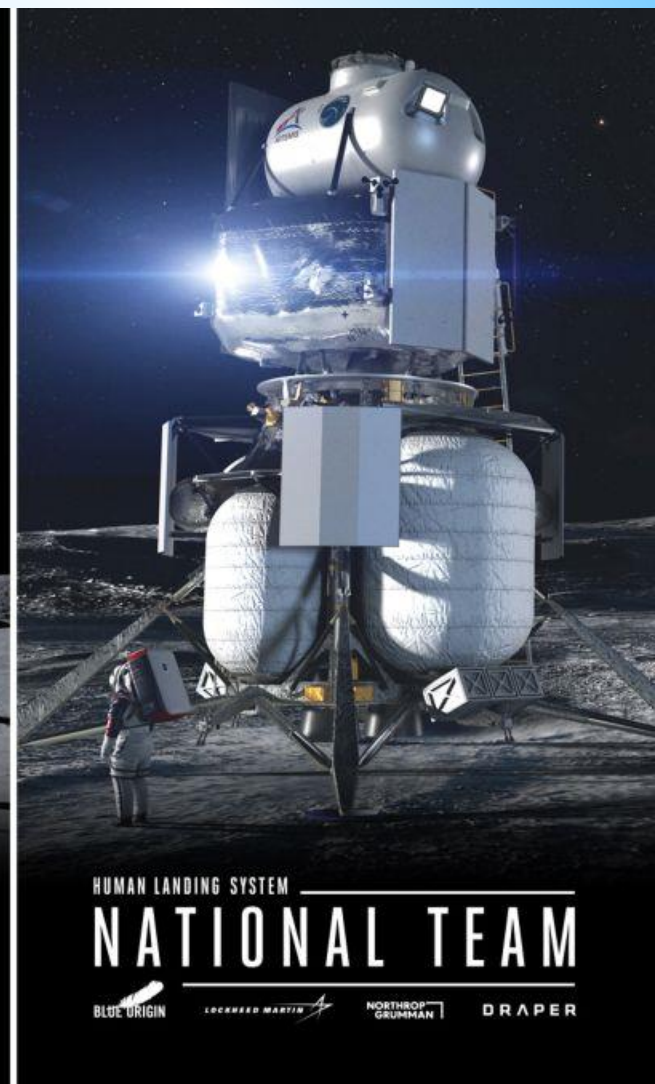
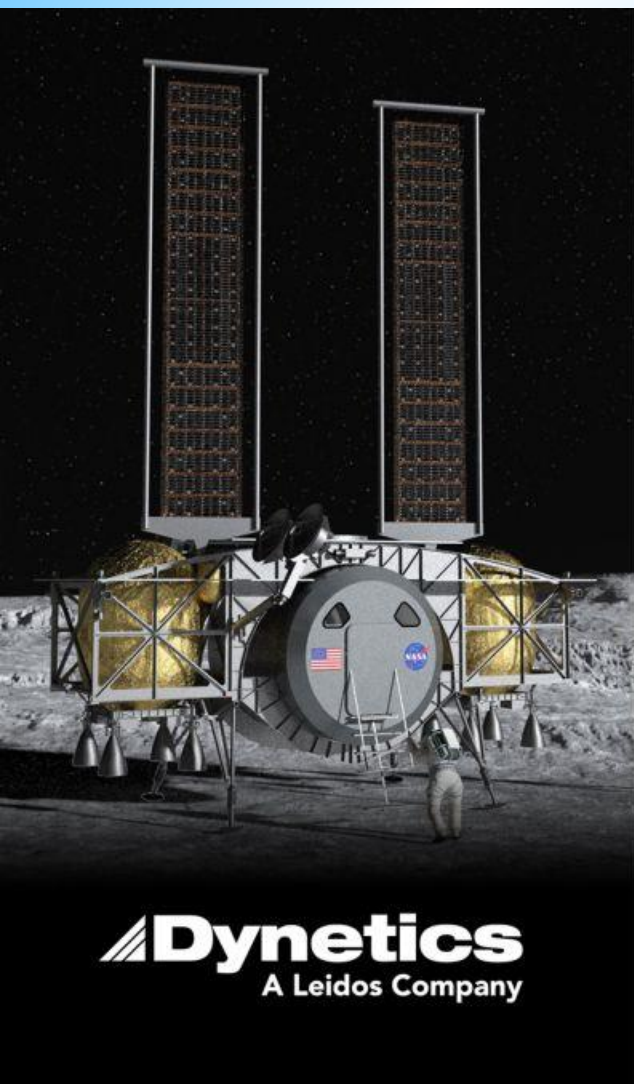
Solar Cycle : 10.7 cm Radio Wave



Van Allen Belt



Moon Landing : 2024



Apollo 11 JUL 69
Mare Tranquillitatis
0.67416°N 23.47314°E
LM: 21.6 hours EVA: 2.5 hours

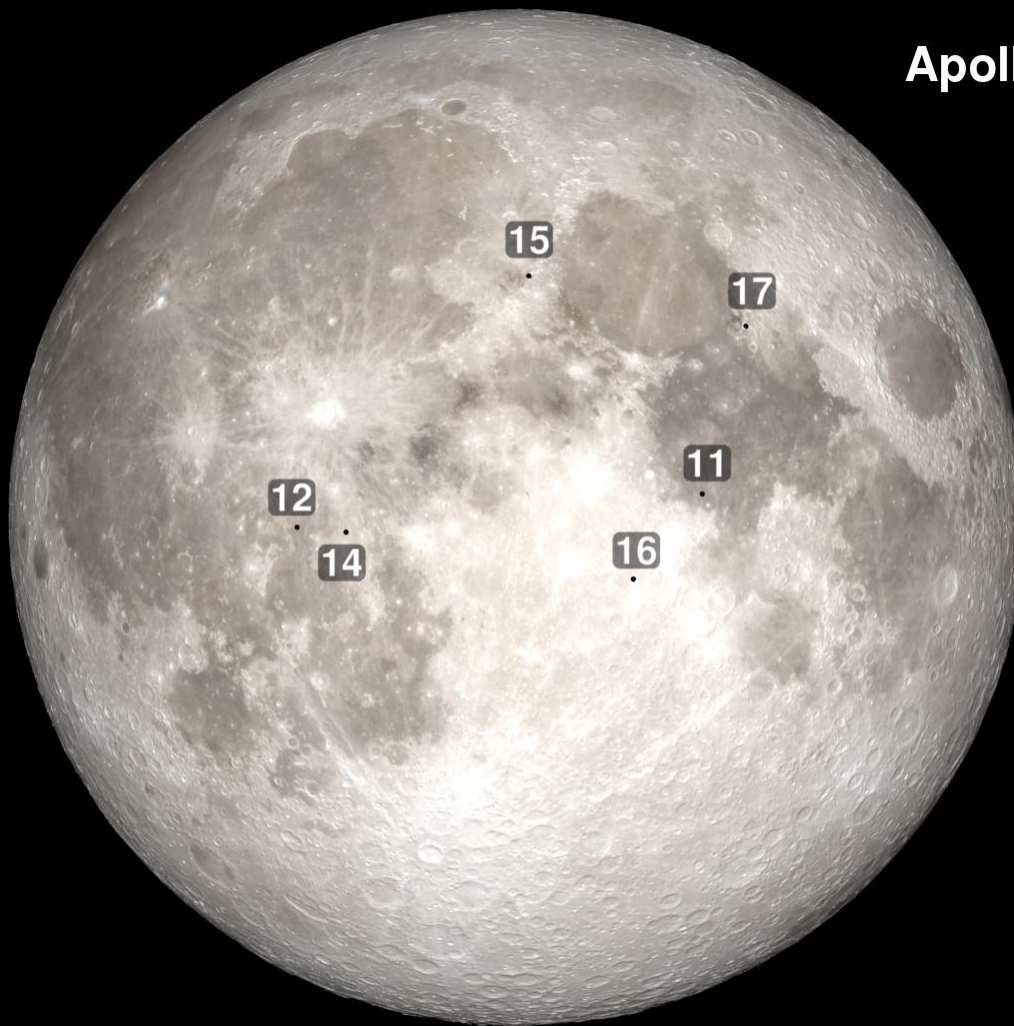
Apollo 12 NOV 69
Oceanus Procellarum
3.0128°S 23.4219°W
LM: 31.5 hours EVA: 7.8 hours

Apollo 14 FEB 71
Fra Mauro Highlands
3.64589°S 17.47194°W
LM: 33.5 hours EVA: 9.4 hours

Apollo 15 AUG 71
Hadley Rille
26.13239°N 3.63330°E
LM: 66.9 hours EVA: 19.1 hours

Apollo 16 APR 72
Descartes Highlands
8.9734°S 15.5011°E
LM: 71.0 hours EVA: 20.2 hours

Apollo 17 DEC 72
Taurus-Littrow Valley
20.1911°N 30.7655°E
LM: 75.0 hours EVA: 22.1 hours



Apollo Landing Sites





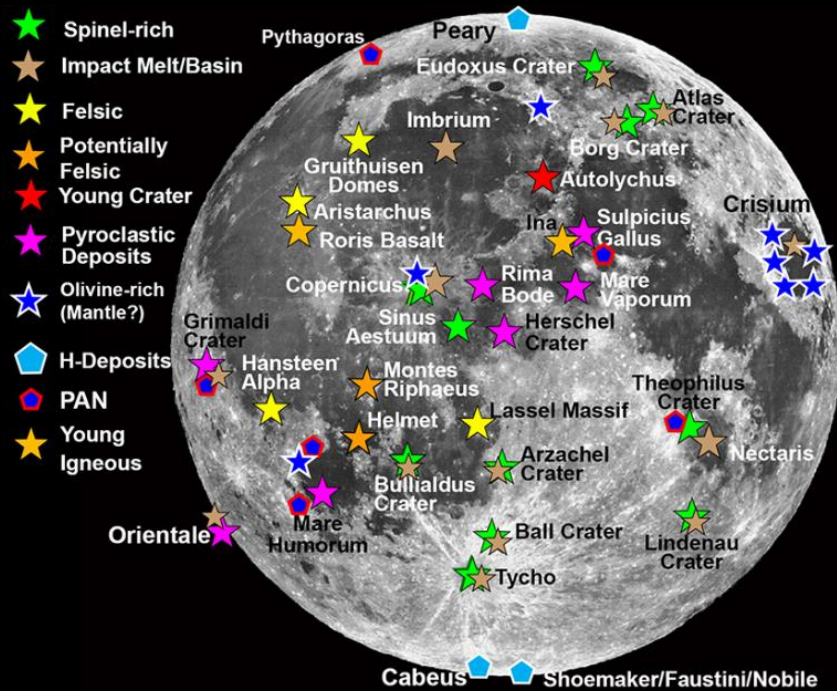
First woman to land on the Moon
Technology validation on Moon for the Human
Space Exploration of Mars



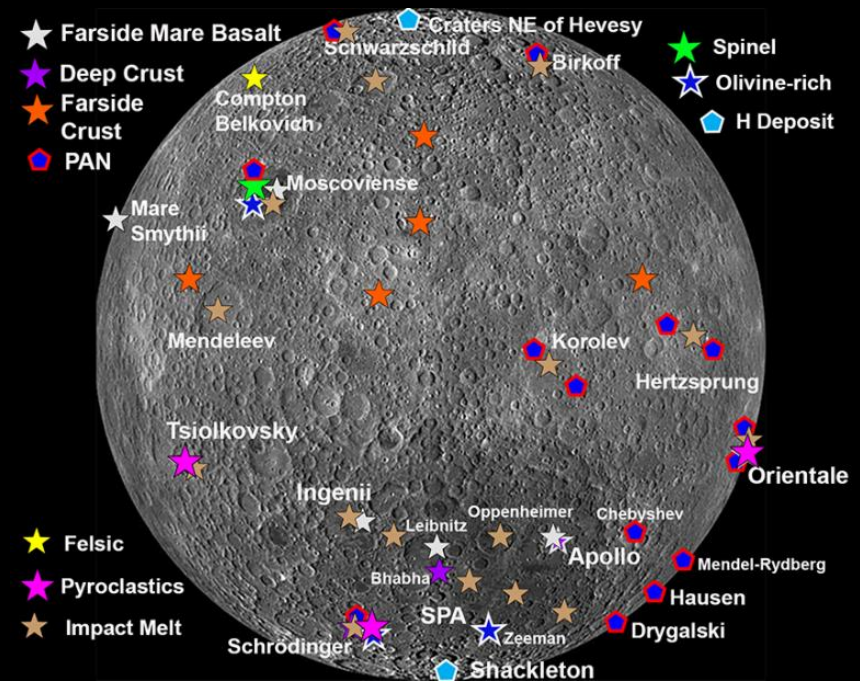
In Greek Mythology, Artemis is the twin sister of Apollo

Lunar Scientists have a lot of places they would like to go!

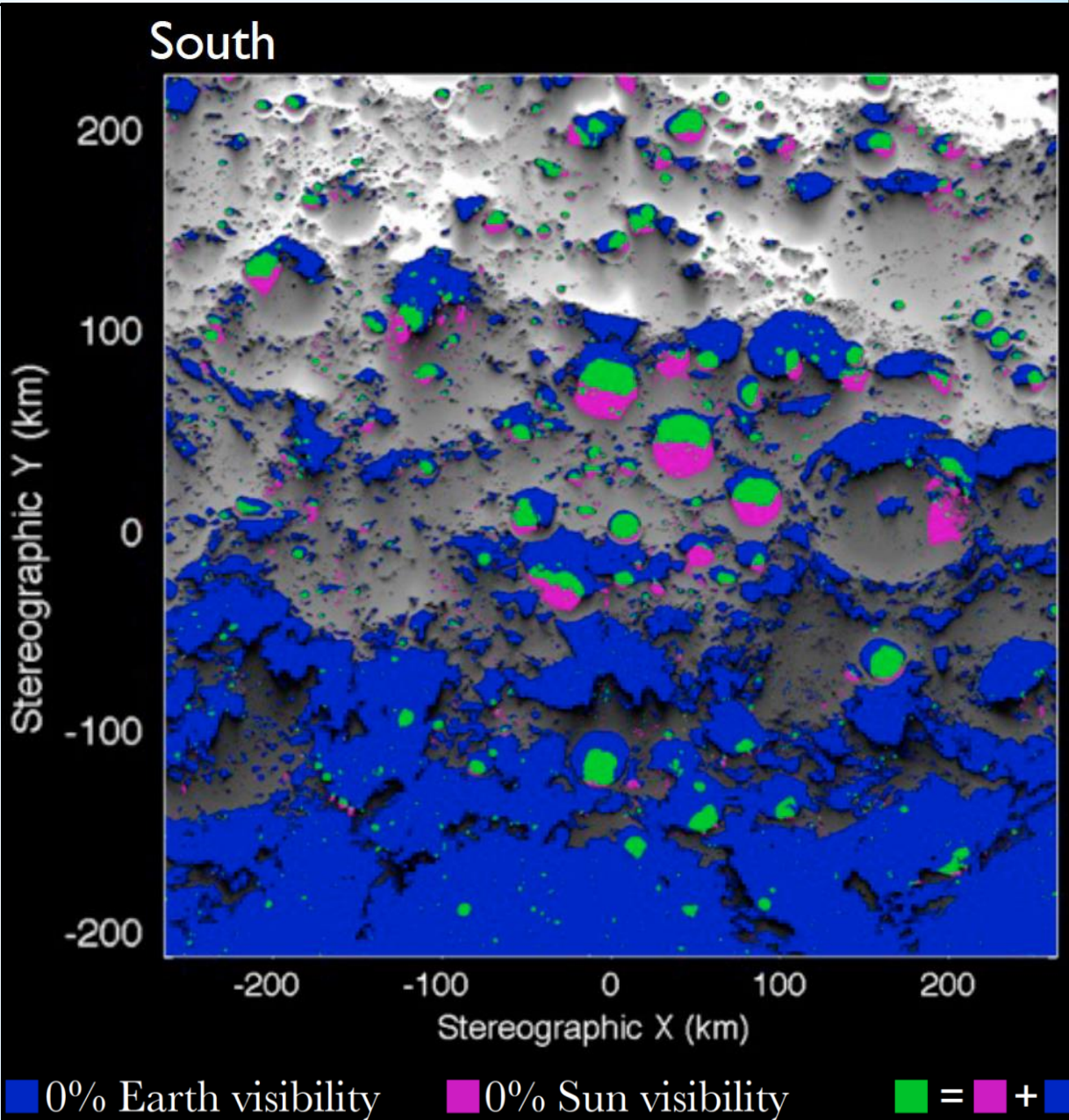
(<https://lunar-landing.arc.nasa.gov/>)



Near Side



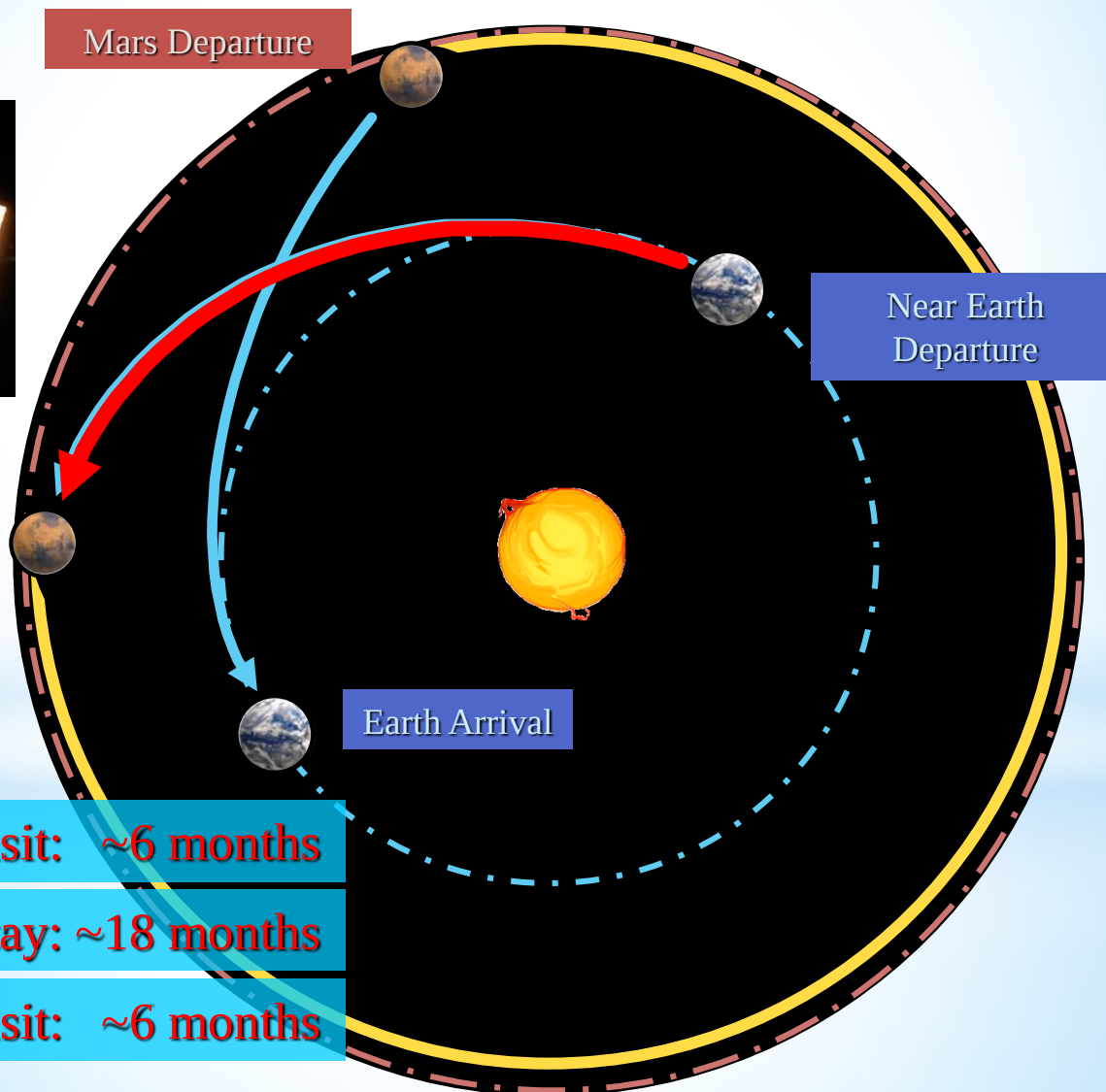
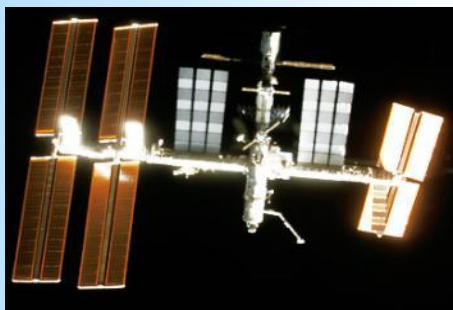
Far Side



Mazarico, LEAG 2013



Overview of Notional Mars Expedition



Mars Arrival

Mars Departure

Near Earth
Departure

Earth Arrival

Earth-to-Mars transit: ~6 months

Mars surface stay: ~18 months

Mars-to-Earth transit: ~6 months



Why Mars?



* Mars is our most hospitable planetary neighbor

- * Venus is closer, but its average temperature of 462°C (864°F) and the sulfuric acid atmosphere—90 times higher pressure than Earth—would crush our spaceships

* Mars will feel like home in many ways:

- * Approximately the same day/night cycle as Earth
- * 4 seasons: cold winters, but as warm as 20°C (70°F) on a summer day
- * Vistas similar to Earth's deserts: mountains, cliffs, valleys, dunes, dust devils
- * Abundant natural resources: oxygen (from ice or CO₂), water, iron, sunlight
- * Enough atmosphere to provide some radiation protection

* Mars is also exotic:

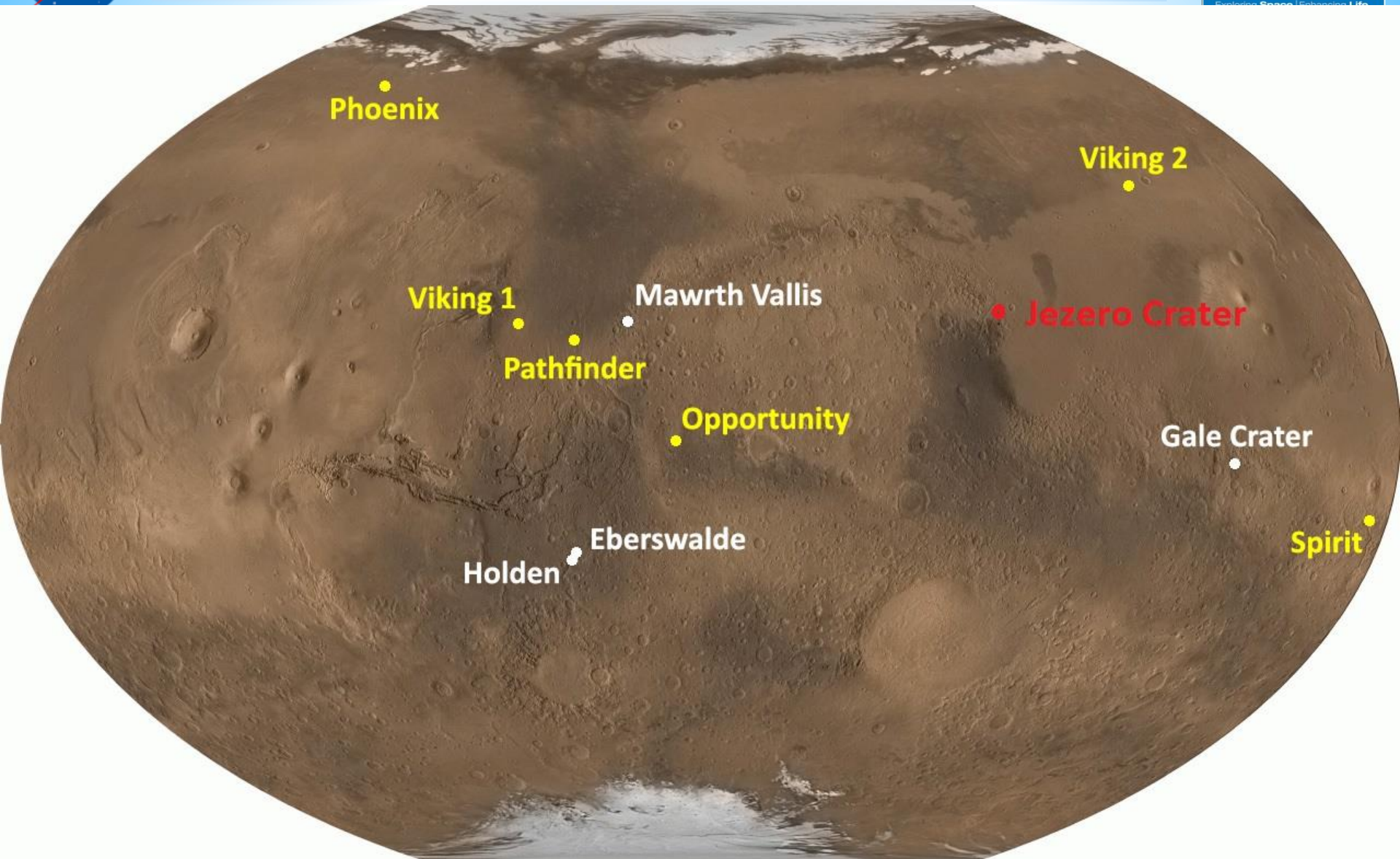
- * 0.64 of Earth's gravity and 2 moons that cross each other traveling different directions
- * May have once supported life
- * We don't know what may be underground--our rovers have only explored a fraction of Mars' surface



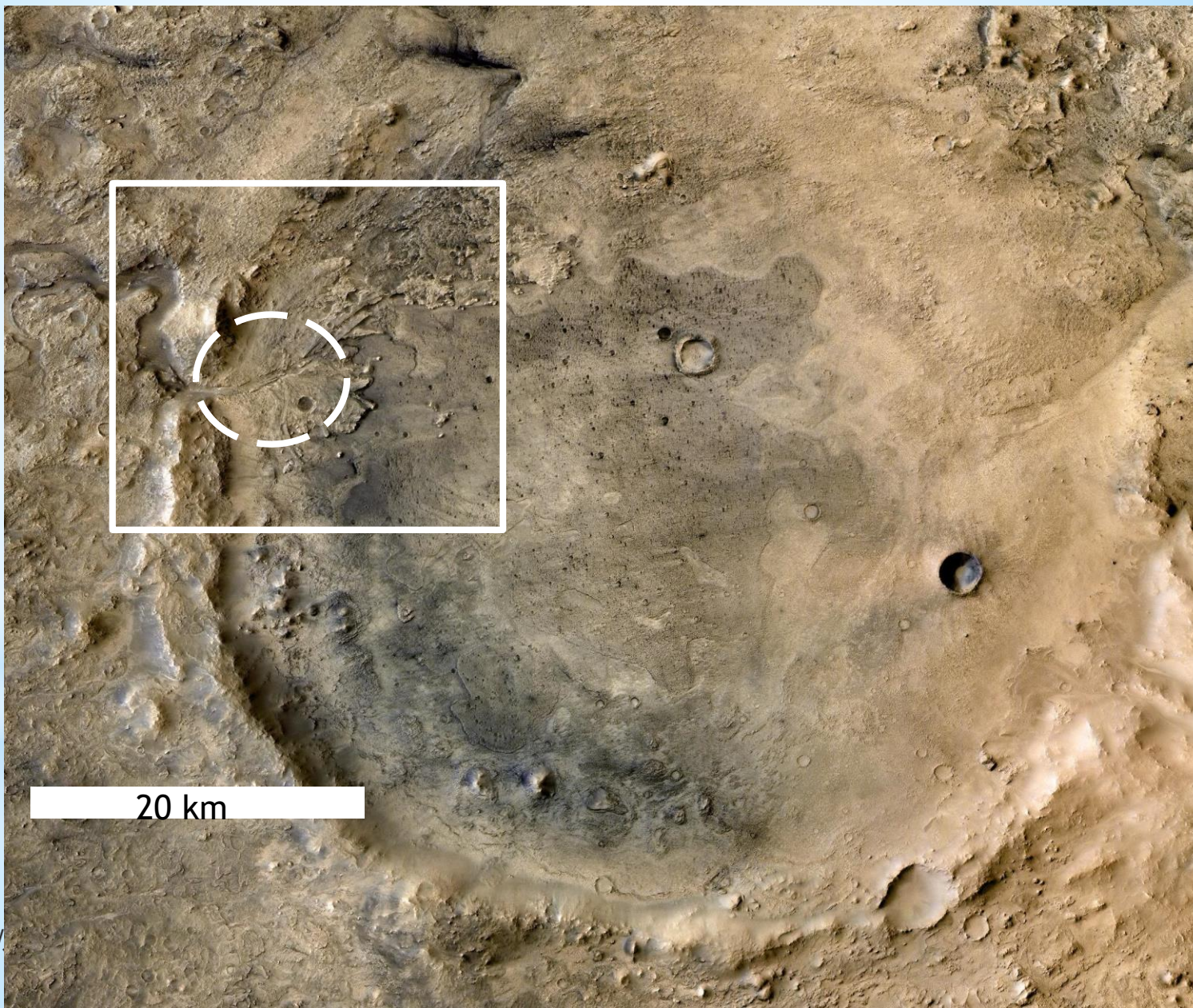
Mars-Earth Mutual View



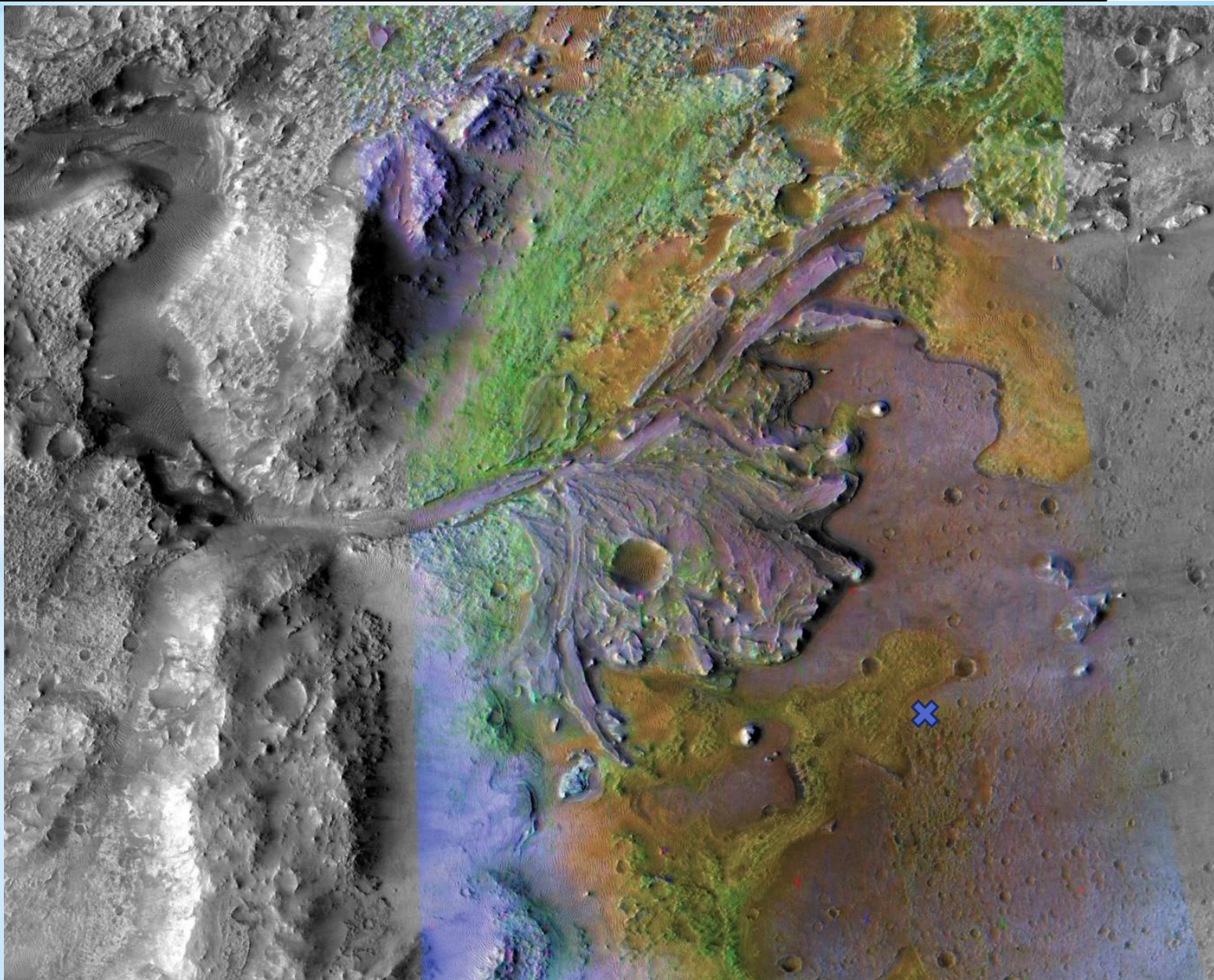
Mars Landing Sites



Mars 2020 : Jezero Crater



Mars 2020 : Jezero Crater

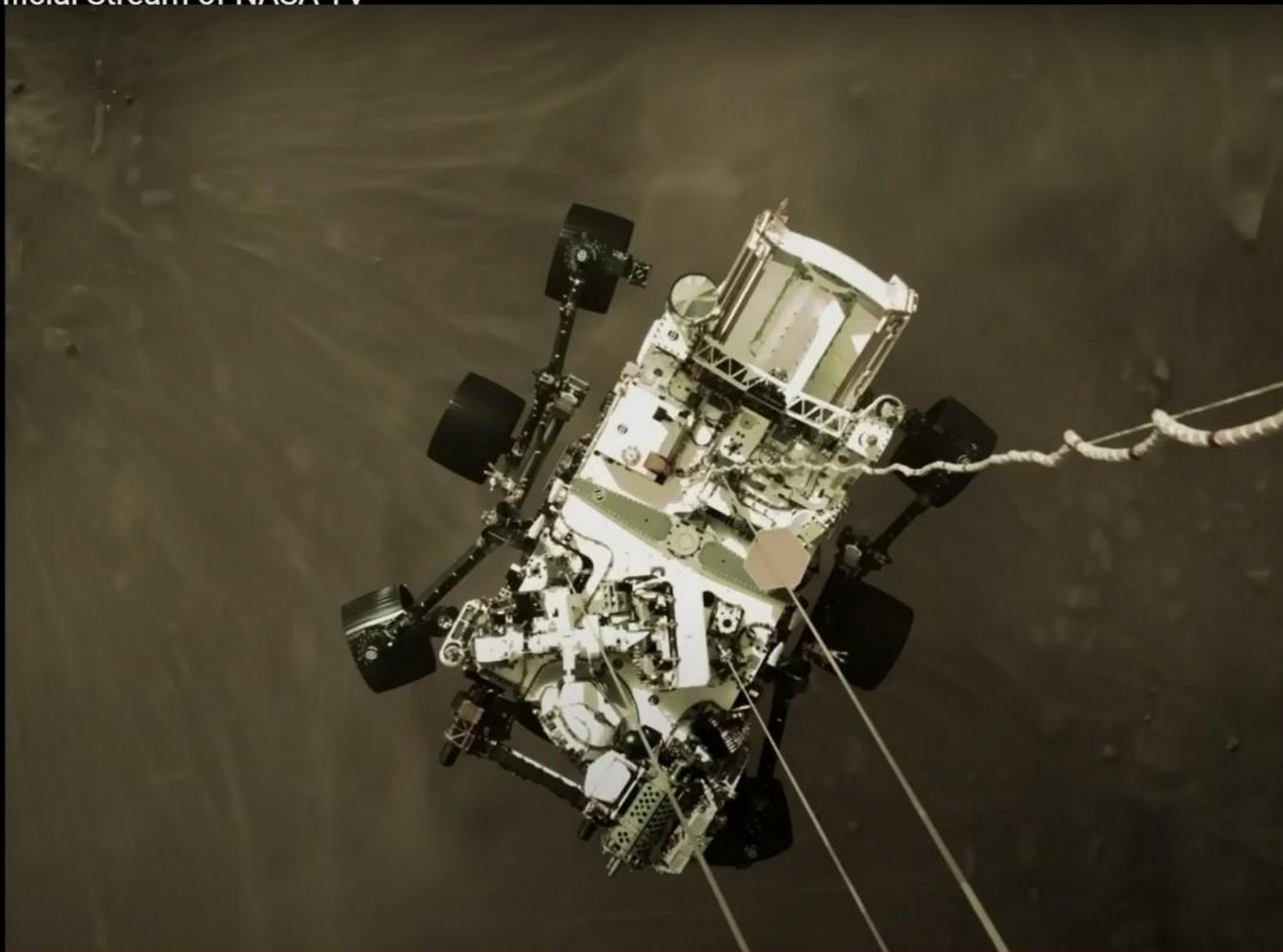




Perseverance Landing



NASA Live: Official Stream of NASA TV



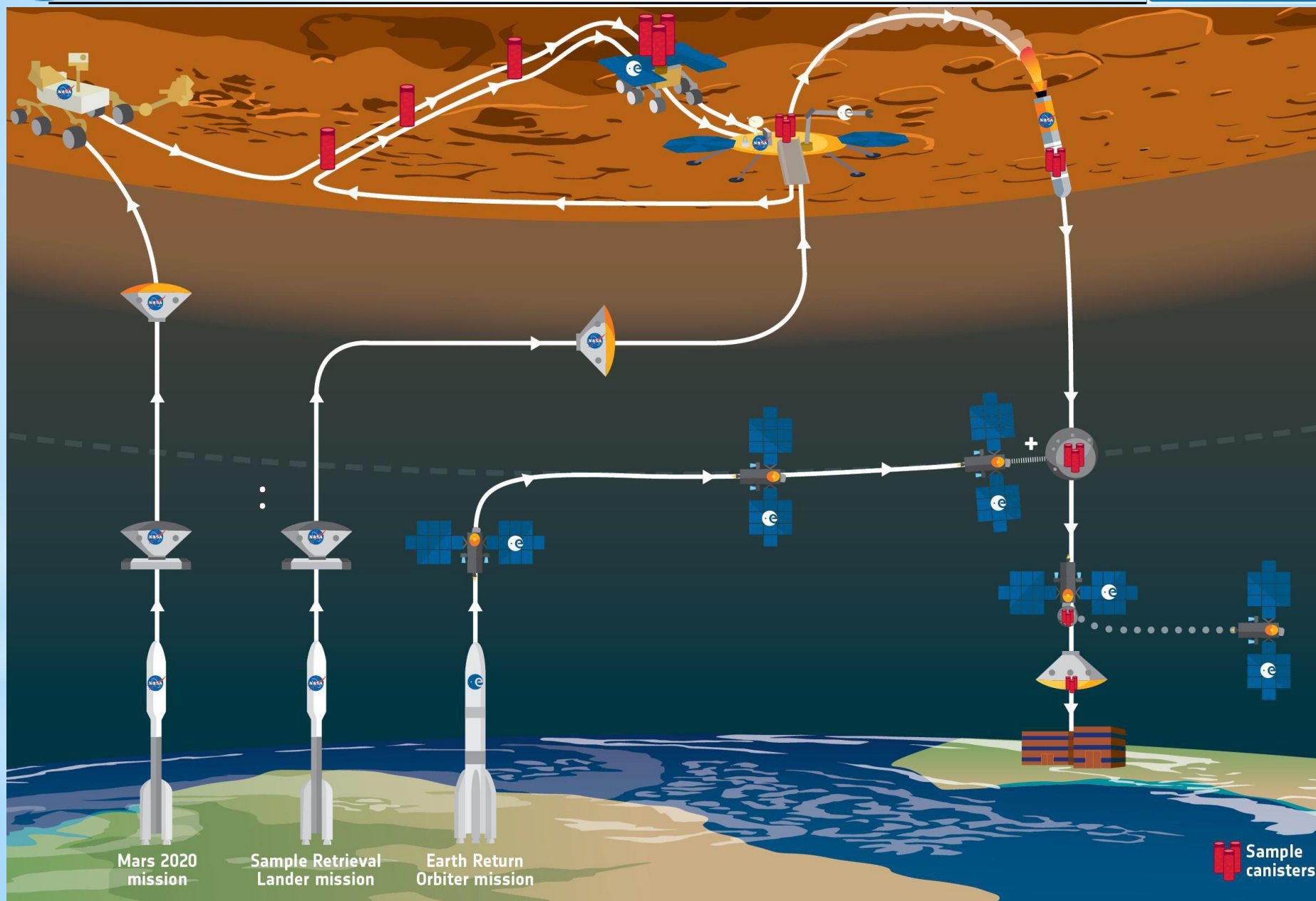
Scroll for details

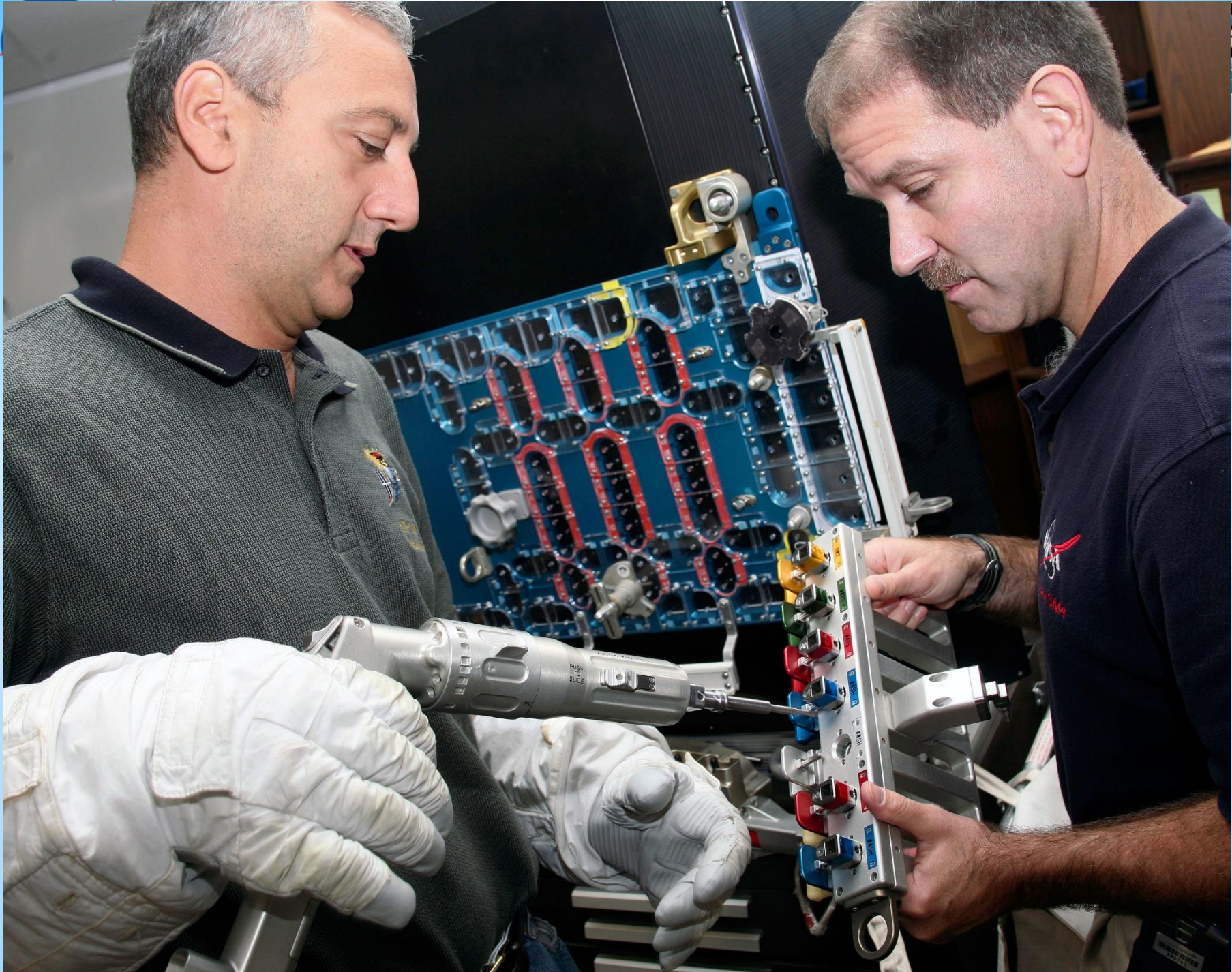


[minutes-of-terror/](#)



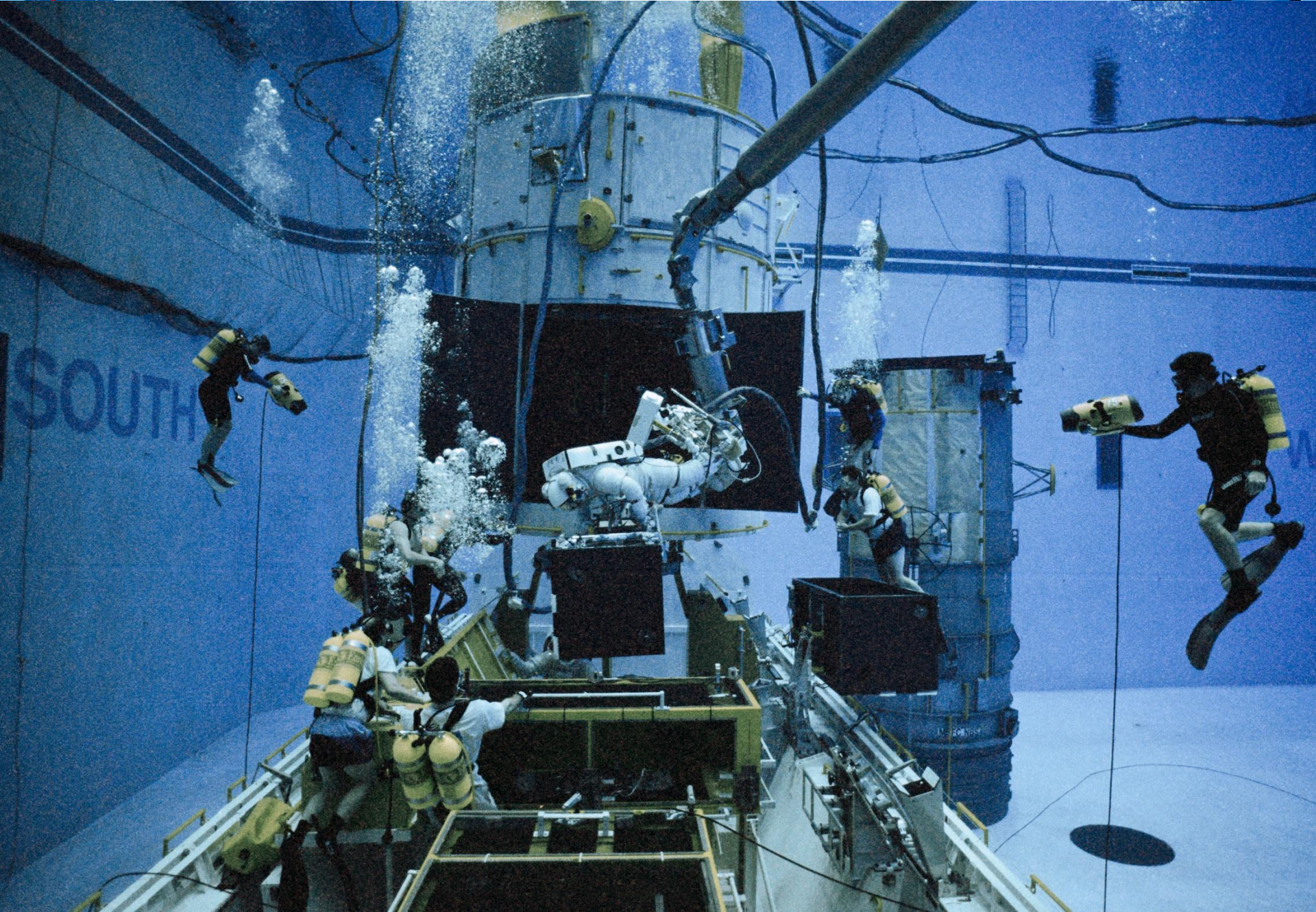
Mars 2020 : Rove, Fly, Persevere, Sample, Return







Hubble Repair Mission

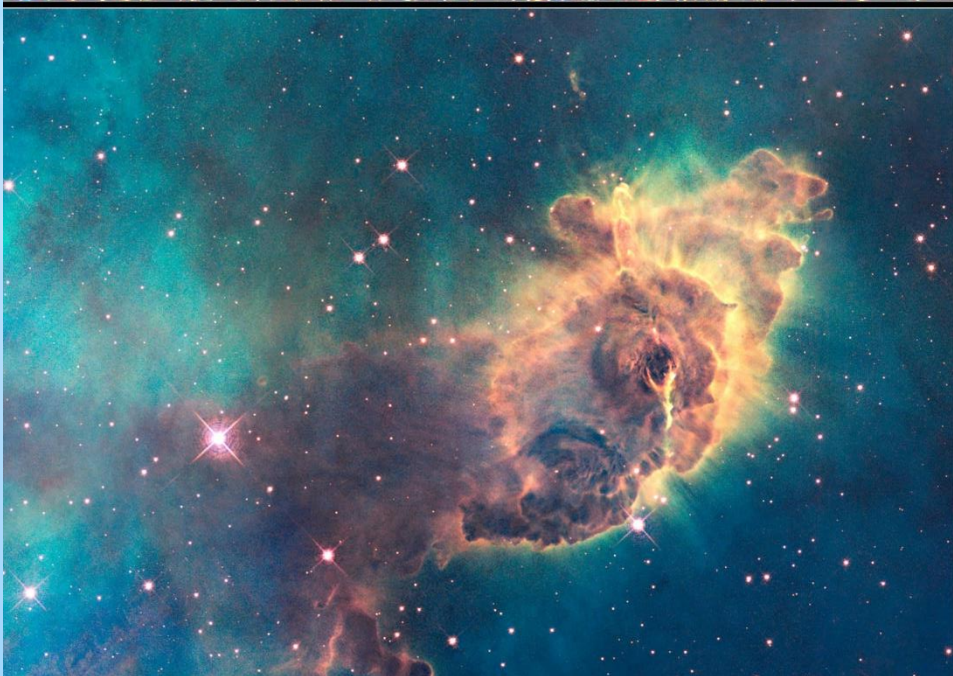
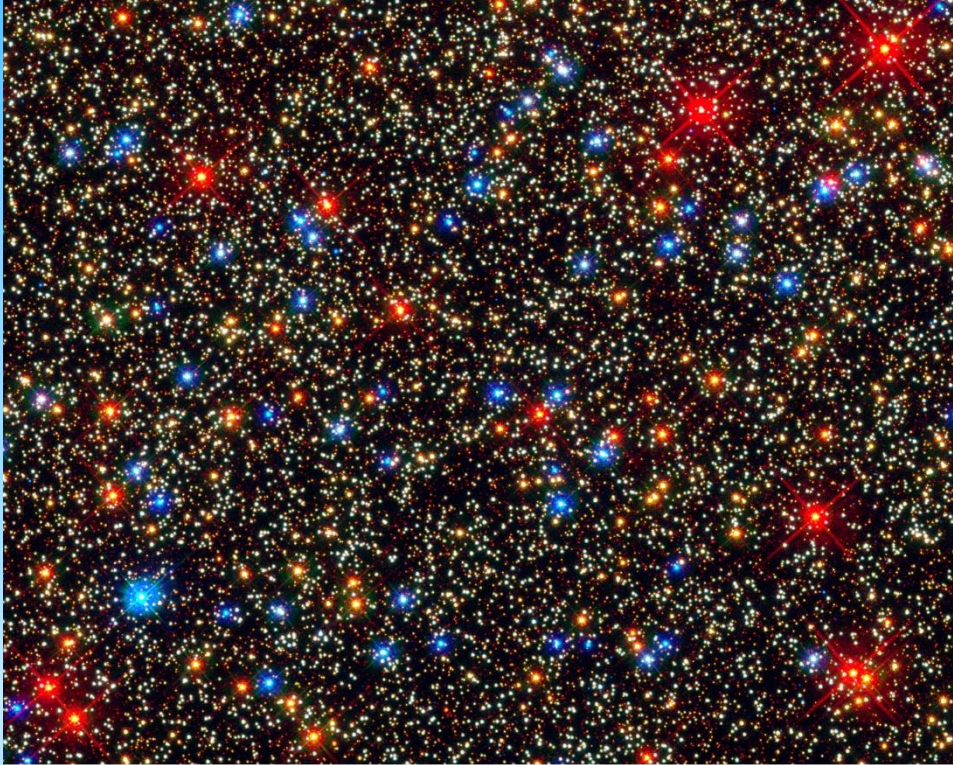




Hubble Repair Mission









Stephan's Quintet Galaxies

V838 Monocerotis Light Echo • October 2004



May 2002



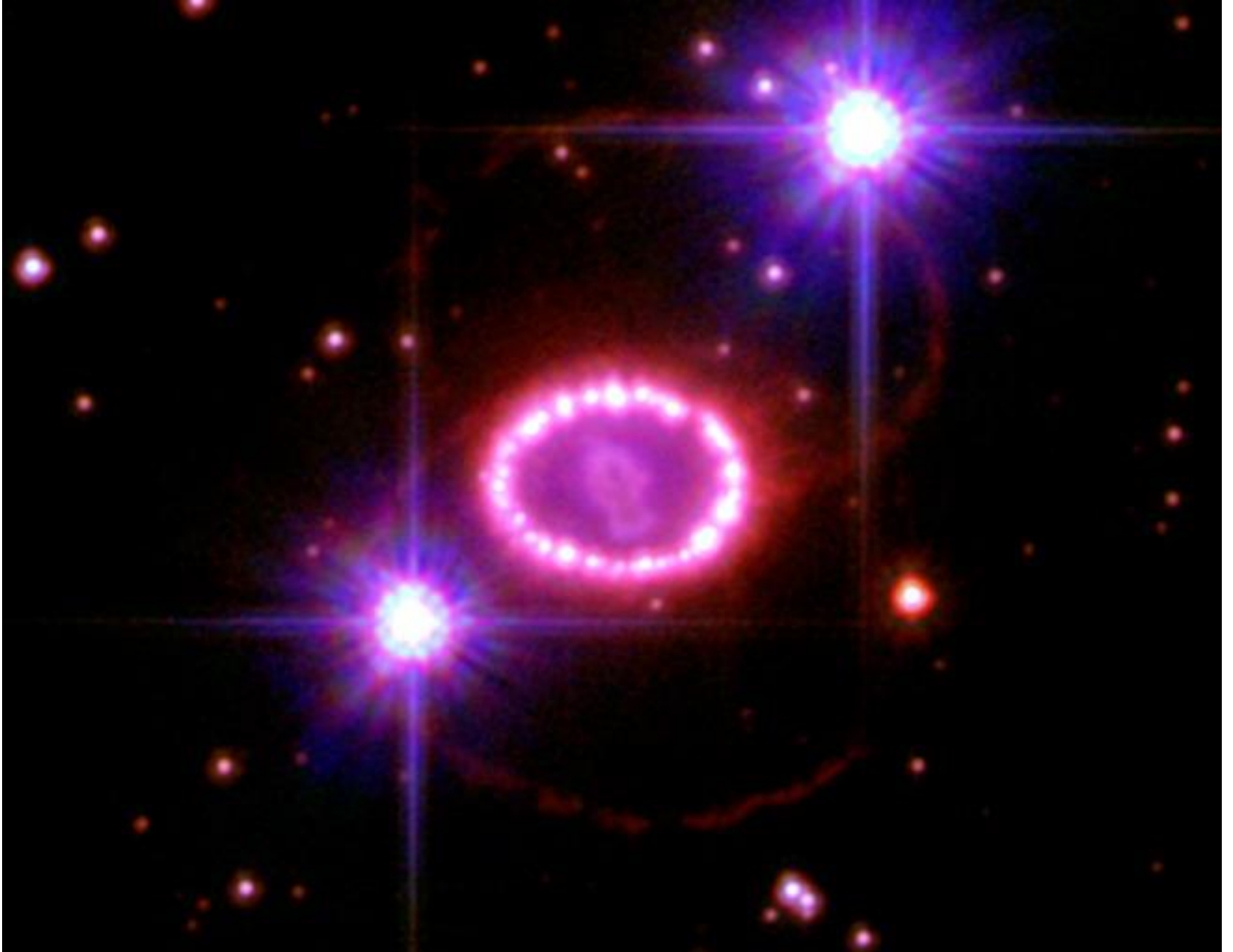
September 2002



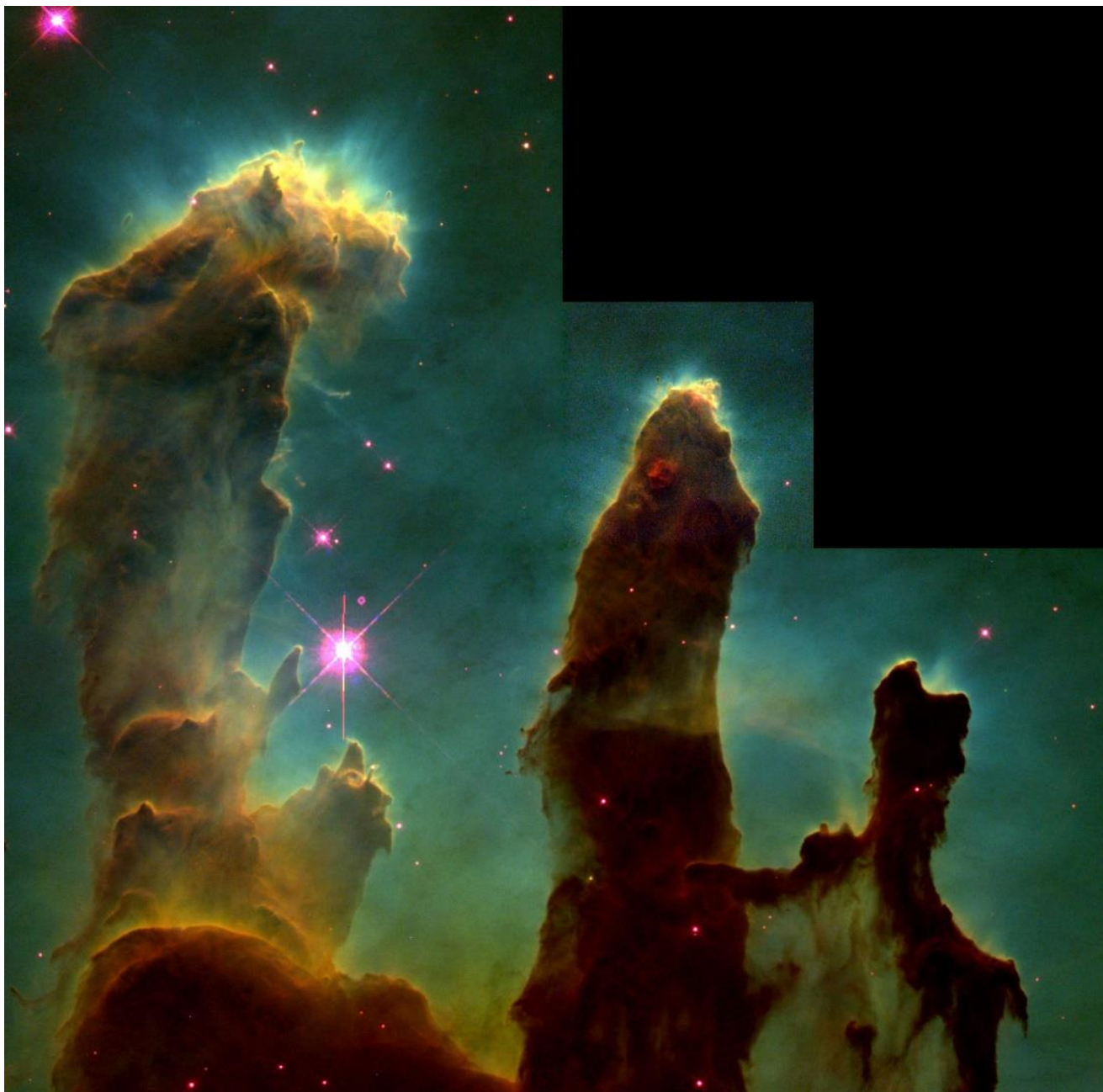
October 2002



December 2002



Supernova Explosion, Feb. 1987



S95

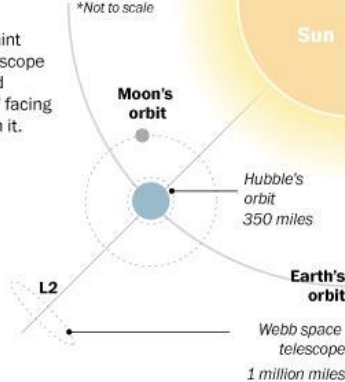
Nebula





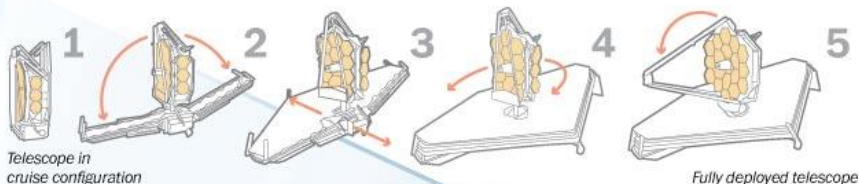
Away from the Earth and the Sun

The Webb's primary mirror must be kept very cold to see faint infrared light without interference. To achieve this, the telescope will orbit the Sun a million miles from Earth at a spot called Lagrange Point 2 (L2). The telescope will have a "hot side," facing the Sun, and a "cold side" — the mirror — facing away from it.



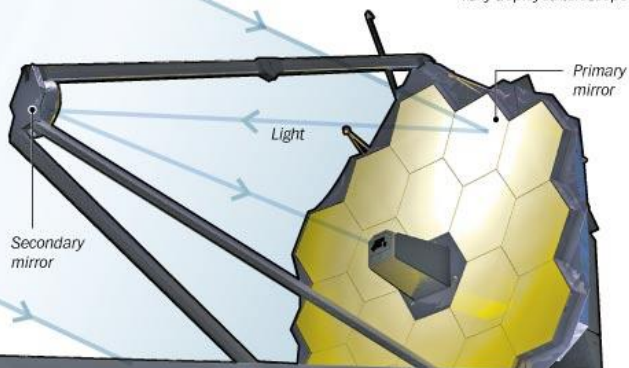
Telescope's unfolding

No launch vehicle is large enough to hold the Webb telescope unfolded, so the space observatory is designed to deploy its primary mirror, composed of 18 hexagonal segments, and heat shield in space.



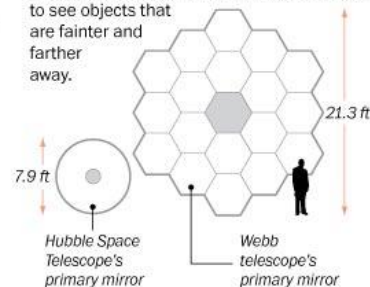
Seeing infrared

Webb is optimized to capture infrared light. Seeing the infrared is essential for viewing objects on the edge of the universe. The huge primary mirror captures and concentrates light from distant planets, stars and galaxies. The secondary mirror directs the light into the telescope's science instruments.



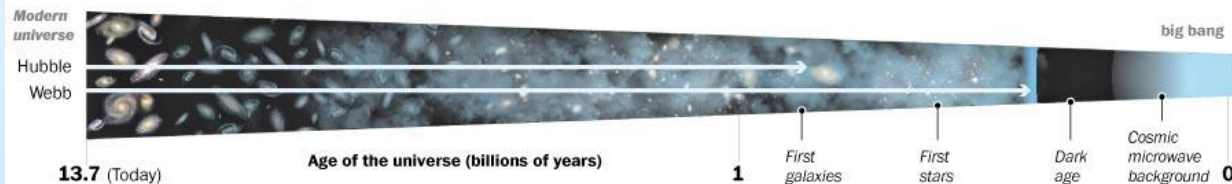
Size matters

One of the main differences between Webb and Hubble is the size of their mirrors. The area of Webb's primary mirror is six times the size of Hubble's, which will enable Webb to see objects that are fainter and farther away.

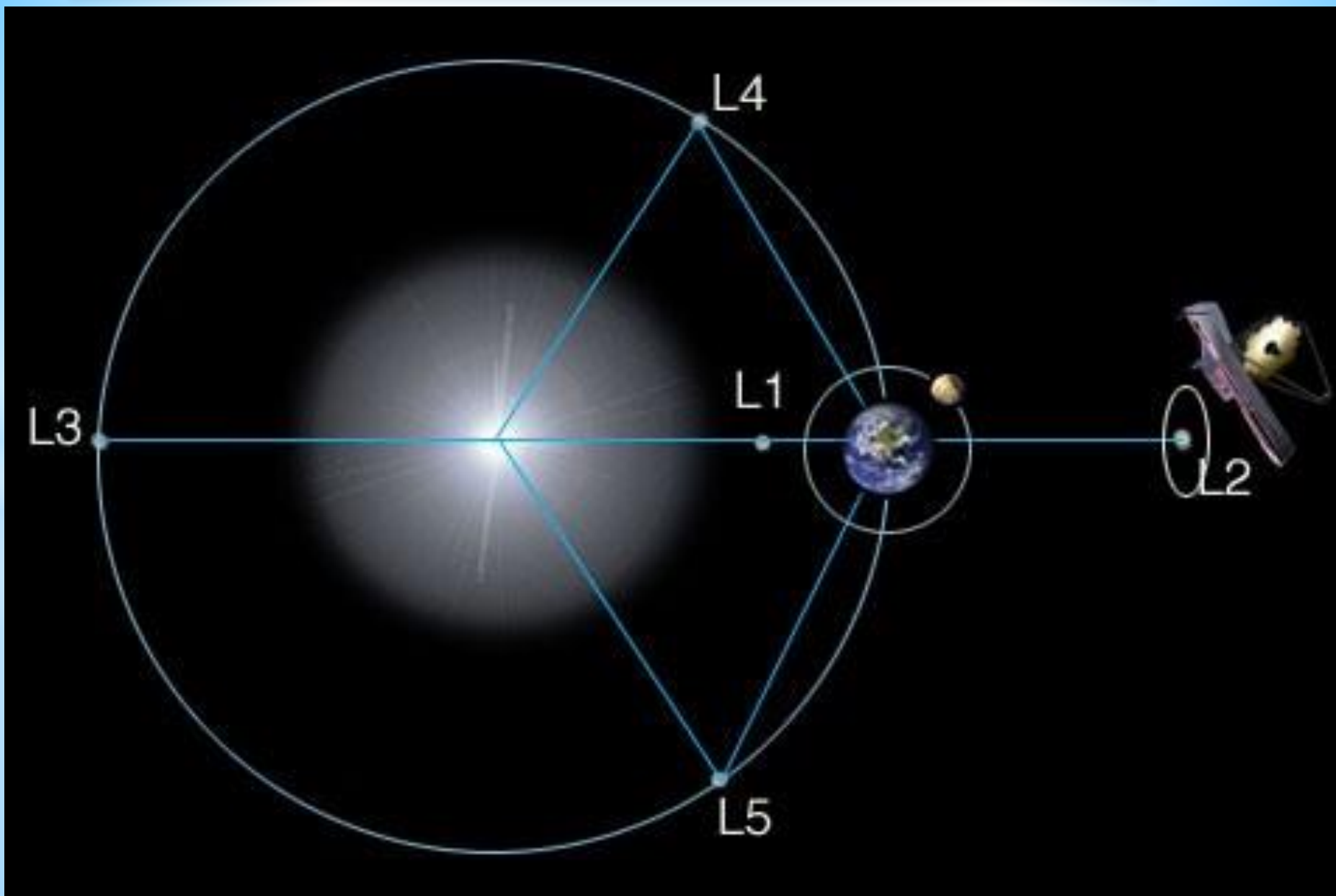


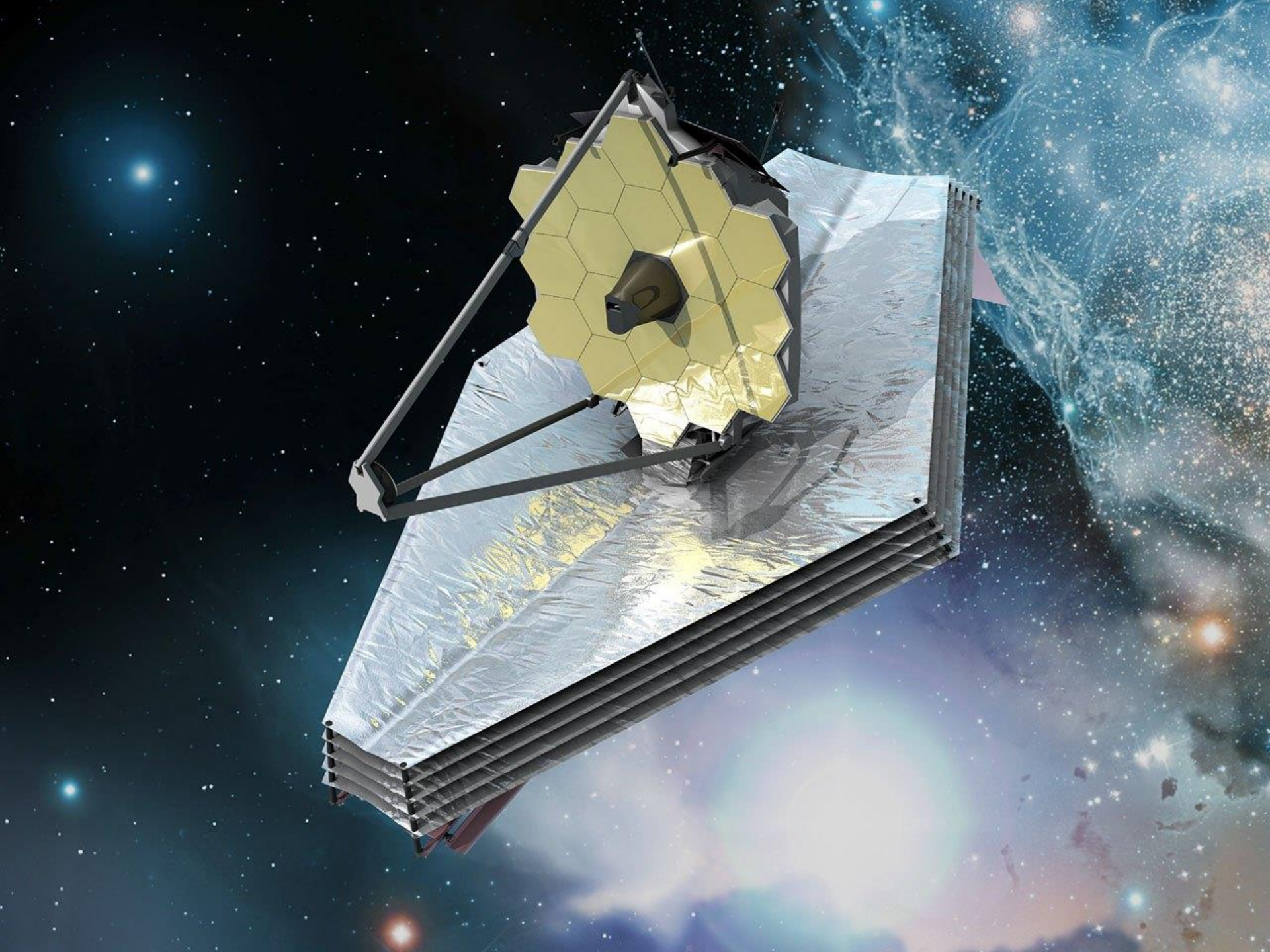
Universe's 'baby' pictures

Because light travels at about 186,000 miles per second, the farther away an object is, the further back in time we are looking. The Hubble telescope, expected to operate through 2020, can peek into the "toddler" stage of stars and galaxies, when the universe was barely 1 billion years old. The Webb is capable of capturing light from the "baby" stage of the Universe, when the very first stars were born after the big bang.

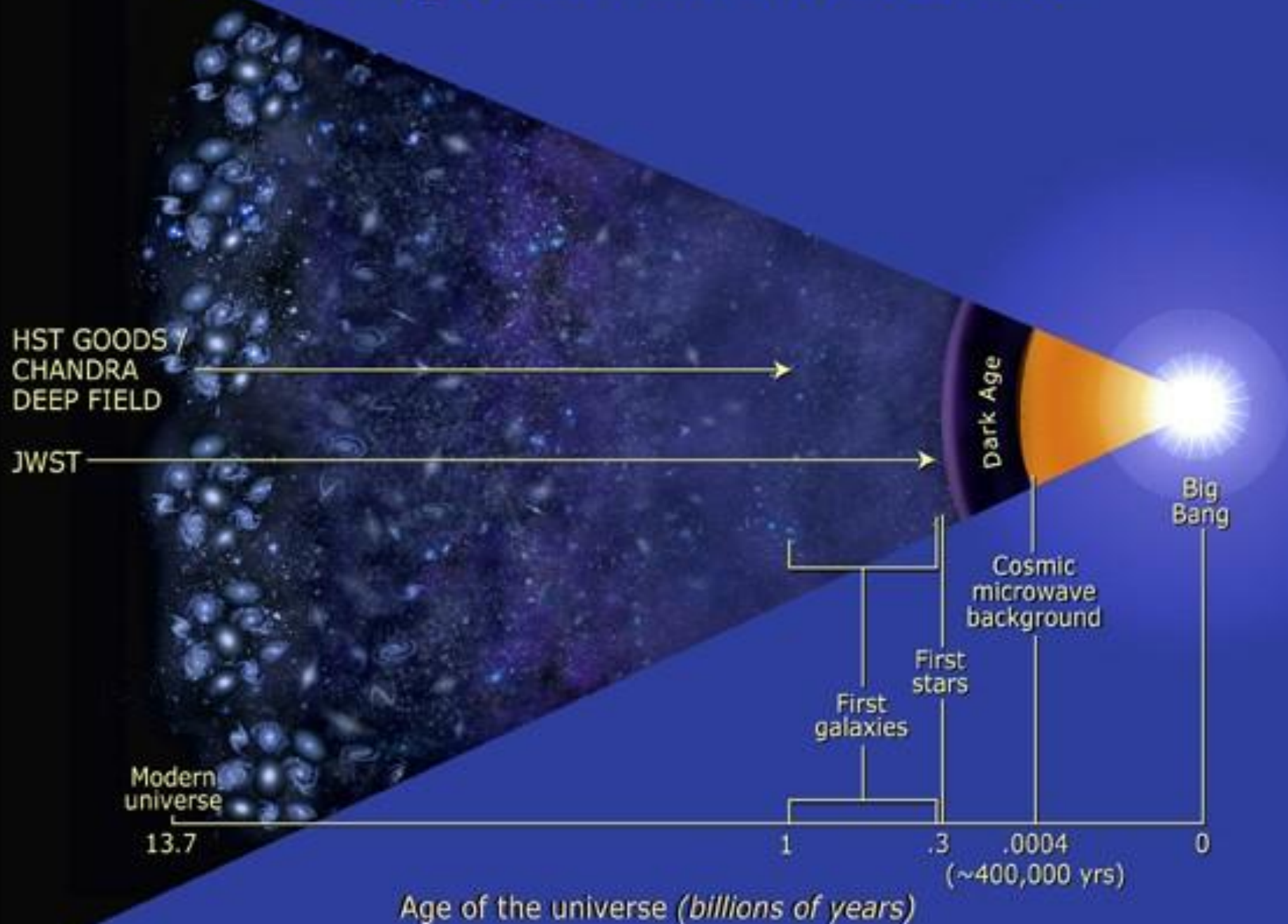


Webb Telescope at L2





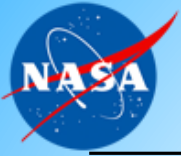
Seeing back into the cosmos



Acknowledgment

Engineers, Scientists
and Physicians

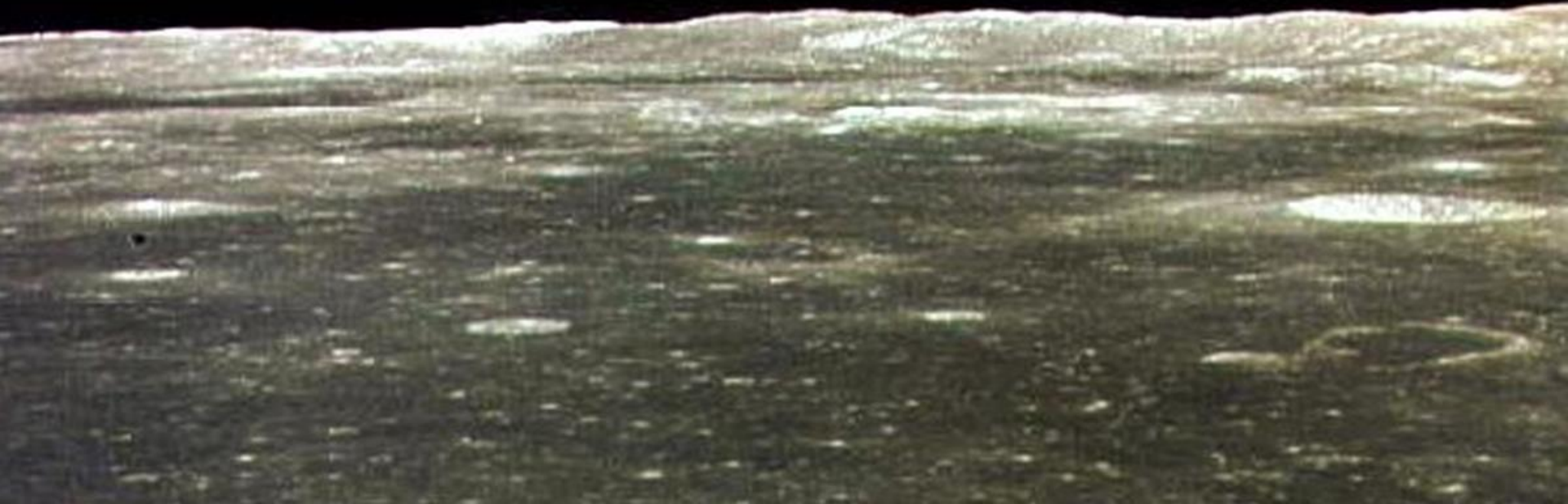
Thanks



Beautiful Fragile Blue Planet



With God's grace, Make a difference
Passion, Perseverance and Patience





Back up



Human Health & Performance

Enable successful space exploration by minimizing the Human System Risks of spaceflight hazards

Hostile Spaceflight Environment

Radiation
Isolation
Distance from Earth
Altered Gravity
Environment

SPACE MISSIONS

HAZARDS

RISKS

MITIGATIONS

Human Risks

- Bone loss
- Muscle atrophy
- Balance Disorders
- Neuro-ocular issues
- Sleep disorder
- Radiation induced
- Toxic Exposure
- Behavioral Health etc.,

Deliverables:

- Standards
- Preventions
- Technologies
- Countermeasures
- Treatments



Hazards of Spaceflight (RIDGE)

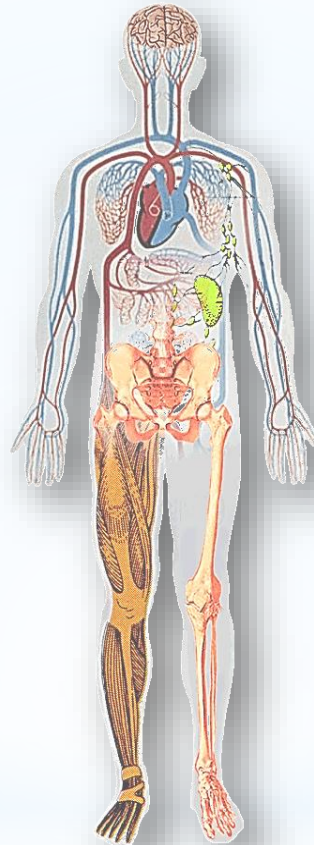
Hazards Drive Human Spaceflight Risks

Radiation

Acute In-flight effects
Long term cancer risk

Distance from earth

Autonomous Medical Care and
Operations; Communication
Delay



Isolation & Confinement

Behavioral aspect of isolation
Sleep disorders

Altered Gravity - Physiological Changes

Balance Disorders
Fluid Shifts
Cardiovascular Deconditioning
Decreased Immune Function
Muscle Atrophy
Bone Loss

Environment (Closed/Hostile)

Vehicle Design
Environmental – CO₂ Levels,
Toxic Exposures, Water, Food

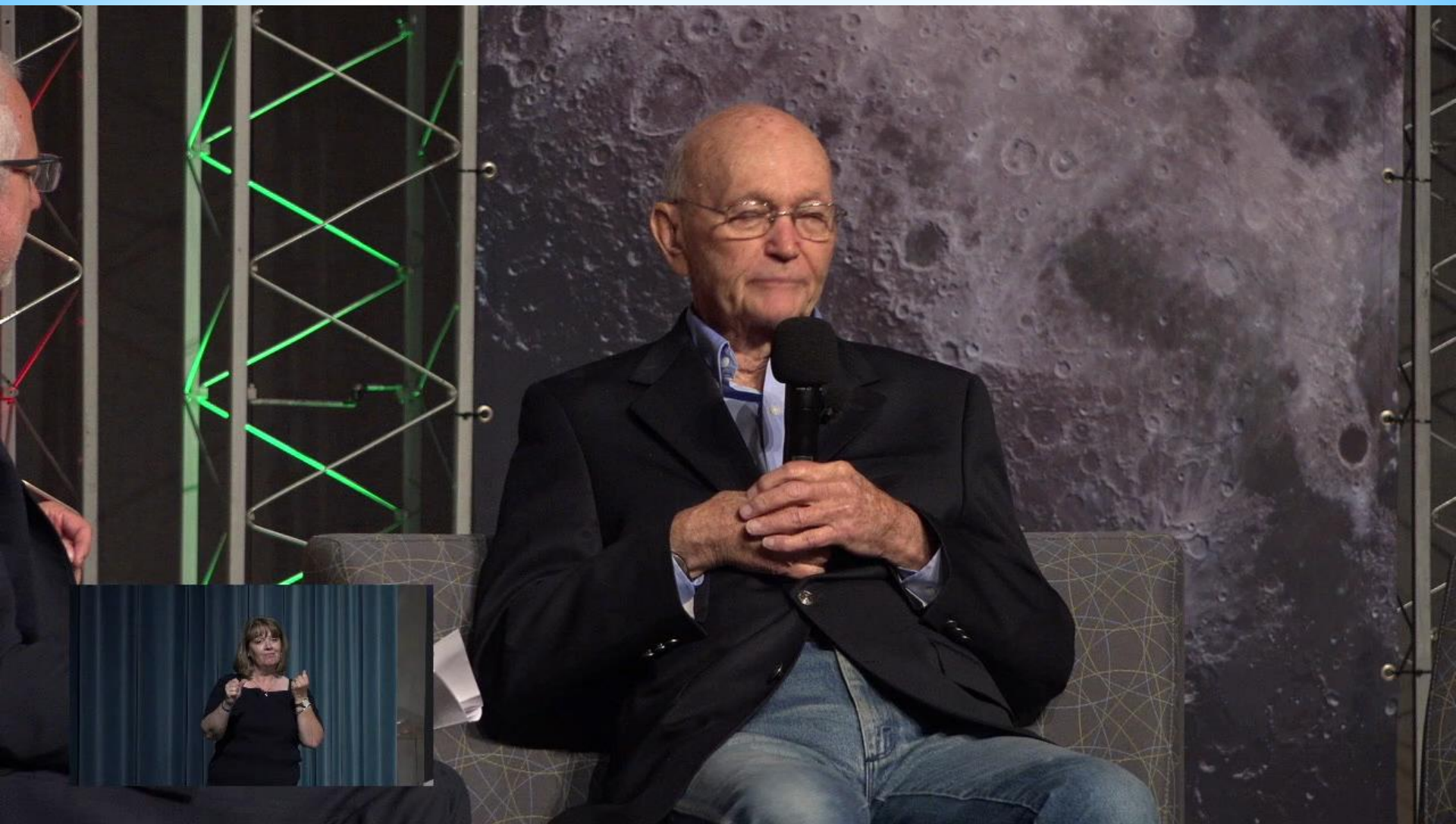
Back up



Who is at Your Window?



I feel responsible - Collins



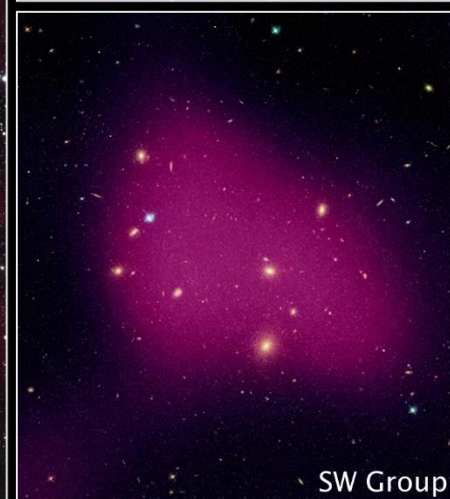
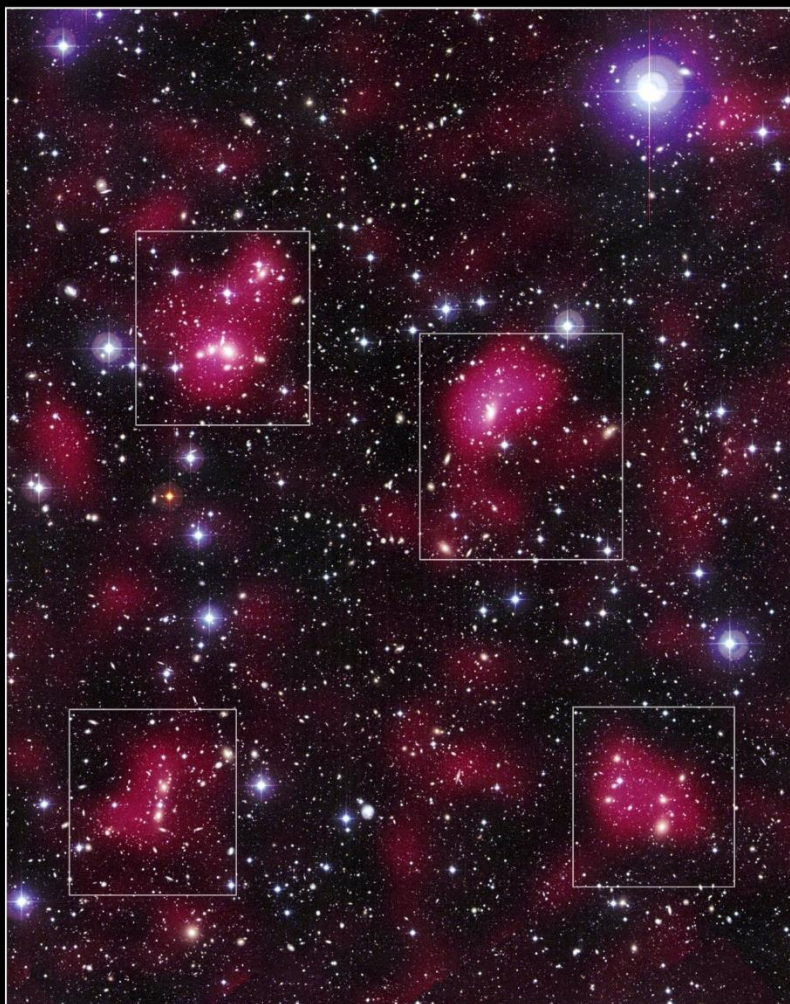
I feel responsible - Collins



Messier 74 or NGC628



Spiral Galaxies NGC 2207 and IC 2163



Abell 901/902 Supercluster Dark Matter Map ■ STAGES
Hubble Space Telescope ■ ACS/WFC



Spiral Galaxy M101

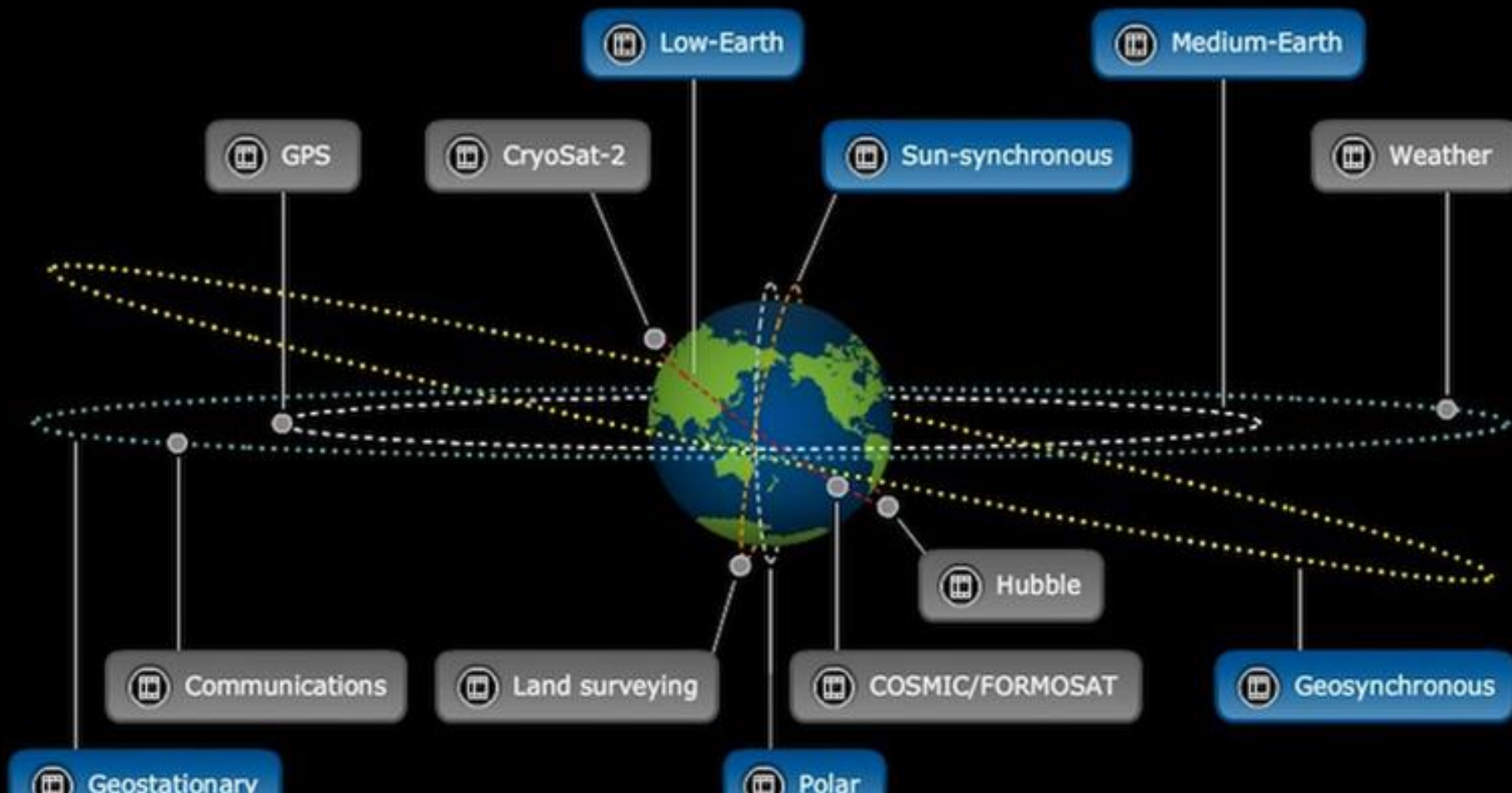
Hubble Space Telescope ■ ACS/WFC

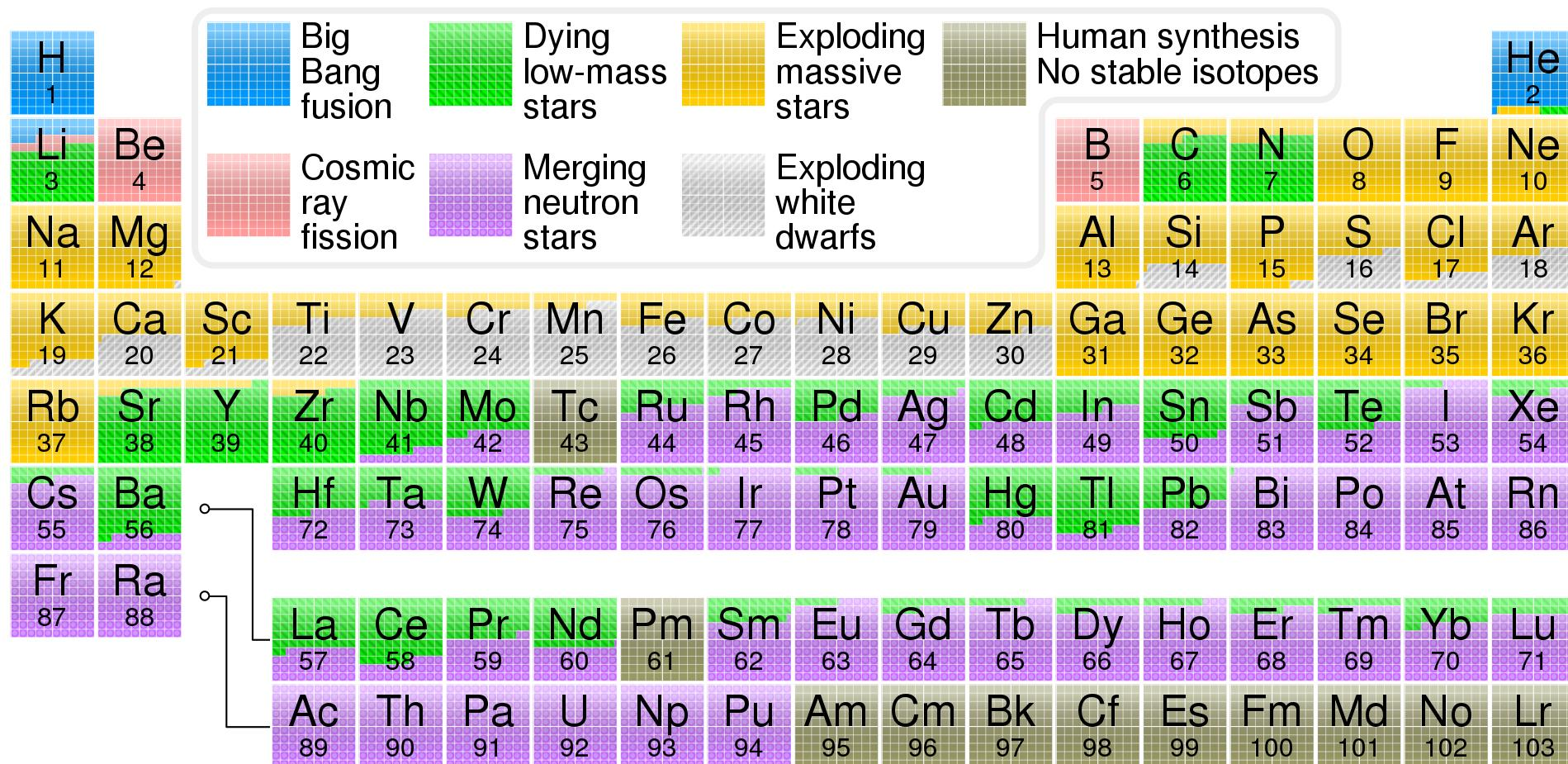


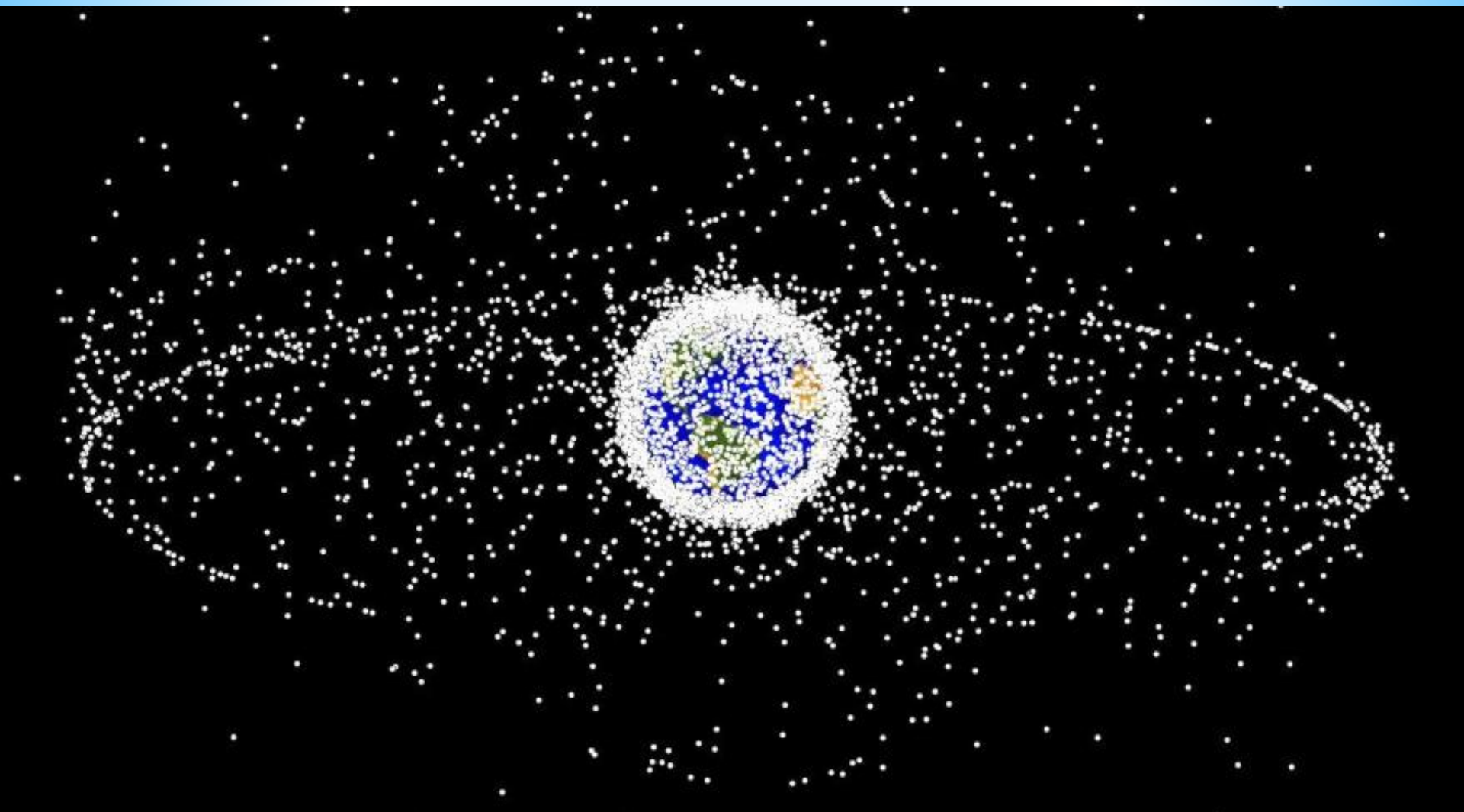
NASA and ESA

STScI-PRC06-10a

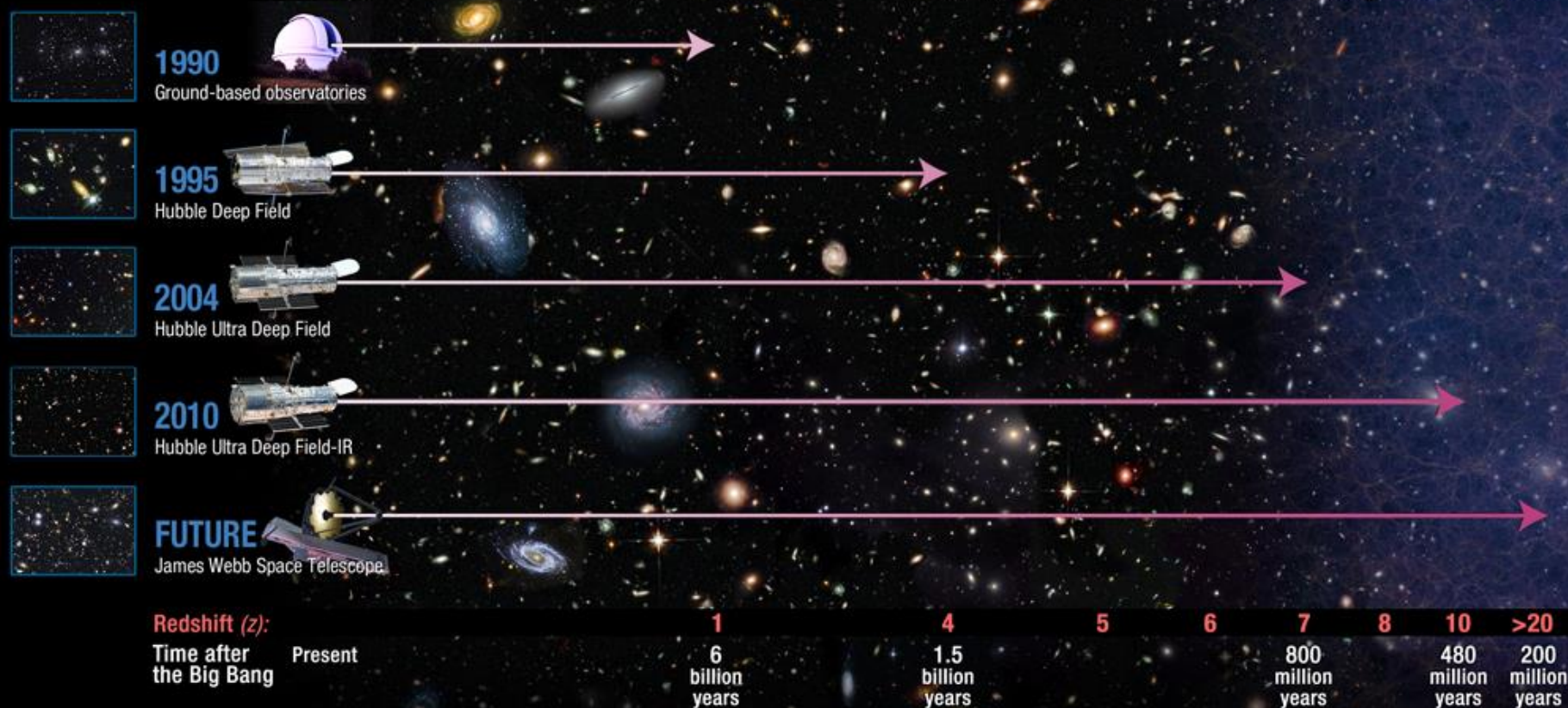
SATELLITES AND ORBITS







Hubble Probes the Early Universe





To become an Astronaut?

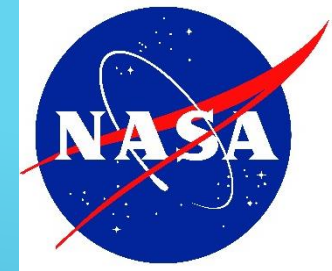


- Training in one of the STEM (Science, Technology, Engineering and Mathematics) disciplines
- Diverse Experience
- Team Player

- Group Living Skills
- Teamwork Skills
- Performance under Stress
- Self-regulation
- Motivation
- Judgment/Decision-making
- Conscientiousness
- Communication Skills
- Leadership/Followership Skills

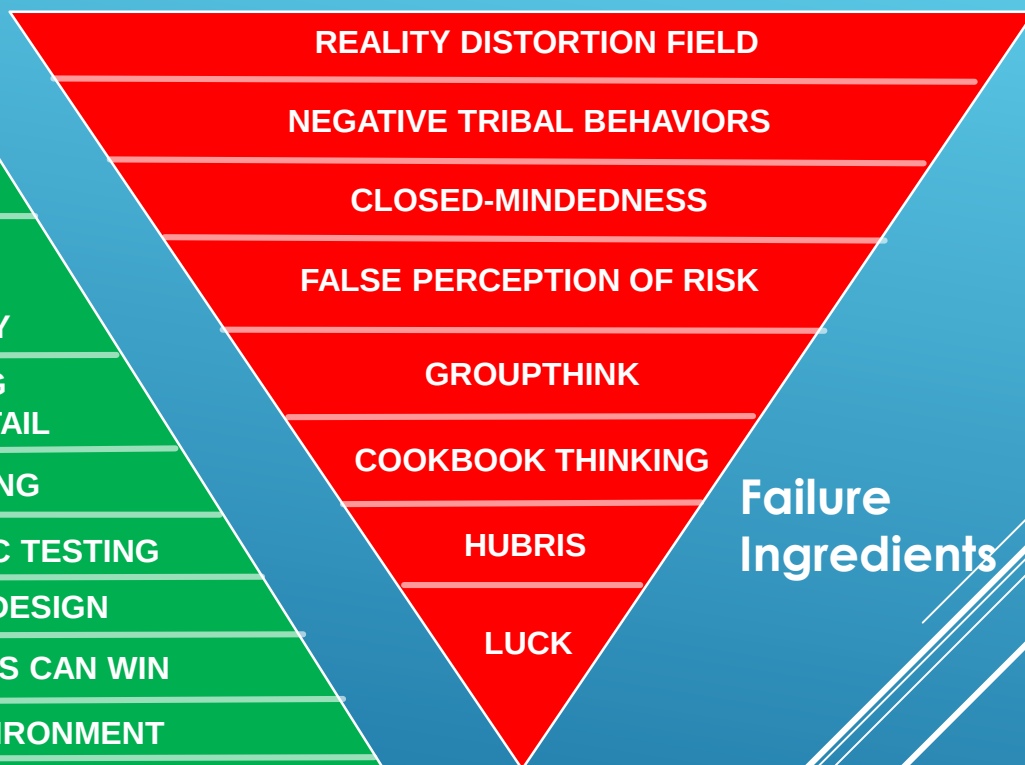
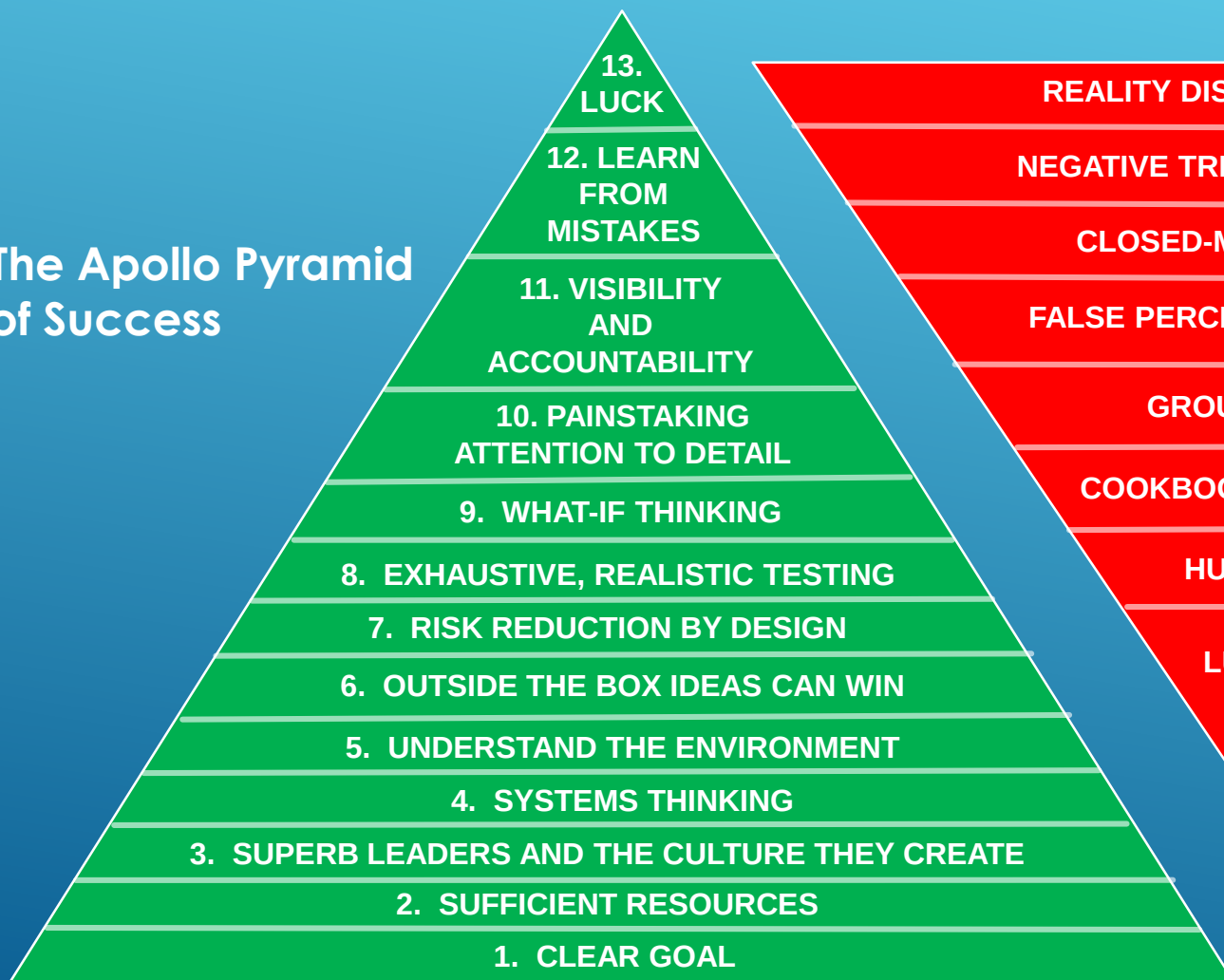


Zena Cardman, Jasmin Moghbeli, Jonny Kim, Frank Rubio, Matthew Dominick, Warren Hoburg, Robb Kulin, Kayla Barron, Bob Hines, Raji Chari, Loral O' Hara and Jessica Watkins.



THE SUCCESS OF APOLLO

The Apollo Pyramid of Success

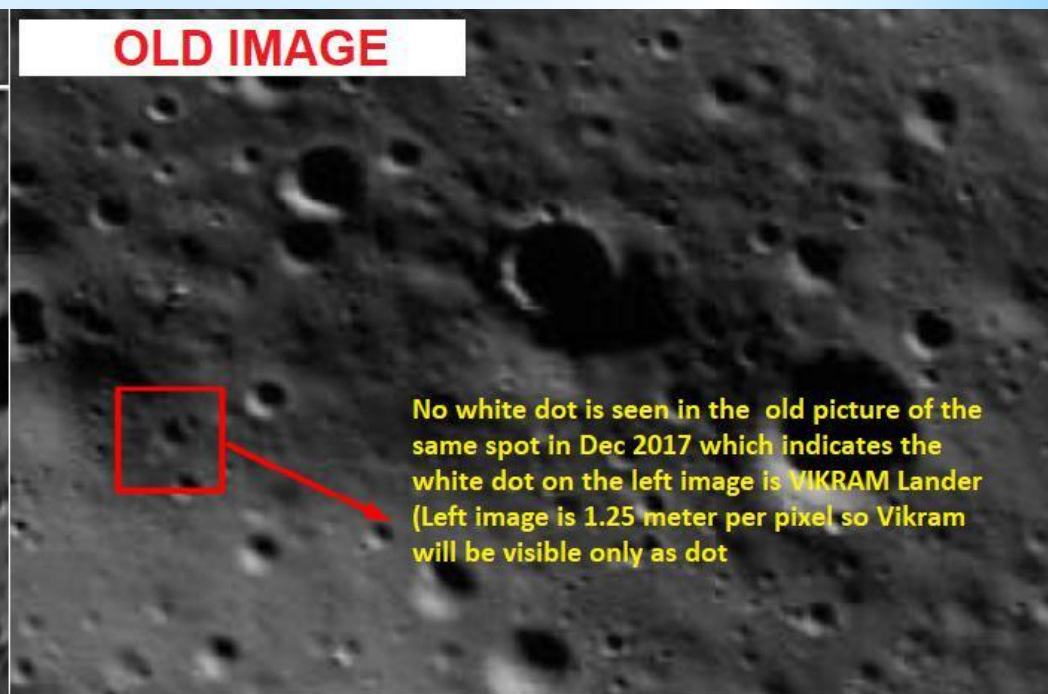
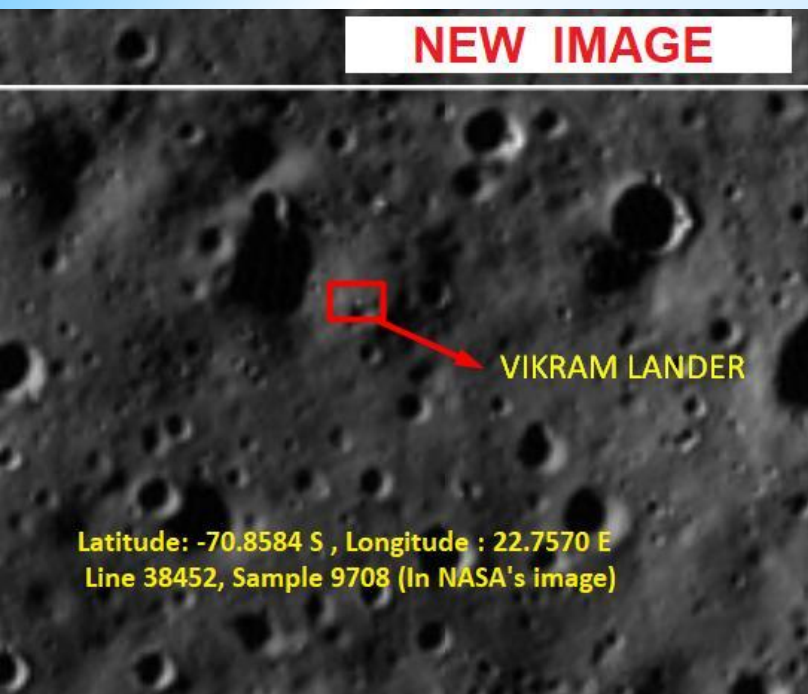


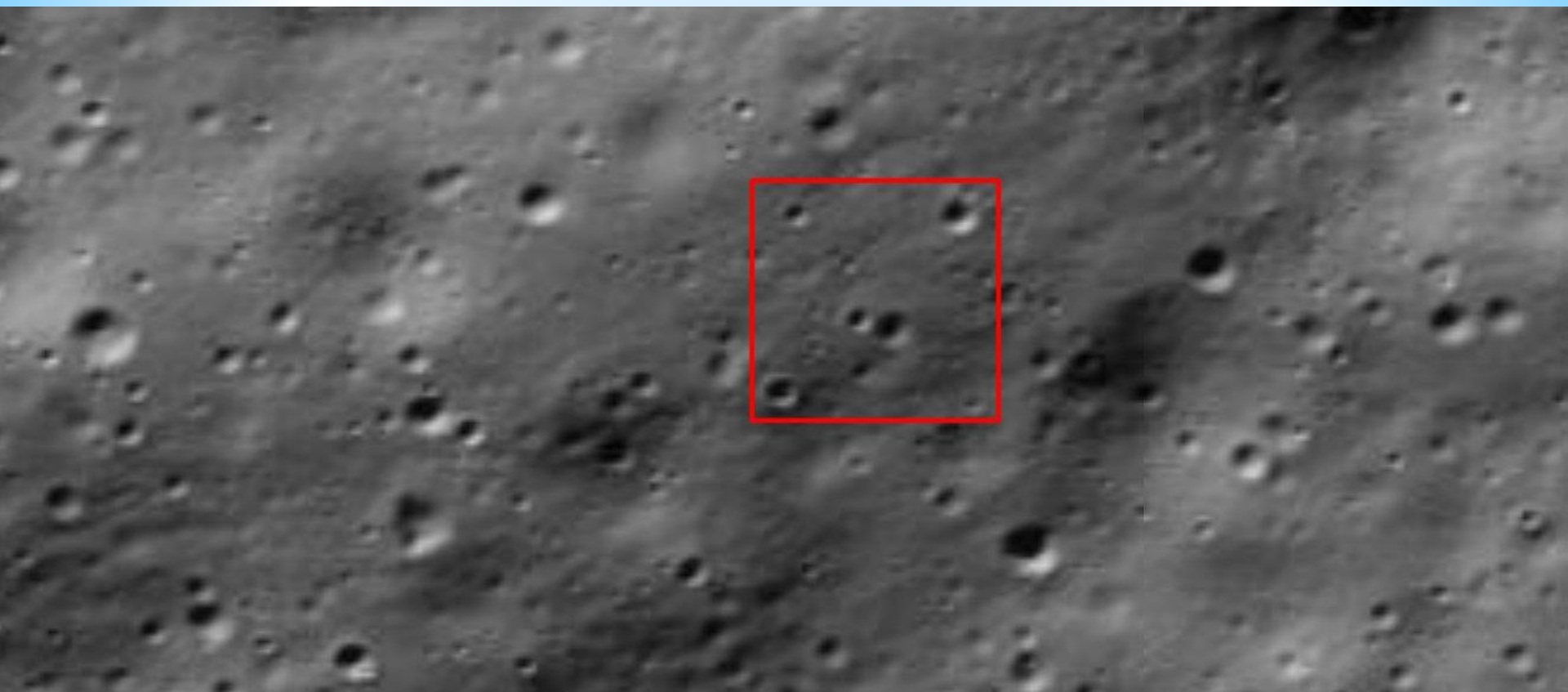
Adapted from Andrew Chaikin



Crew Debriefing at Bld 37 (July 27, 1969)







Mastcam-Z

Zoomable Panoramic Cameras

SuperCam

Laser Micro-Imager

MEDA

Weather Station

SHERLOC

Ultraviolet Spectrometer

WATSON (Camera)

PIXL

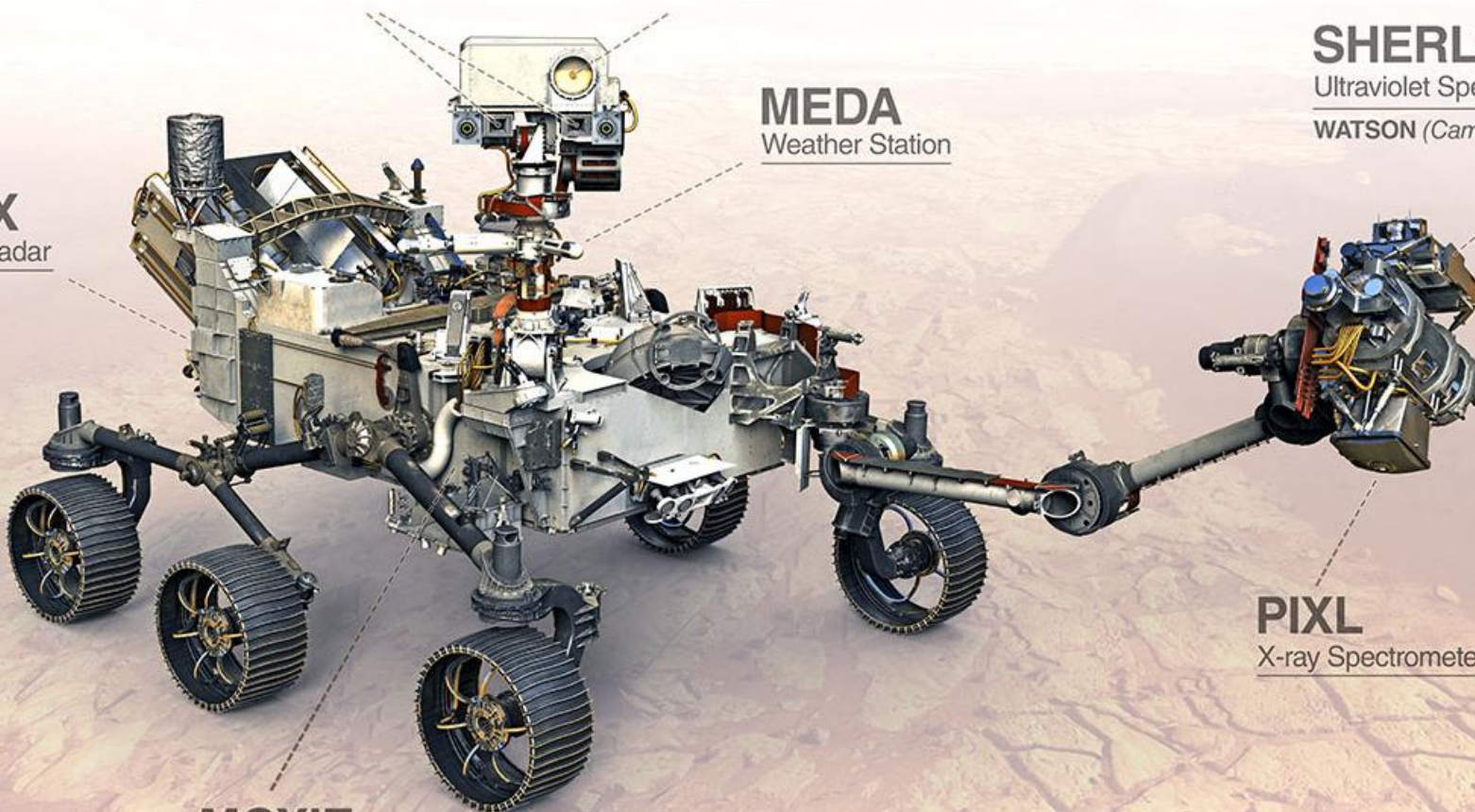
X-ray Spectrometer

MOXIE

Produces Oxygen from Martian CO₂

RIMFAX

Subsurface Radar



Mars Rover from China in 2020





Zuma Pilot Picture





View from Sudan





Magnitude of the Universe



Number of Atoms in the Universe $< 10^{80}$

Atoms in the earth = $6 \times 10^{27} \text{ g} / 12 \text{ g}) \times 6 \times 10^{23} = 3 \times 10^{50}$

Atoms in the solar system = $3 \times 10^{50} \times 1000 = 3 \times 10^{53}$

Atoms in the Milkyway Galaxy = $3 \times 10^{53} \times 10^9 = 3 \times 10^{62}$

Atoms in the Universe = $3 \times 10^{62} \times 10^9 = 3 \times 10^{71}$



One Day in other planets



Planet	Day Length
Mercury	1,408 hours
Venus	5,832 hours
Earth	24 hours
Mars	25 hours
Jupiter	10 hours
Saturn	11 hours
Uranus	17 hours
Neptune	16 hours





Still
daylight in
California.

Chicago

Cities of Boston, New
York, Philadelphia and
Washington.

Dallas

Houston

Miami

Puerto Rico





EVA at Neutral Buoyancy Lab (NBL)



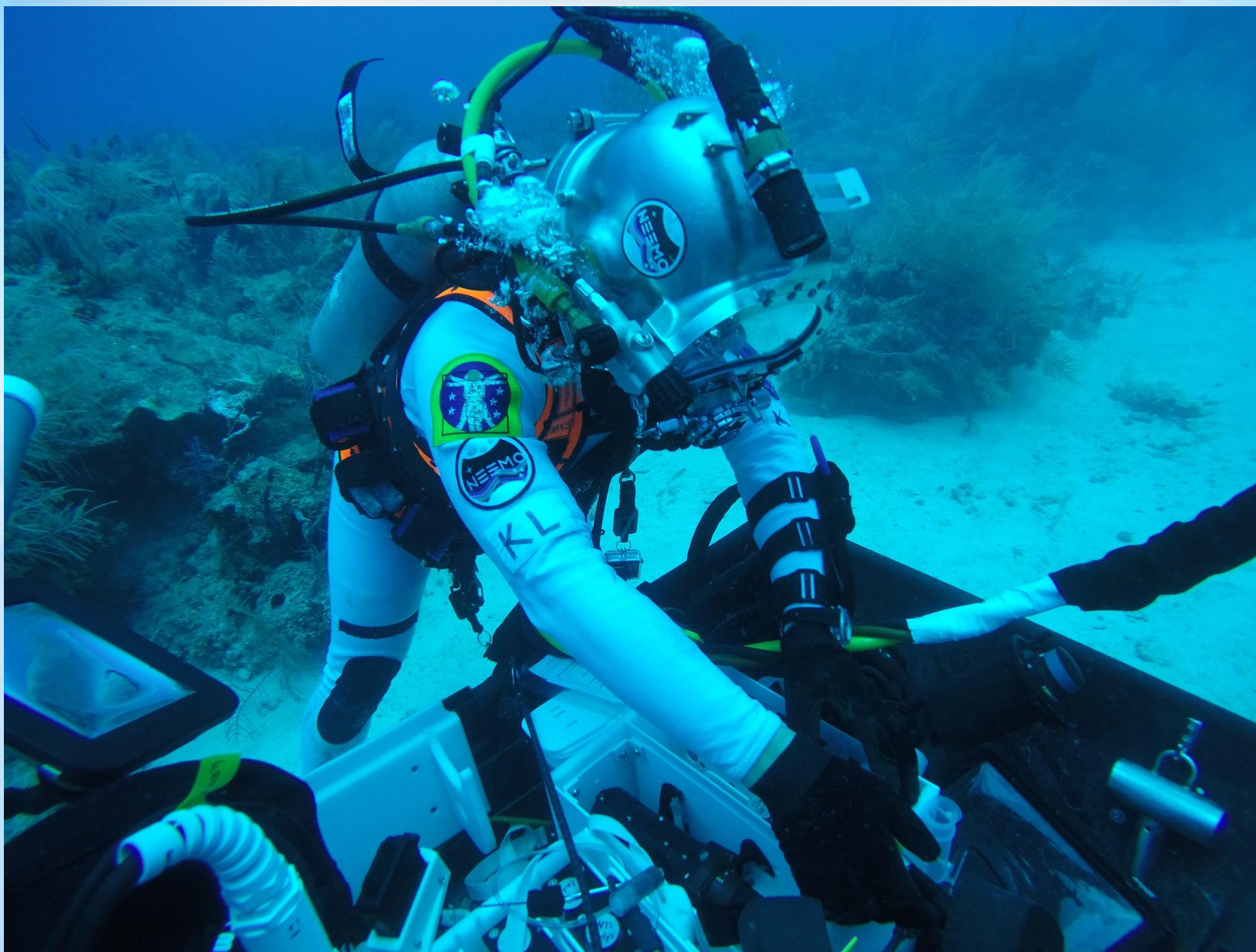


Bed Rest Studies :envihab





Under Water NEEMO





Mars 500 Analog





Rover : Desert Rat





Deep Space Habitat : Isolation and Confinement



Shuttle Launch : Speed of Rocket



Gross Lift-off weight : 2 Million tons

Thrust : 33,327 kilonewtons

SRB Separation : 45 km

External Tank Separation : 111 km

Orbital velocity : 27,869 km/hour

Payload weight : 25 tons

Shuttle weight : 78 tons

Routes into biologically isolated sections of the Lunar Receiving Lab are shown here by red lines. At upper left, lunar samples arrive and are taken to vacuum system and radiation lab by elevator. Other entrances indicated are for astronaut, for the command module, for food and laundry. Lines at far right show where lab personnel come and go through ultraviolet airlocks (purple).

Lunar Sample Laboratory

More than 300 scientists and technicians will perform tests with lunar materials in the lab area, shaded green.

- 1 Vacuum system where lunar material is received and processed
- 2 Canisters for storage and transfer of lunar material
- 3 Controls for vacuum system
- 4 Equipment for postflight food sterilization
- 5 Gas analysis laboratory
- 6 Special air conditioning system to sterilize air entering and leaving building
- 7 Elevator
- 8 Viewing room for participating scientists
- 9 Pump room and electrical support equipment for vacuum system
- 10 Transfer tubes for moving samples directly from vacuum system to lab
- 11 Physical chemical test lab—mineralogy, petrology, geochemistry
- 12 Bio preparation lab where lunar material is prepared, weighed and packaged for distribution
- 13 Bio-analysis lab for blood tests and other tests on mice
- 14 Holding lab for conventional mice
- 15 Holding lab for conventional mice
- 16 Lunar microbiology lab to isolate, identify and possibly grow lunar microorganisms
- 17 Spectrographic lab and darkroom (connects to 11)
- 18 Bird, fish and invertebrate lab where shrimp, quail, cockroaches, crickets and other creatures are exposed to lunar material
- 19 Microbiology lab for test cultures of lunar and astronaut material
- 20 Egg and tissue culture lab (support and additional facilities for 21)
- 21 Crew virology lab for postflight virological analysis of astronauts
- 22 Plant lab where green-free algae, spores, seeds and seedlings will be exposed to lunar material
- 23 Entrance to lunar sample operations area. Showers and facilities for all personnel passing in and out to change clothing
- 24 Autoclave for sterilizing all material entering or leaving area
- 25 Bio-safety lab to monitor all systems
- 26 Support offices
- 27 Entrance to radiation counting lab

Anatomy of a Lunar Receiving Lab

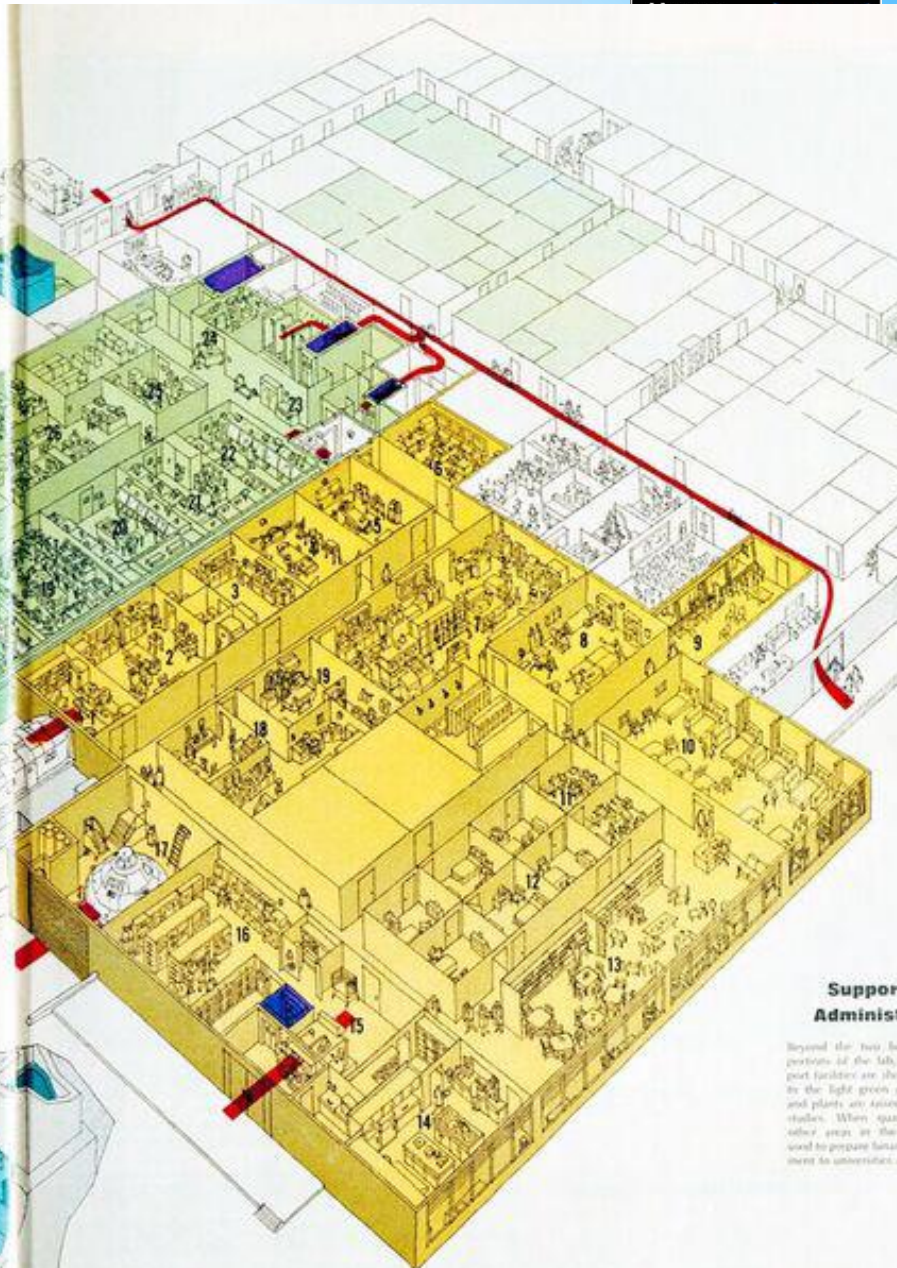
Astronaut Reception Area

Quarantine area where astronauts will live and be examined is shaded yellow. In an emergency, lunar lab workers could also be quarantined there.

- 1 Crew reception area (connected to transfer van)
- 2 Medical and dental examination room
- 3 Medical examination room
- 4 Operating room
- 5 Life-table room for physiological testing
- 6 Tape-out room where data can be passed into nonquarantine area electronically
- 7 Biomedical lab—clinical chemistry and immunology of astronauts and support personnel
- 8 Exercise room
- 9 Astronaut debriefing room, separated by glass from family visiting room
- 10 Dormitory for support personnel

Radiation Laboratory

Chips from the first lunar samples will be sent to a radiation lab (blue in drawing) built 50 feet underground. There, their radioactivity will be measured and results may help indicate the age of the rocks and whether they ever existed in molten form.



Support Administrative

Beyond the two biologically isolated sections of the lab, support facilities are shown in light green. Air and plants are raised in special studies. When quarantine areas are used to prepare lunar material for universities and



Can we hear sound in space?

How do astronauts communicate in space?



- In empty space, there is no air, and what we call "sound" is actually vibrations in the air.
- There are indeed light waves and radio waves in space, but these waves are not sound, but light.
- Light does not need air to travel, but then you don't hear it; you see it, or it is interpreted by your radio set and then translated into sound.
- Astronauts in space do talk to each other. In the spacecraft, there is plenty of air, so they just talk normally.
- When they are spacewalking, they talk by means of radios in their helmets.
- The radio waves, again, have no problem in space, but they're not sound. They're radio waves (electromagnetic radiation), which has to be converted into sound by the astronauts' headsets.

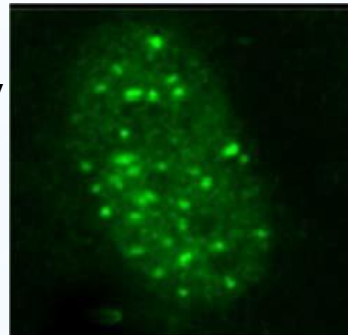
The Space Radiation and Fibroblast Cells

National Aeronautics and Space Administration

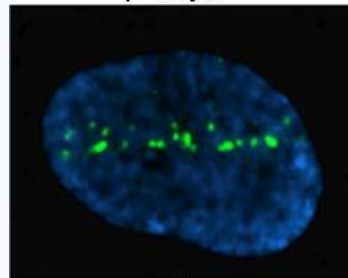


Space radiation is comprised of high-energy protons and heavy ions (HZE's) and secondary protons, neutrons, and heavy ions produced in shielding

- Unique damage to biomolecules, cells, and tissues occurs from HZE ions
- No human data to estimate risk
- Animal models must be applied or developed to estimate cancer, and other risks
- Shielding has excessive costs and will not eliminate galactic cosmic rays (GCR)



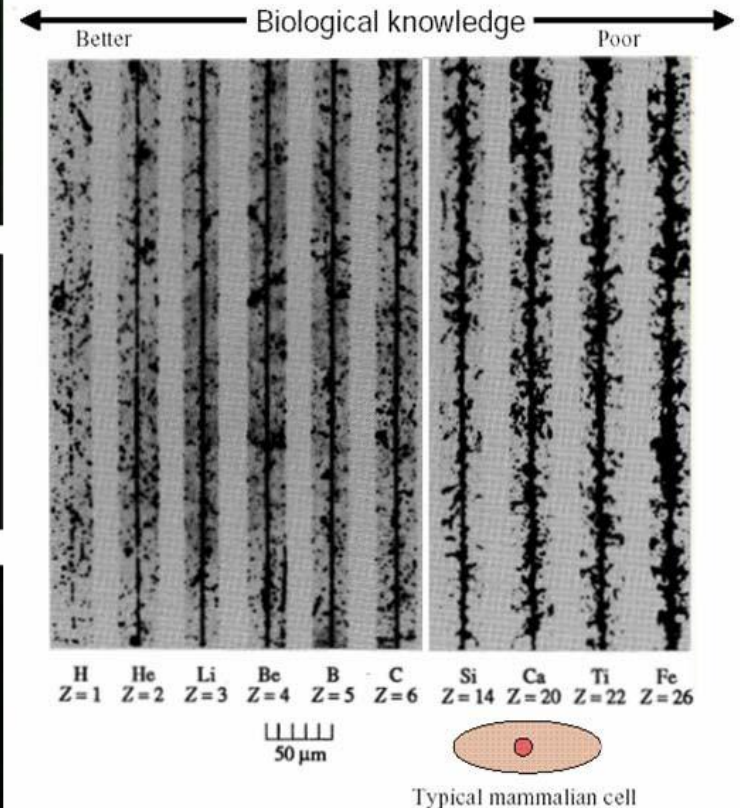
γ - rays



silicon



iron



Single HZE ions in human fibroblast cells and DNA breaks

Single HZE ions in photo-emulsions Leaving visible images

