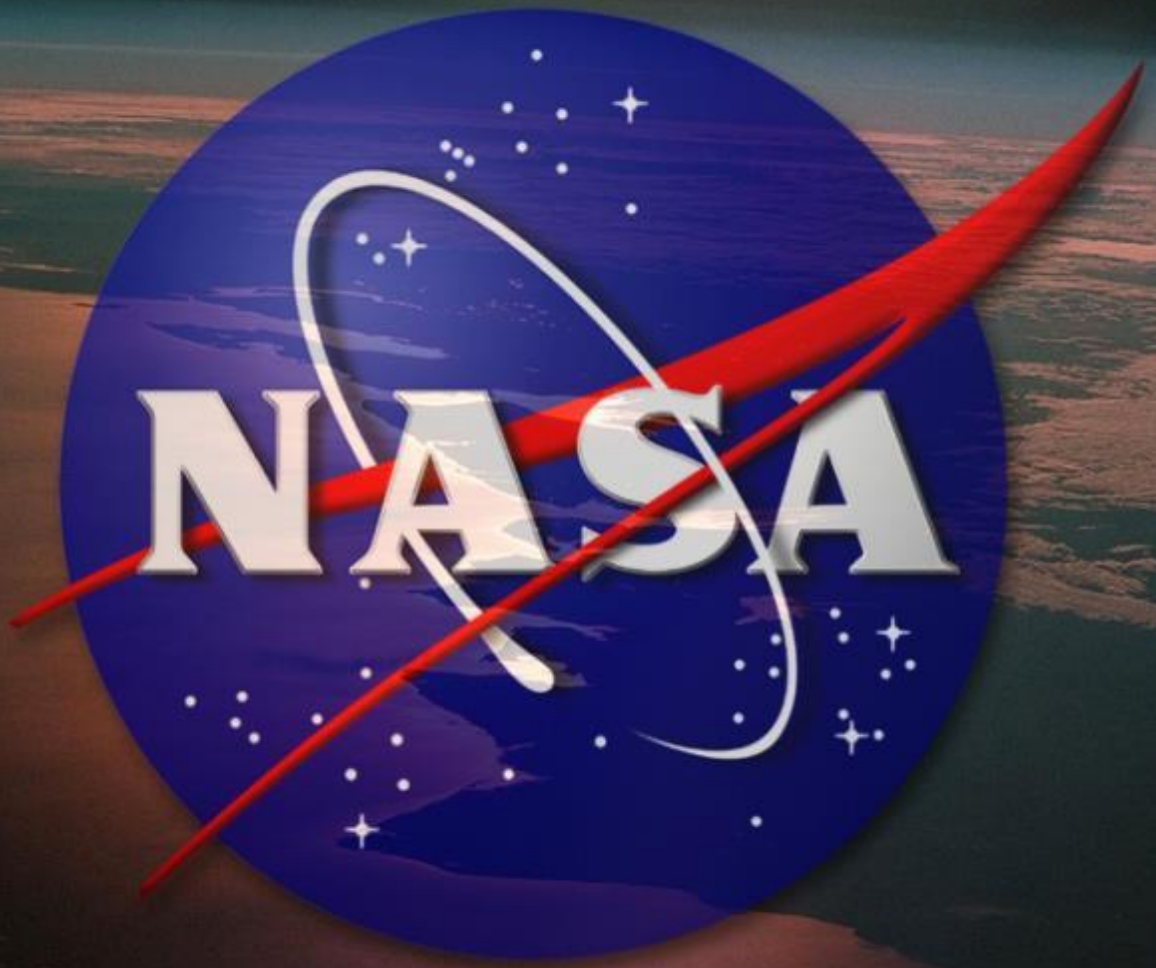
National Aeronautics and Space Administration

STEM Adventure Weekend 2016

NASA/JSC/Tim Hall

Welcome STEM Adventurers



A little about the speaker…Tim Hall

- Born & raised in West Virginia
- Graduate of West Virginia University (WVU)School of Engineering with a BS Mechanical Engineering

Lets Go Mountaineers!!

- Involved in the space industry for 18+ years
- Space career includes working 30+ Space Shuttle and International Space Station (ISS) Missions in the Mission Control Center
- Currently Chief of the Extravehicular Activity (EVA) Operations Branch

National Aeronautics and Space Administration

What's Going On Now At NASA?

www.nasa.gov/exploration

Human Spaceflight….

2000 — 224 humans have visited ISS! — 2016

JAXA HTV

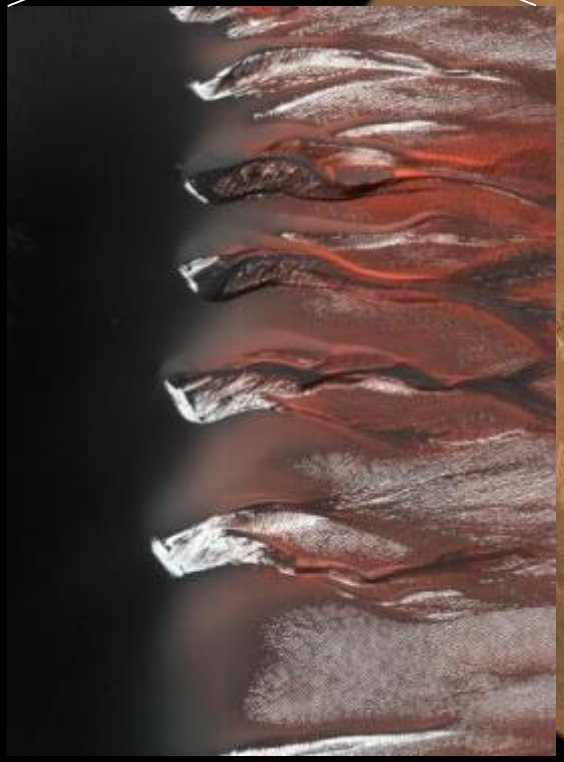
SpaceX Dragon

Orbital Sciences ATK Cygnus

Expedition 48

Expedition 49

Planetary Missions, Mars is busy!…



Kaiser Crater hosts a large field of sand dunes. Every winter the dunes are covered with a layer of seasonal carbon dioxide ice (dry ice)

MRO

Mars Odyssey

MAVEN

Mars Express

Phoenix

Viking 2

Viking 1

Mawrth Vallis

Pathfinder

Opportunity

Gale Crater

Curiosity

Spirit

Eberswalde

Holden

Planetary Missions, Mars is busy!…

The layered geologic past of Mars is revealed in stunning detail new images from NASA's Curiosity Mars rover exploring the lower region of Mount Sharp.

MSL- Mars Science Laboratory "Curiosity"

MSL Selfie

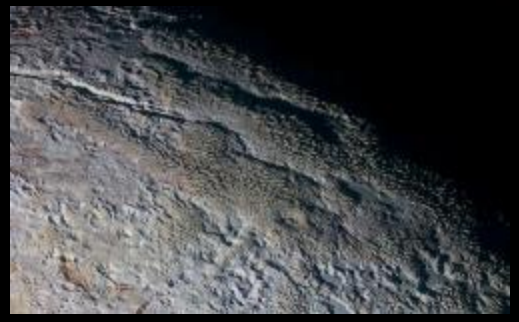
MSL Wear and Tear

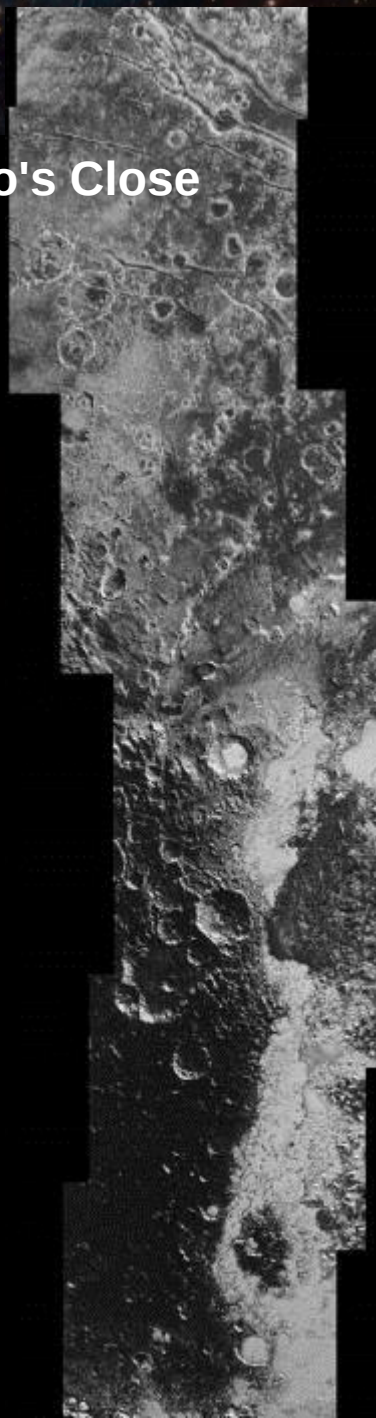
MER
Mars Exploration Rover– "Opportunity"
Still Going – 13+ yrs, Driven 26.59 miles (42.79 kilometers).

New Horizons @ Pluto!

- **New from NASA's New Horizons: Increasing Variety on Pluto's Close Approach Hemisphere, and a 'Dark Pole' on Charon**

NASA’s New Horizons spacecraft passed Pluto in July 2015

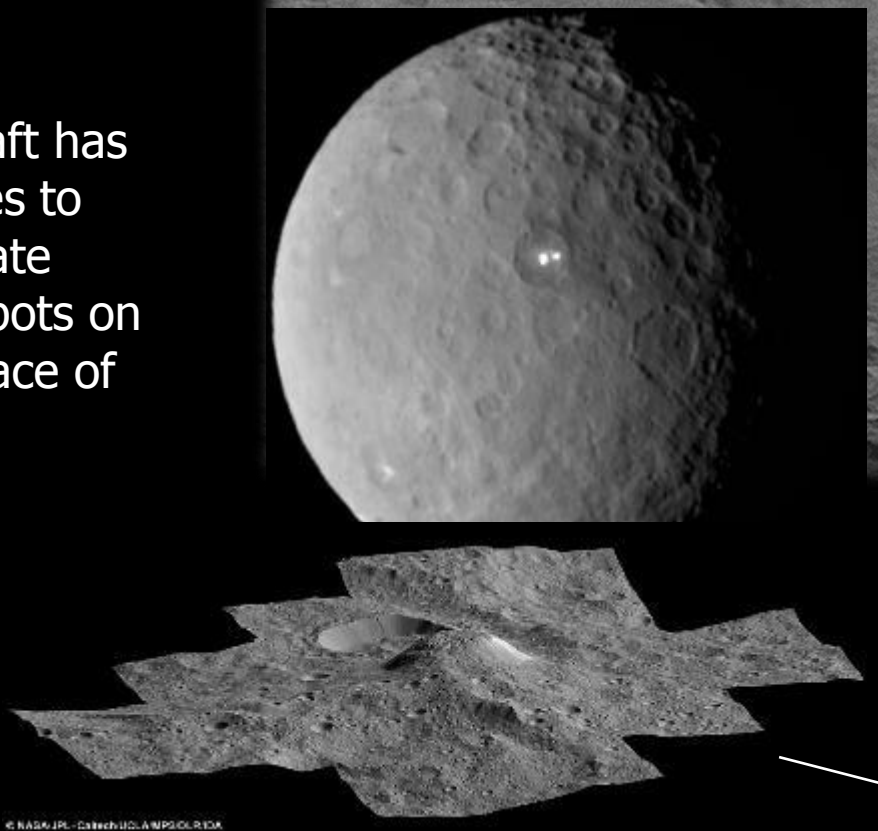


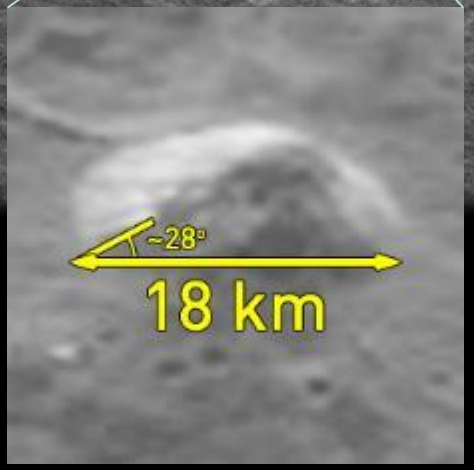


Dawn Spacecraft @ Ceres

Dawn is continuing to unveil a **Ceres** of mysteries at the first dwarf planet discovered

Dawn spacecraft has continues to investigate bright spots on the surface of Creres





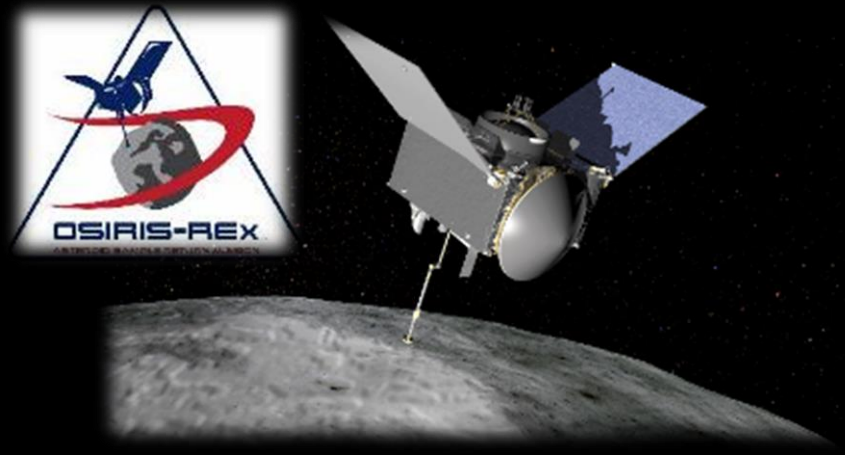
A pyramid-like peak jutting out of the frigid world's surface was discovered in 2015

OSIRIS-Rex's Complex Route

- The OSIRIS-REx spacecraft is designed to rendezvous with in Bennu in 2018, study the asteroid and return a sample to Earth in 2023

- This sample of a primitive asteroid will help scientists understand the formation of our solar system more than 4.5 billion years ago

- As of one week post launch (Sept 15th 2016) , the spacecraft was approximately 2 million miles (3.2 million kilometers)) from Earth, traveling at approximately 12,300 miles per hour (19,800 kilometers per hour) relative to Earth

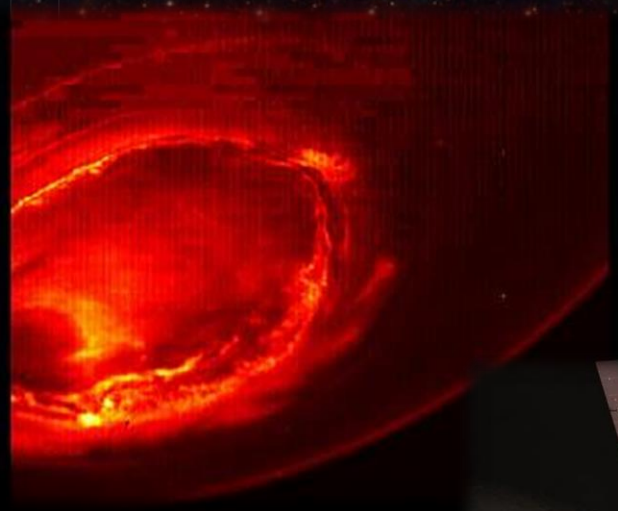


Juno – Jupiter rendezvous

- Juno is a NASA New Frontiers mission currently on station (arrived July 4th 2016) orbiting the planet Jupiter

- The spacecraft is in a polar orbit to study Jupiter's composition, gravity field, magnetic field, and polar magnetosphere

- Juno 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, how its mass is distributed, and its deep winds (~400 mph)



This infrared image of the southern aurora of Jupiter, as captured by NASA's Juno spacecraft on August 27, 2016

Many, many other cool missions…

Just a few to mention…

Cassini

Saturn orbit, last year of operation

Juno

Arriving at Jupiter July 2016

Hubble

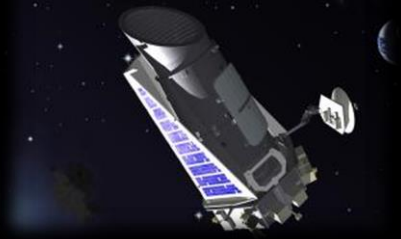
Still researching origins of the universe

Kepler

Planet Count

Confirmed Planets: 977

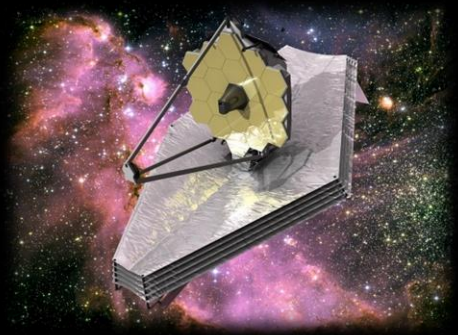
Planet Candidates: 4,234



Voyager 1

Has left the building…

Traveling interstellar space



James Webb Telescope

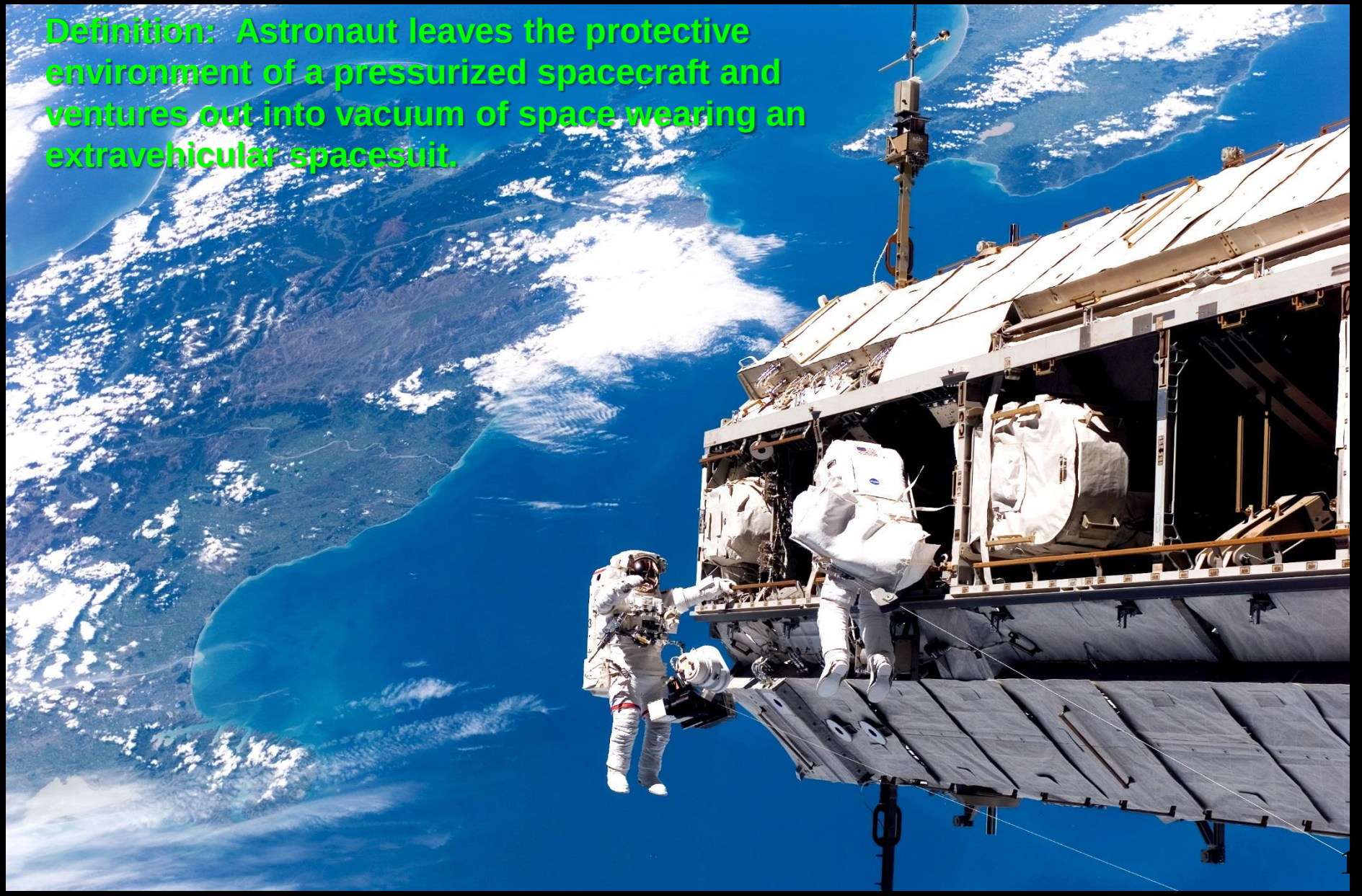
Launch in 2018

Eyes on the Solar System

http://eyes.nasa.gov/

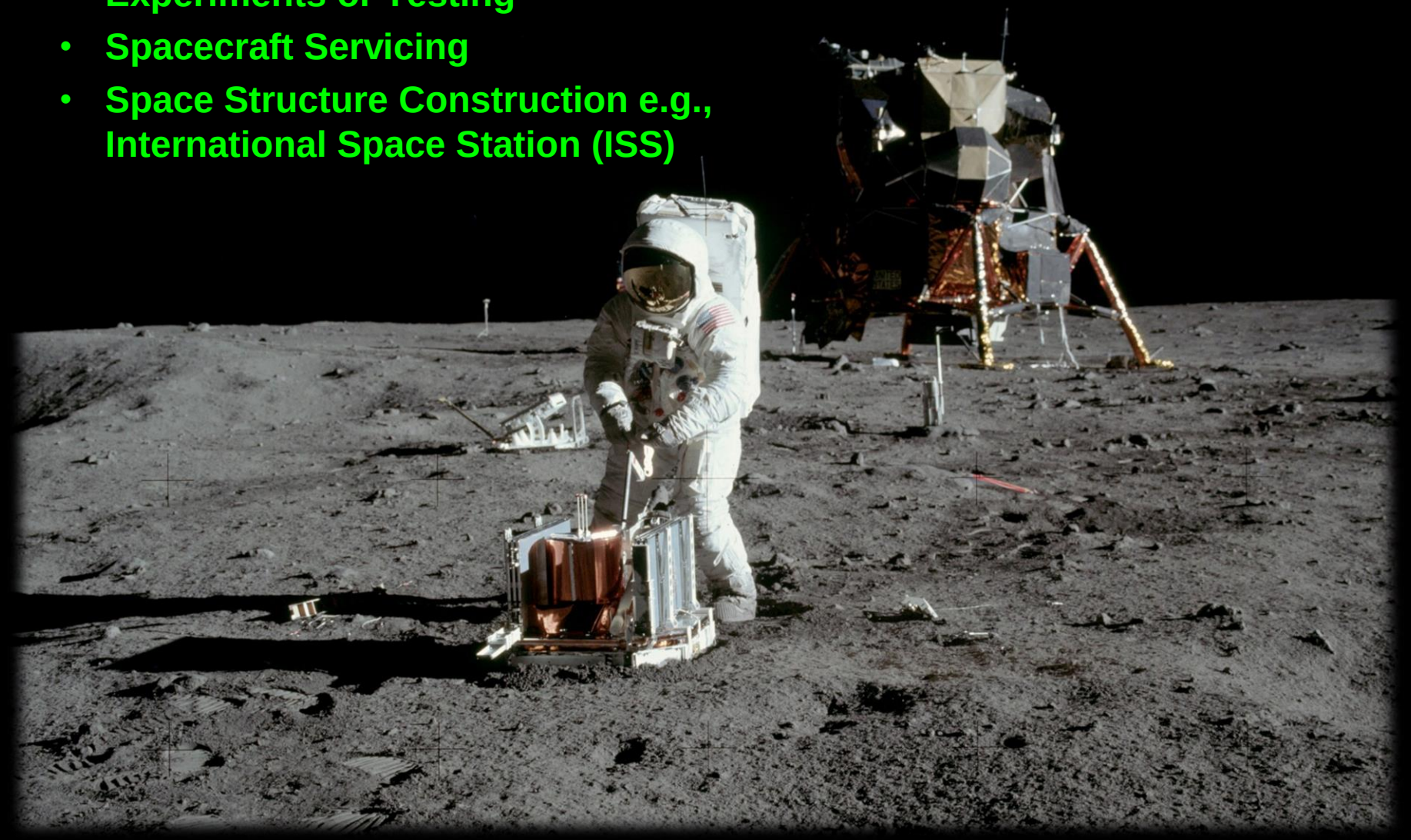
Extravehicular Activity (EVA) Hardware & Operations Overview

Definition of Extravehicular Activity (EVA)



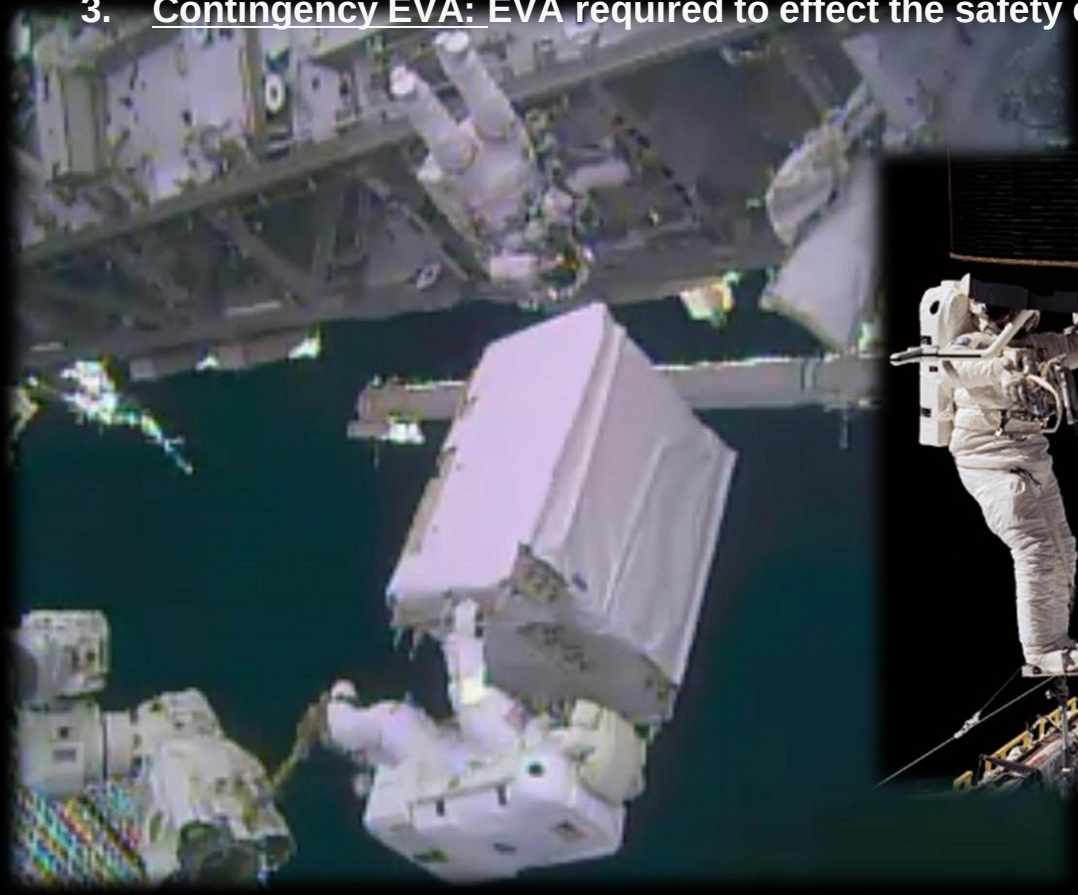
Purpose of EVA

- Contingency or Mission Success Repairs
- Experiments or Testing
- Spacecraft Servicing
- Space Structure Construction e.g., International Space Station (ISS)



EVA Categories

- Three basic categories of EVA:
  1. Scheduled EVA: EVA planned and trained prior to launch and included in the mission timeline.
  2. Unscheduled EVA: EVA, although trained, not included in the scheduled mission activities, but which may be required to achieve mission or operational success.
  3. Contingency EVA: EVA required to effect the safety of the crew and vehicle.



Definition of Spacesuits

- Spacesuits
  - Typically, 2 types of pressurized “spacesuits’ have been constructed to support NASA programs

- Launch, entry, and abort (LEA) spacesuit
  - Used to protect crewmembers from launch, ascent, abort, landing and other dynamic loading.
  - Capable of providing protection from loss of cabin pressure and crew rescue following landing.

- Extravehicular Activity (EVA) spacesuit
  - Used to allow crewmembers to work effectively in the harsh external space environment (provides protection from vacuum, thermal, mircrometeoroids, radiation, etc.).

Historical Overview – First EVA

- First EVA was conducted by USSR/Alexi Leonov on March 18, 1965.
  - Many EVAs have since been accomplished by the Soviet Union & Russia continuing into the International Space Station era.

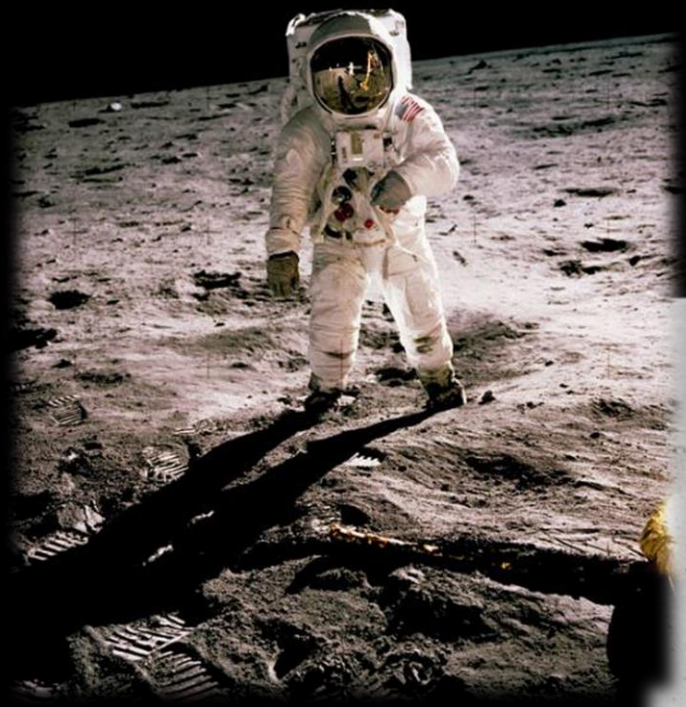
Historical Overview -U.S. EVA Experience

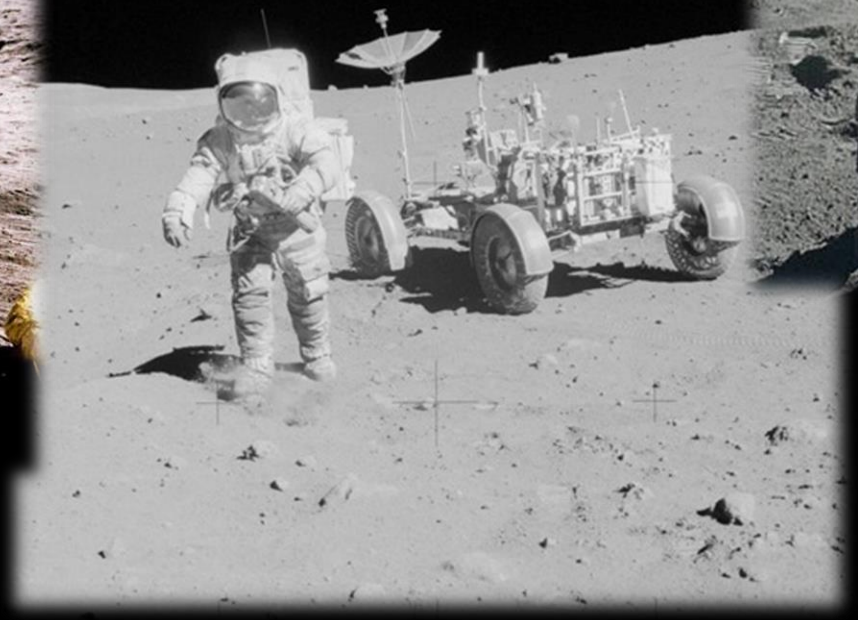
Gemini EVA Experience -

- Astronaut Edward White II performed first U.S. EVA during Gemini IV June 3, 1965 (22 min) and coined the term “Spacewalk”
- Proved EVA to be a viable technique for operations outside the spacecraft crew compartment.
- Problems encountered: helmet fogging, overheating due to high metabolic activity (primarily due to suit constraints and lack of training).

Historical Overview - Apollo EVA Experience

- Spacesuit was redesigned to allow greater mobility.
- Suit used for lunar and in-space EVAs.
- Suit was configured with its own portable life support system providing:



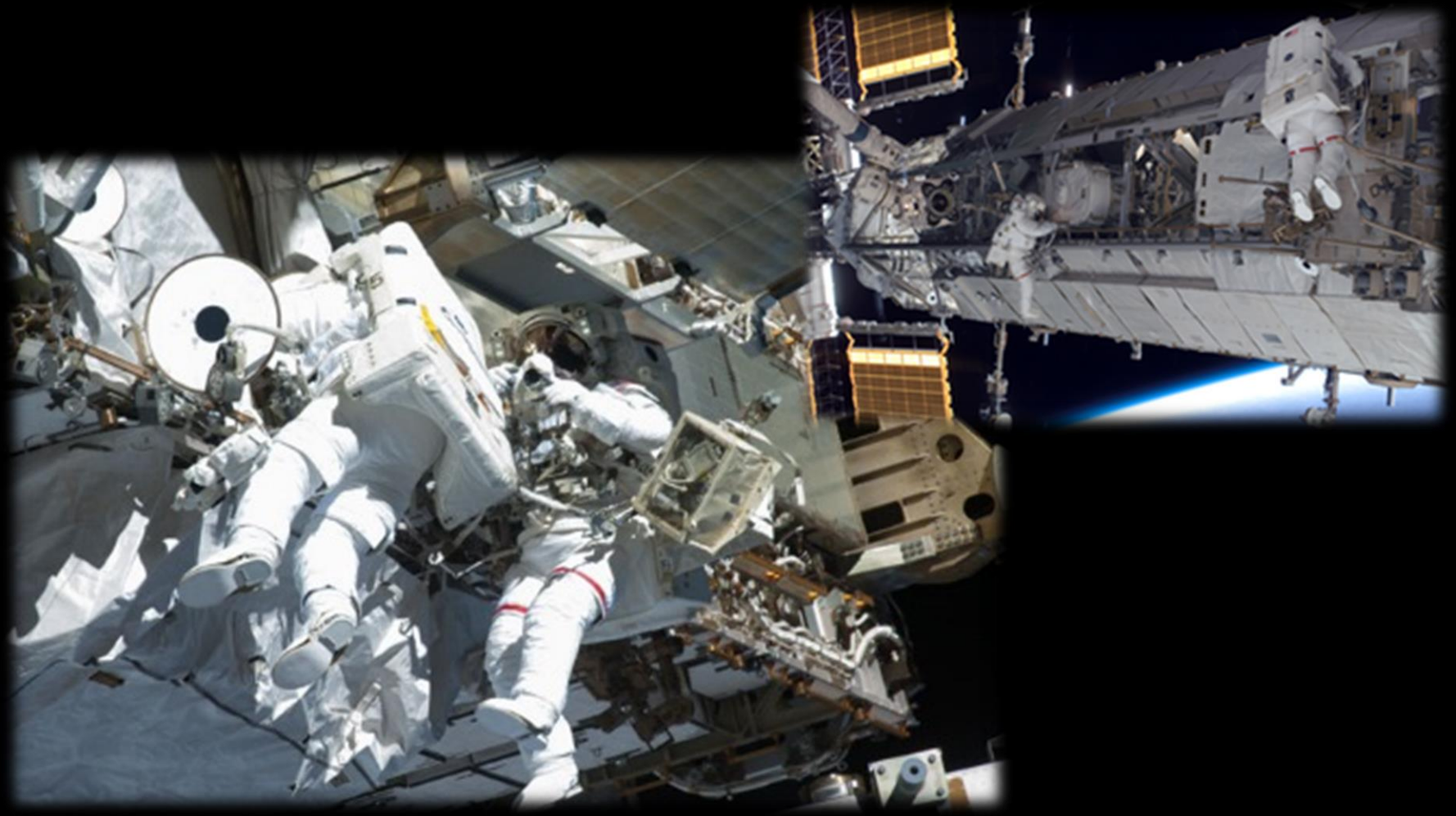


Historical Overview

- Skylab EVA Experience
  - Umbilical replaced portable life support system and provided breathing oxygen, cooling, and served as a tethering device.
  - 10 EVAs were performed during the 3 Skylab missions totaling 82.5 hours.
- Space Shuttle EVA Experience
  - New space suit design for additional mobility and modularity
  - Portable life support system designed for microgravity opera

Historical Overview

- International Space Station (ISS) EVA Experience
  - EMU certified for extended duration on-orbit operations (25 EVAs).
  - Orbital Replacement Unit (ORU) capability added.
  - Accumulated 1000s of hours of EVA experience over 150+ EVAs



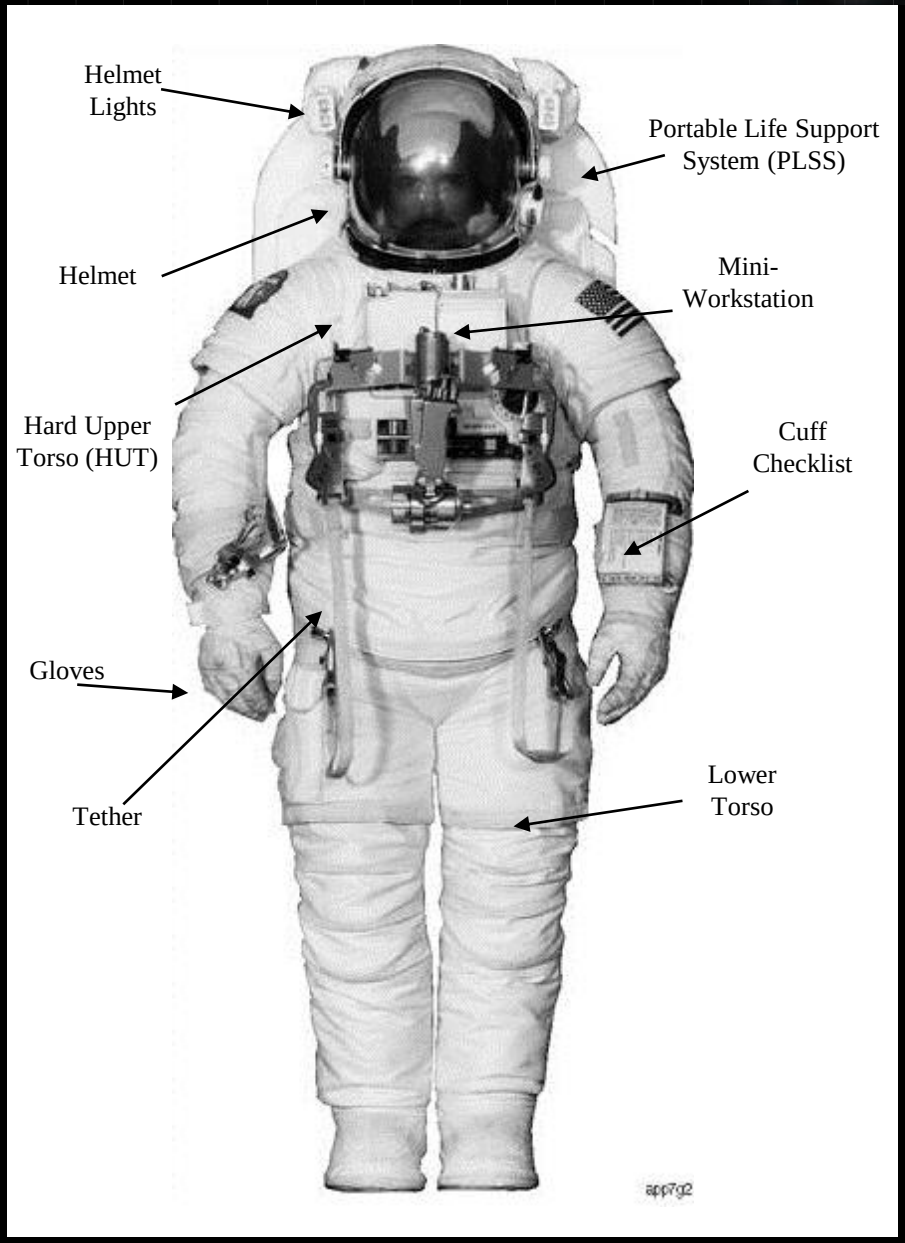
Historical Overview
Apollo EVA Experience

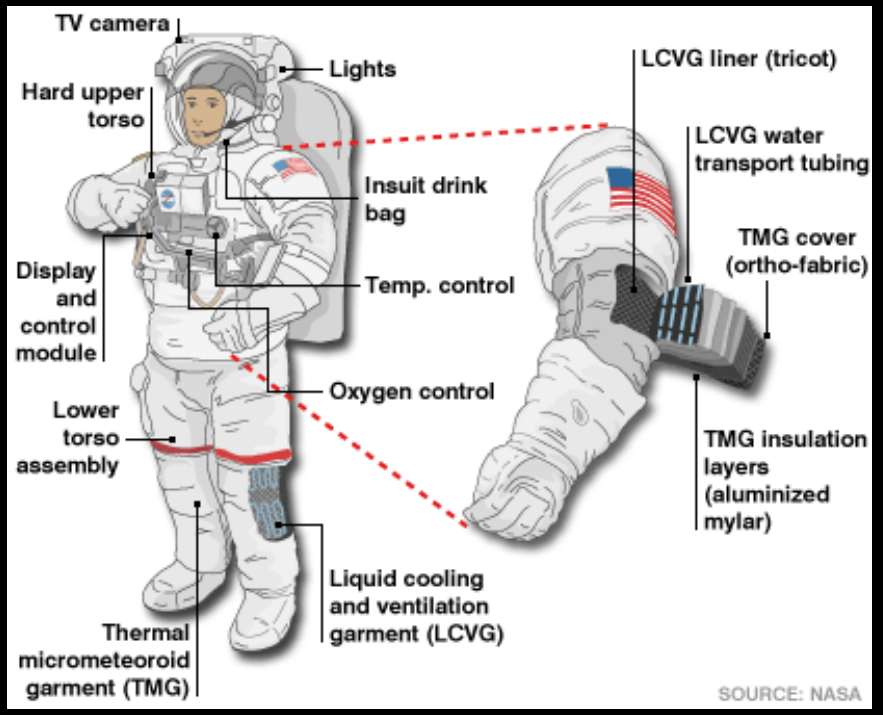
Walking on the moon?

Historical Overview
Apollo EVA Experience

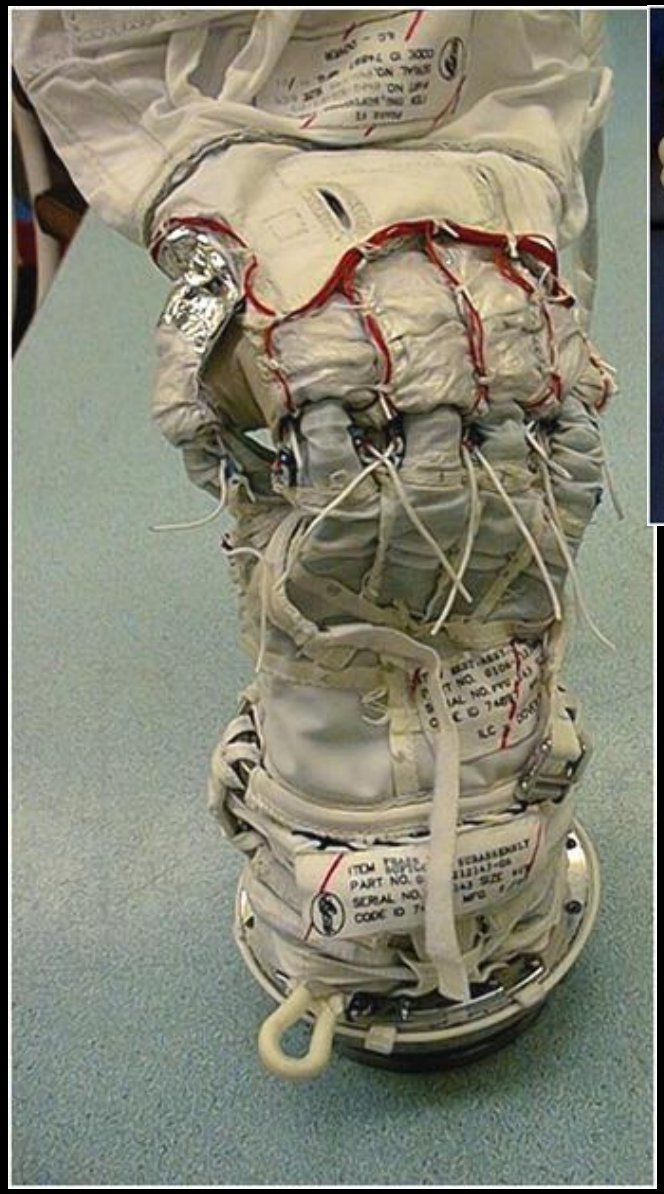
Falling on the moon?

EVA Systems - EMU



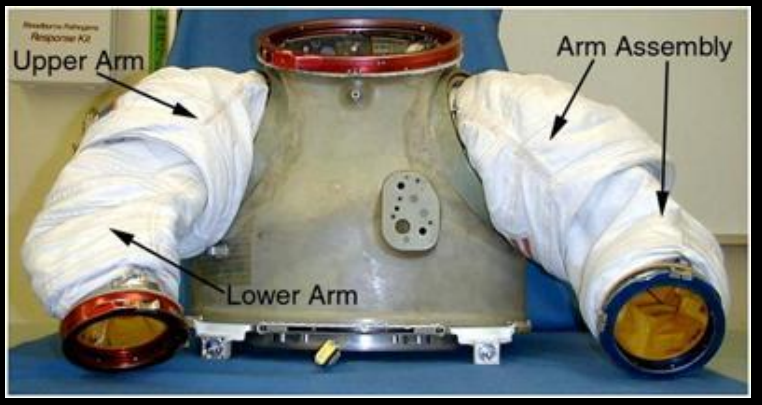


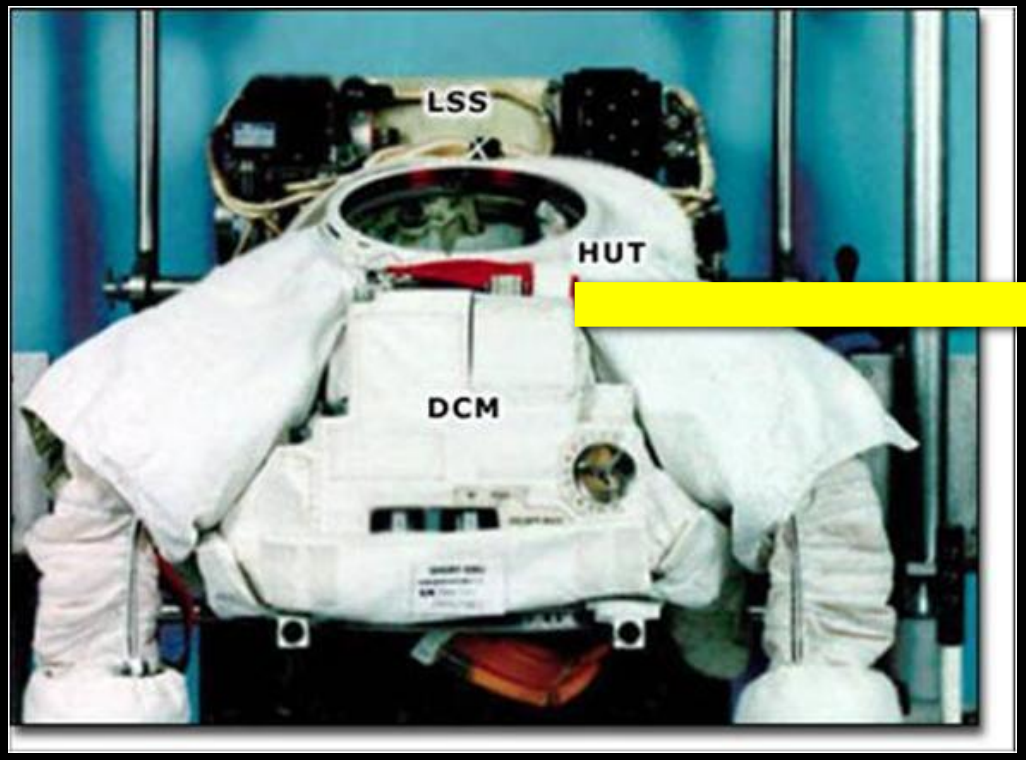
EVA Systems – Space Suit Assembly Gloves & Boots



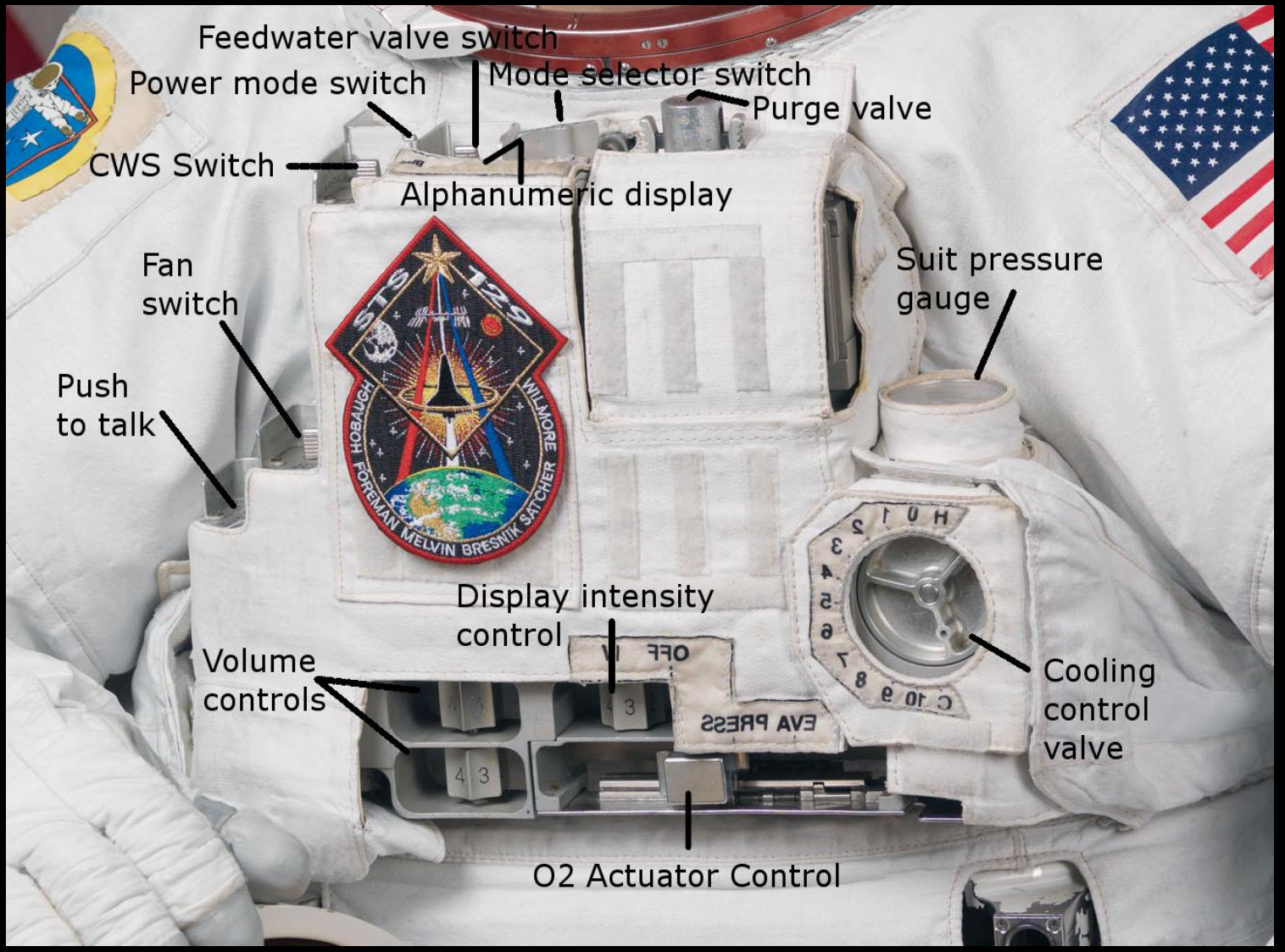
EVA Systems – Life Support Upper Torso

- Life Support System Components:
  - Display and Control Module (DCM)
    - Provides Caution & Warning System (CWS) messages, EMU parameters, and EMU controls to crewmember



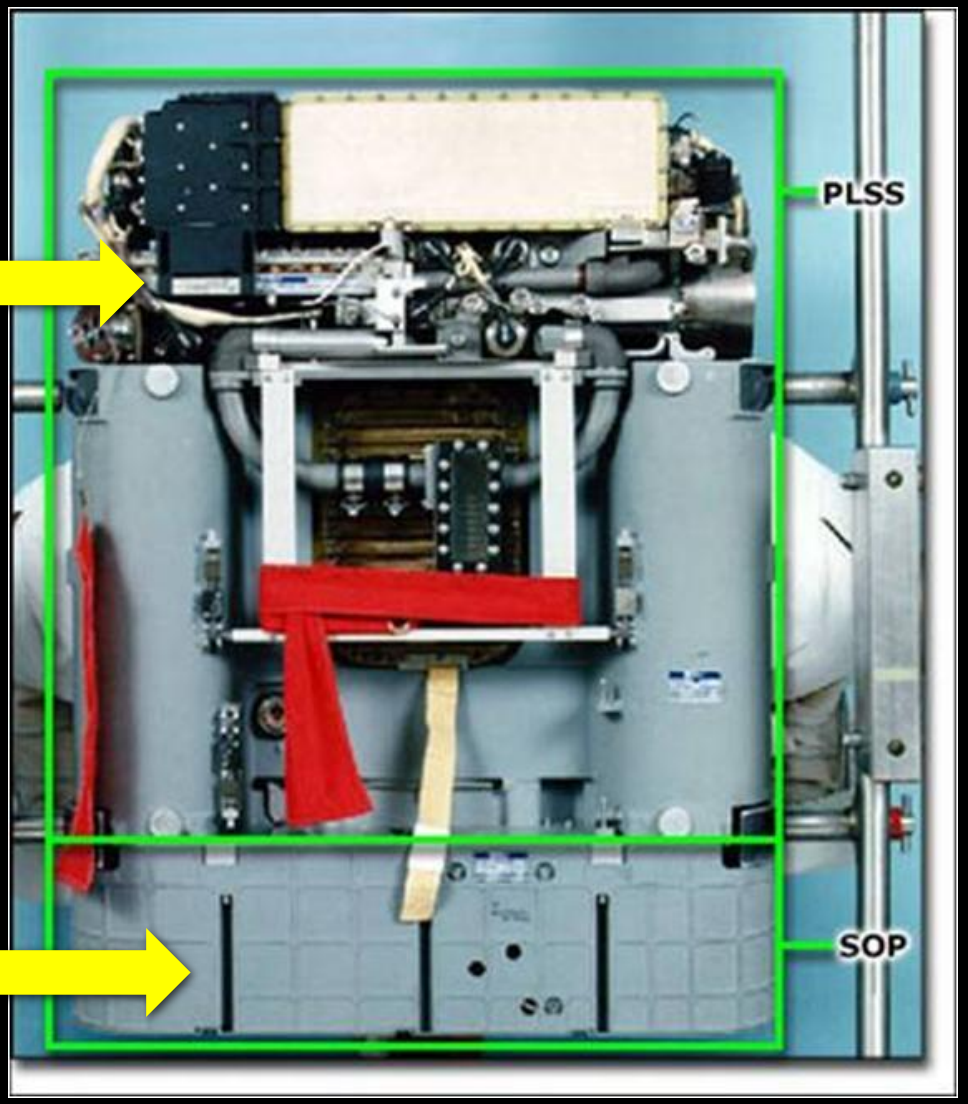


Display Control Module



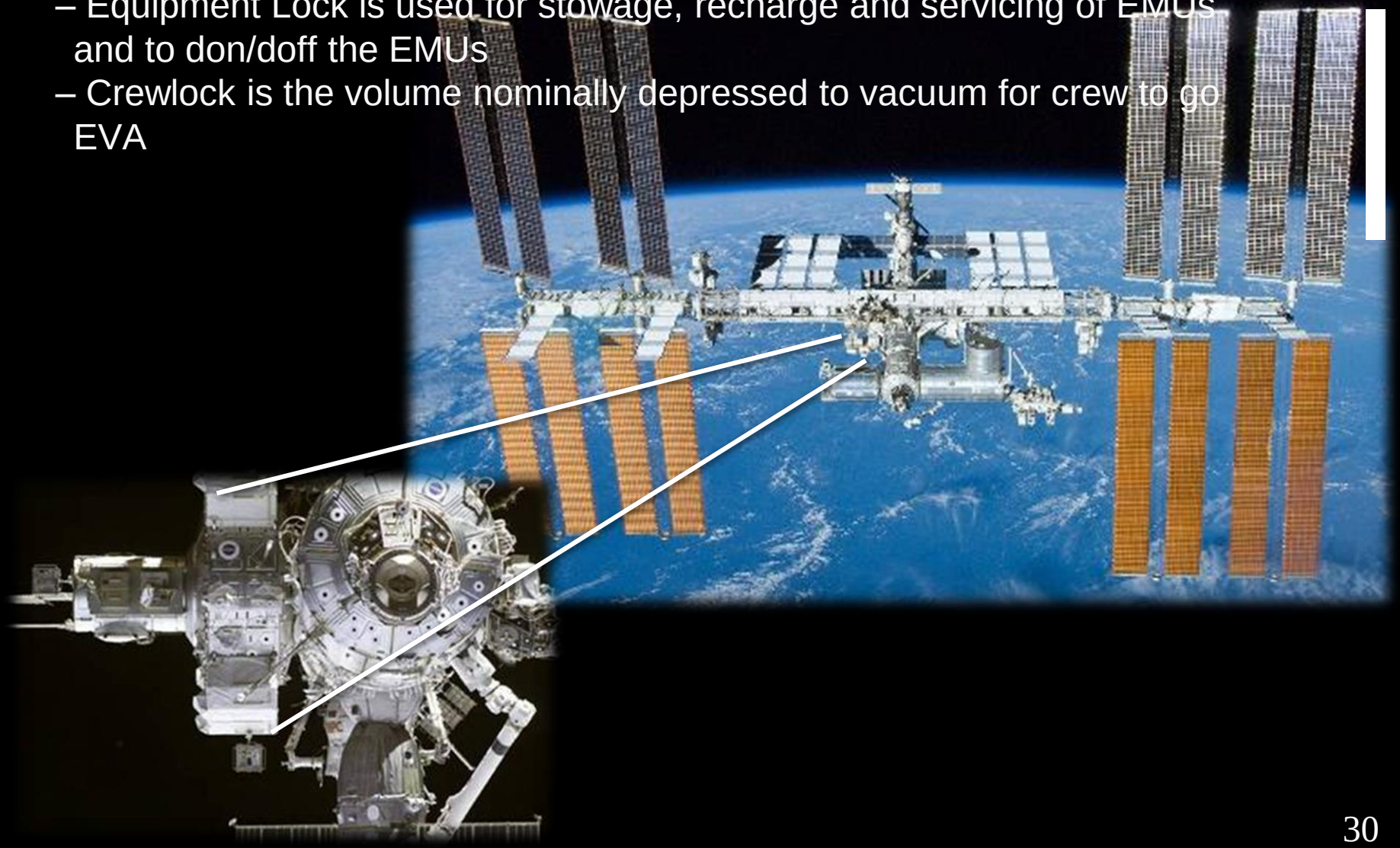
EVA Systems – Life Support

- Life Support System Components:
  - Portable Life Support Subsystem (PLSS)
    - Provides breathing O_2, electrical power, communications, cooling
    - Responsible for suit pressure control
    - Circulates O_2 and removes CO_2, humidity and trace contaminants
    - Controls thermal environment
  - Secondary Oxygen Package (SOP)
    - Provides a minimum of 30 minutes of emergency O_2 in open-loop purge mode
    - Activated automatically during EVA, if necessary

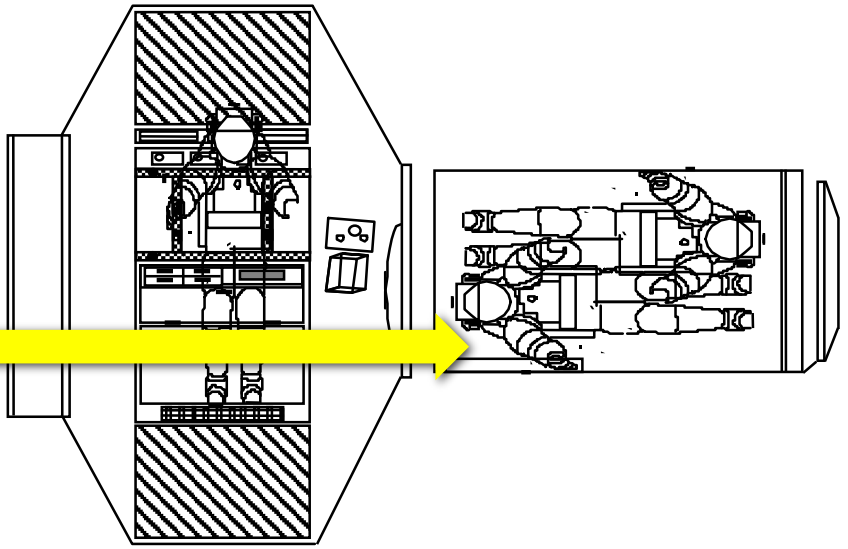


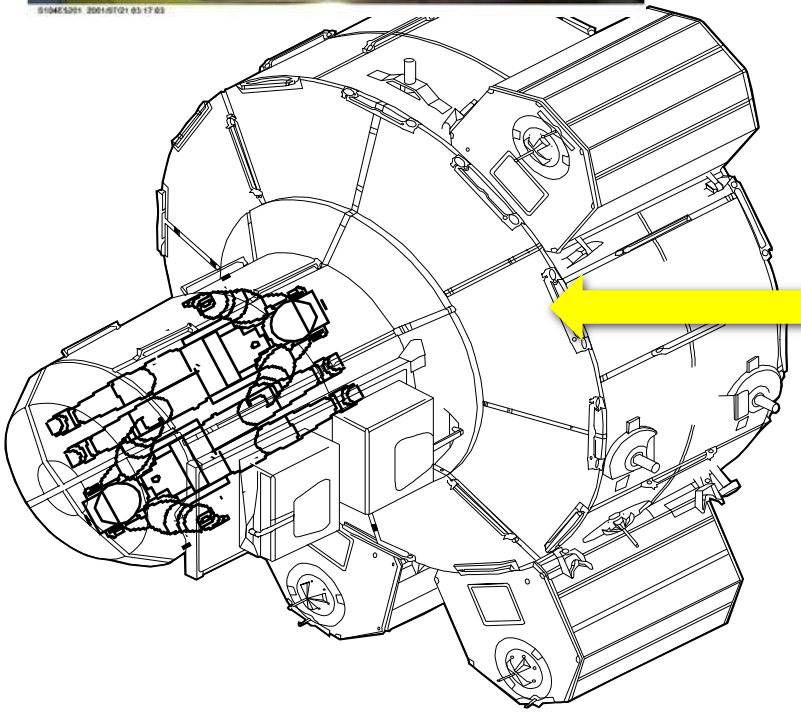
EVA Systems - ISS Joint Airlock

- ISS Joint Airlock:
  - Made up of two parts: Crew Lock and Equipment Lock
    - – Equipment Lock is used for stowage, recharge and servicing of EMUs and to don/doff the EMUs
    - – Crewlock is the volume nominally depressed to vacuum for crew to go EVA



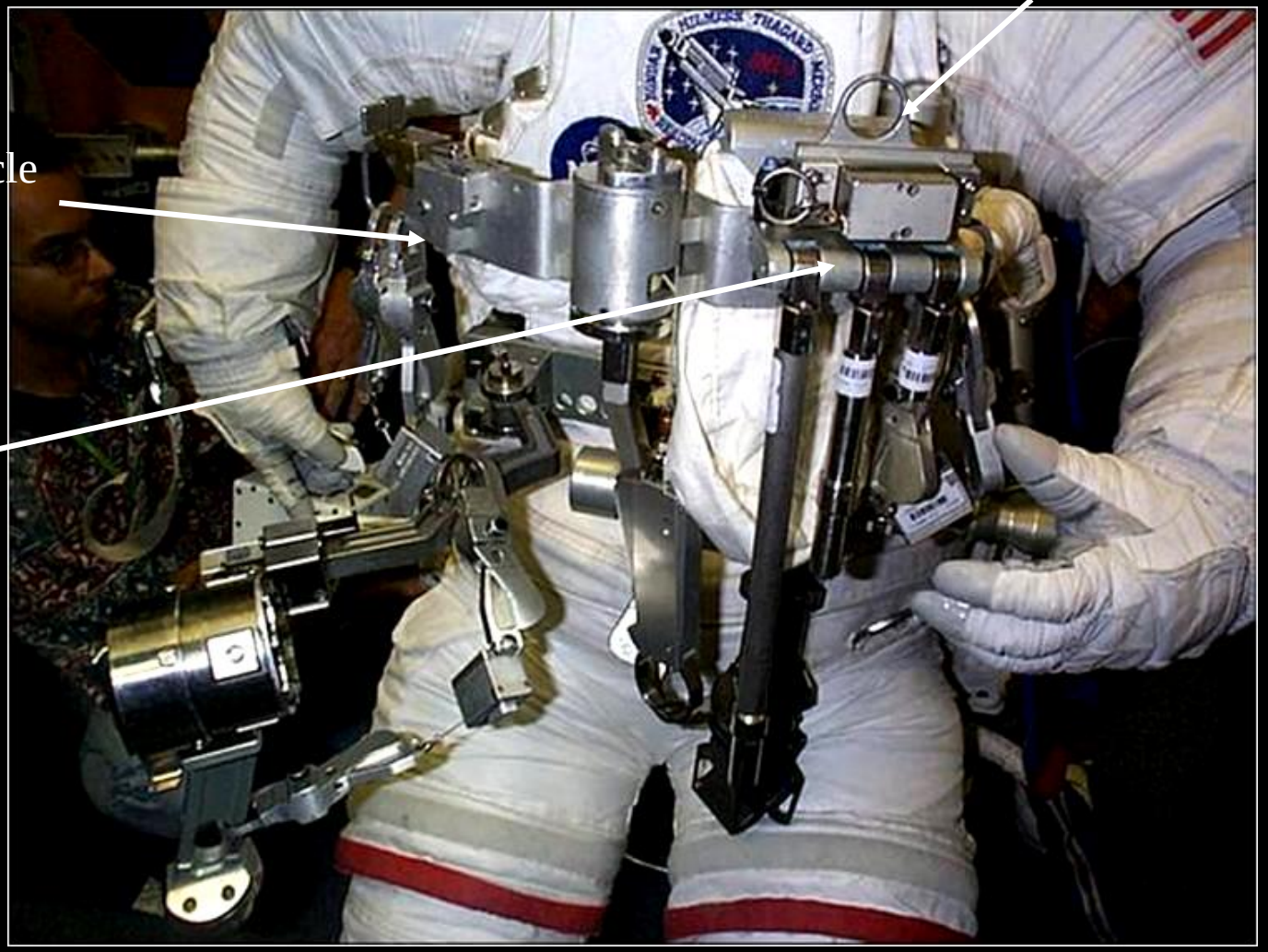
International Space Station (ISS) Joint Airlock





EVA Equipment & Tools

- Mini Work Station (MWS)
  - Attaches to front of the EMU
  - Used to carry small tools
  - Tools are secured via tether rings or via bayonet receptacles



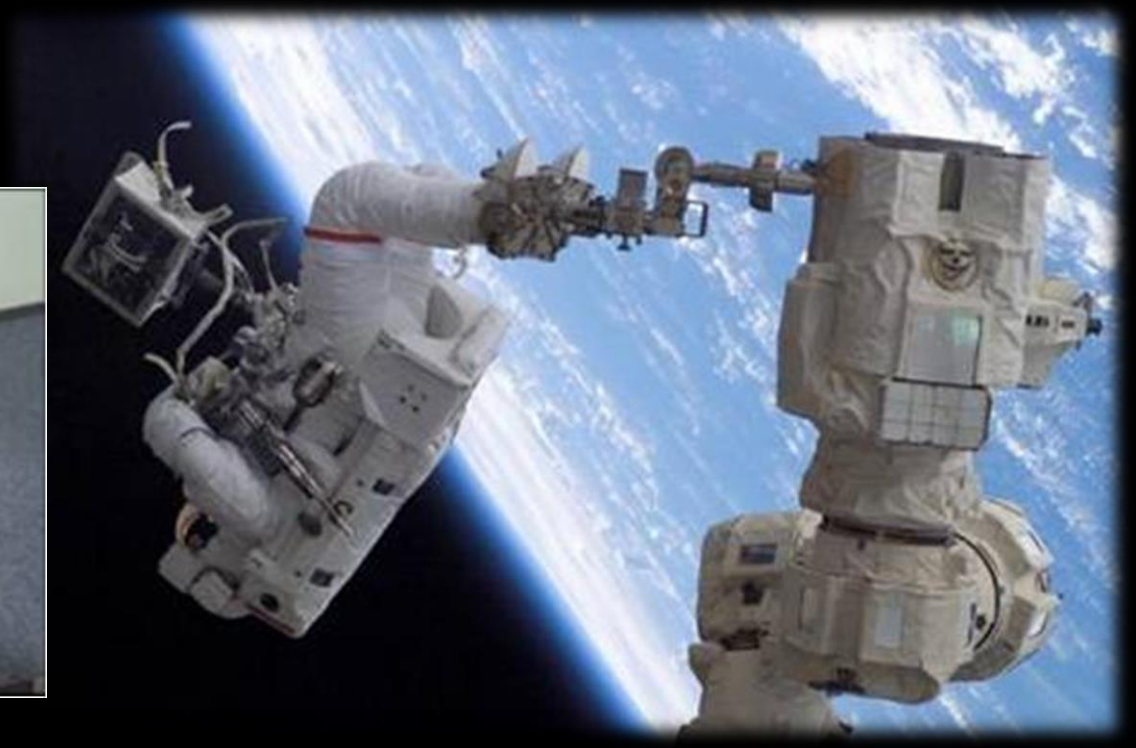
EVA Equipment & Tools

- Pistol Grip Tool (PGT)
- Tethers

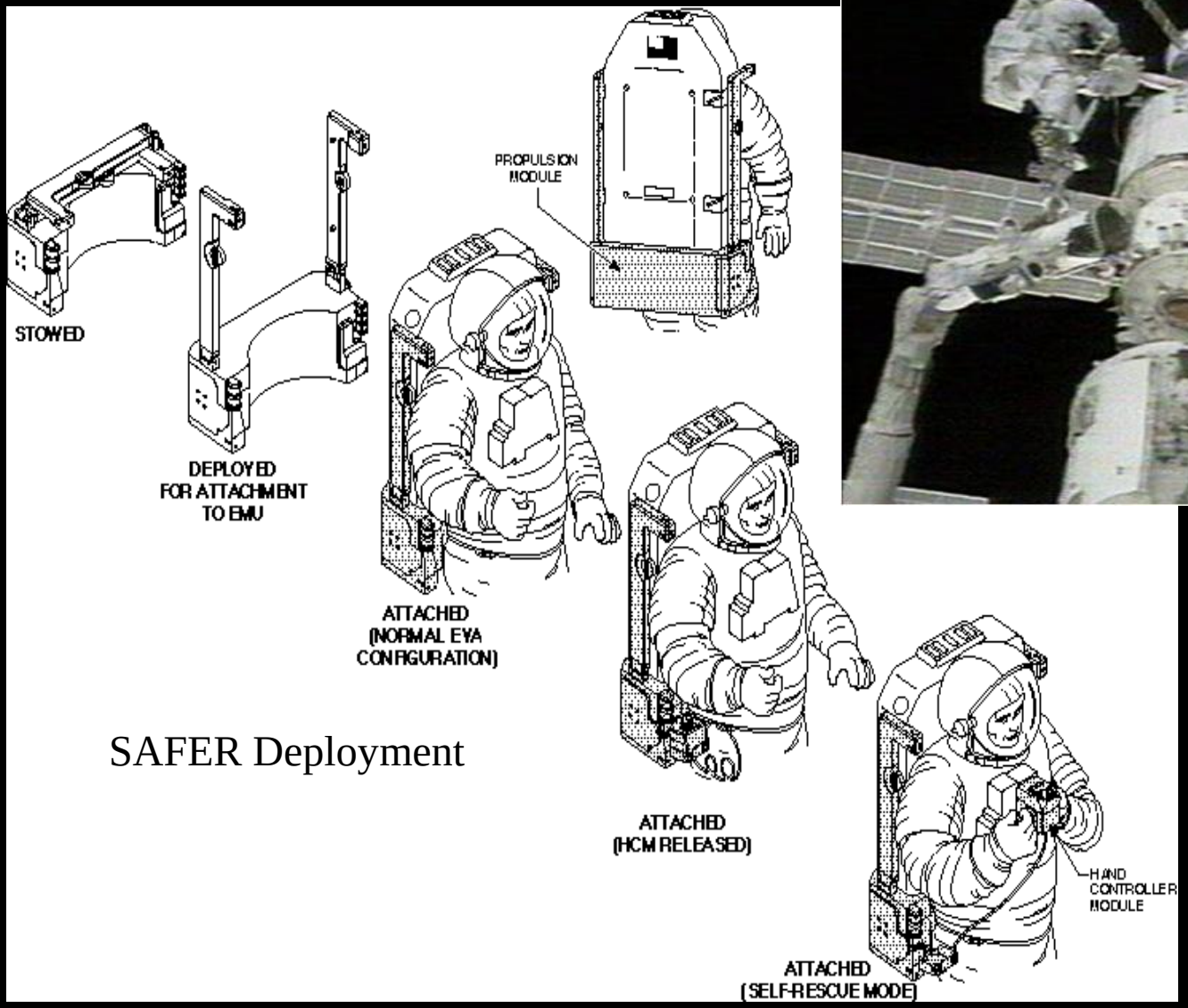
← 1-
of

EVA Equipment & Tools

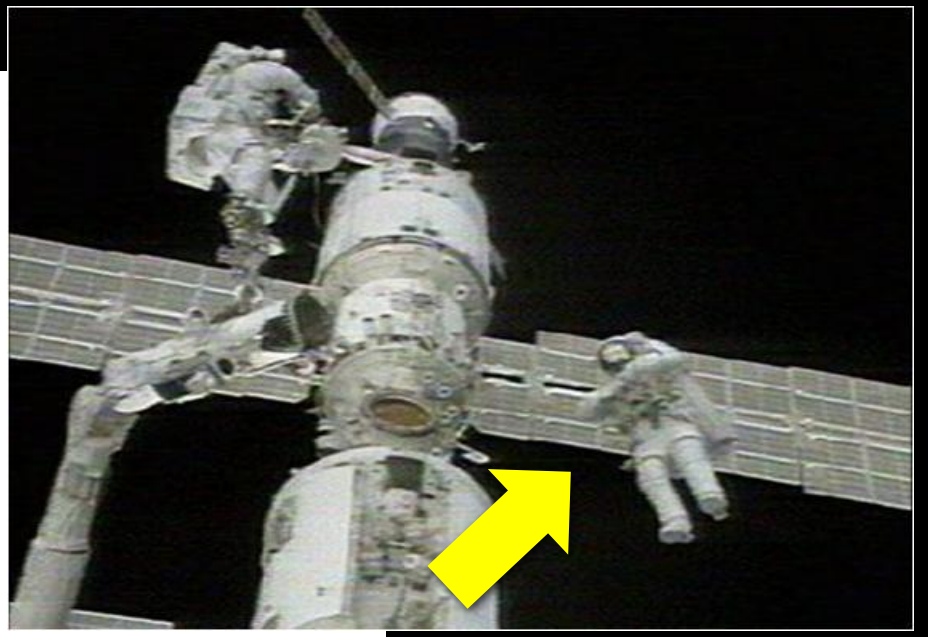
- Foot Restraints
  - Attach to structure via a socket
  - Provides EVA crewmember rigid restraint at a worksite (Newton's 3rd Law)
  - Different types:
    - Articulating PFR (APFR) *(U.S. ISS)*
    - Interoperable APFR (IAPFR) *(U.S. & Russian ISS)*



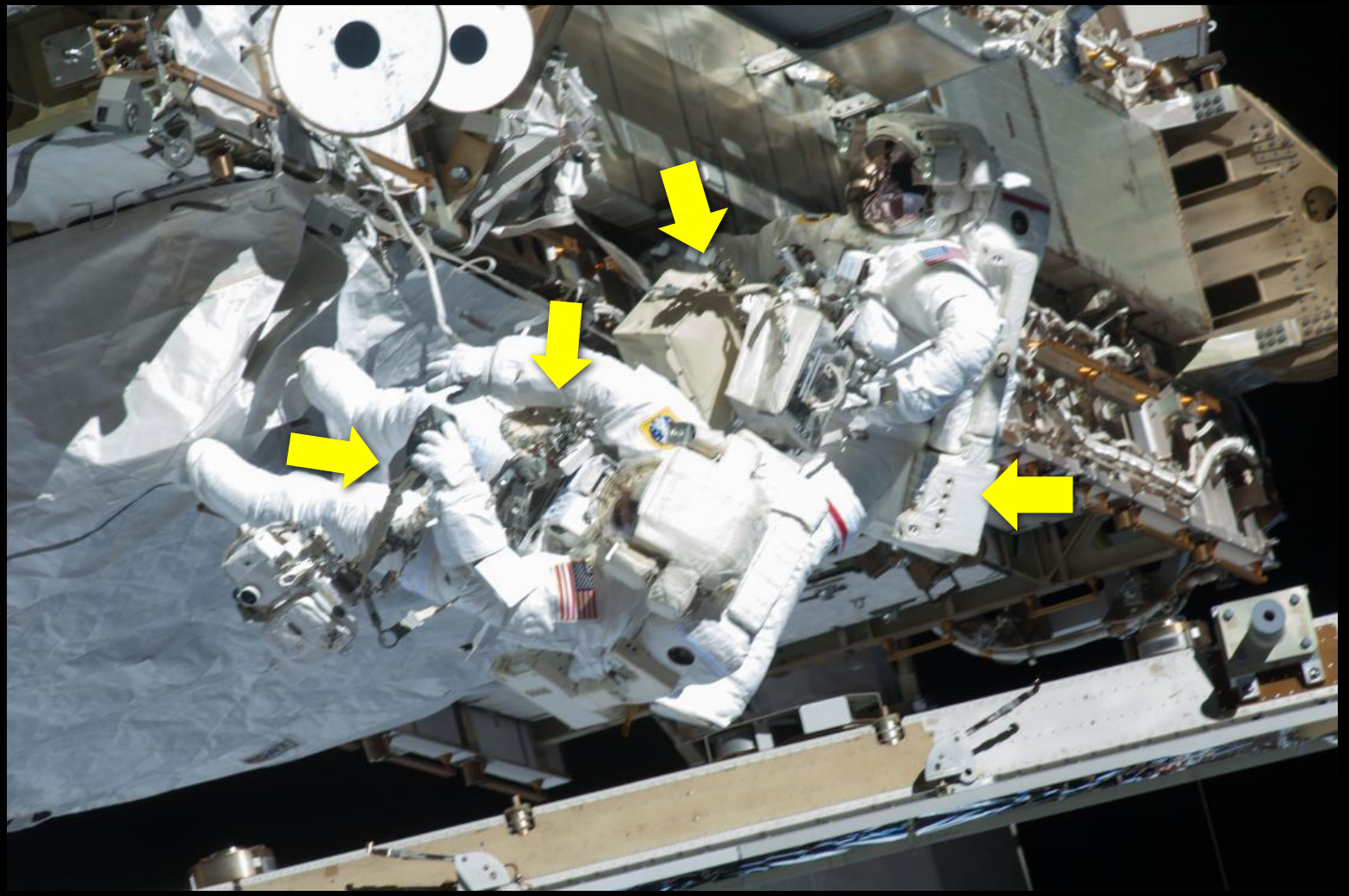
EVA Systems -
SAFER (Simplified Aid for EVA Rescue)



SAFER Deployment



EVA Equipment & Tools



What it looks like in “real-time”

Will show 0:00-2:00

EVA Training Facilities

How do we train the Astronauts to safely complete spacewalks?

EVA Training Facilities

- Space Vehicle Mockup Facility (SVMF) Airlock Mockup

EVA Training Facilities

- EMU Caution and Warning System (ECWS) Trainer

EVA Training Facilities

- Vacuum chambers
  - 11-foot chamber
  - Environmental Test Article (ETA) chamber
  - Space Environment Simulation Lab (SESL) chamber
  - Space Station Airlock Test Article (SSATA)

EVA Training Facilities

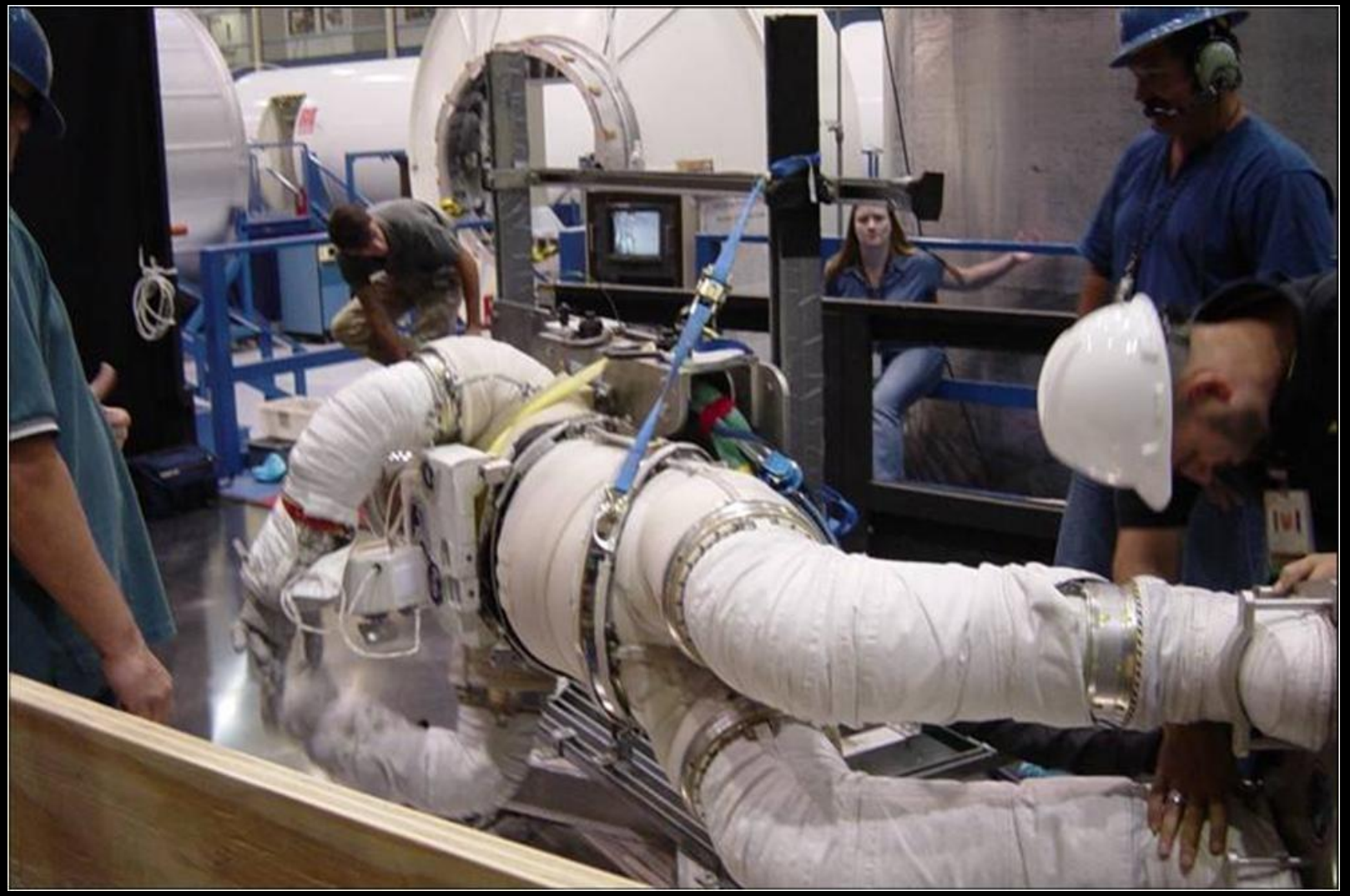
- Virtual Reality Lab

EVA Training Facilities

POGO/ARGOS uses an inline load cell to continuously offload of a portion of a human or robotic subject's weight during all dynamic motions

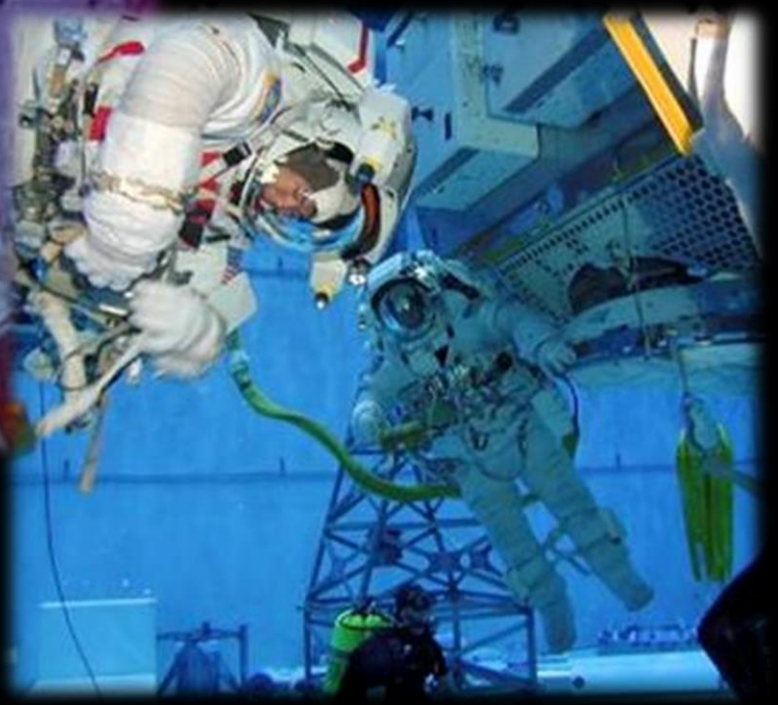
EVA Training Facilities

- Precision Air-Bearing Floor (PABF)



EVA Training Facilities

- Neutral Buoyancy Laboratory (NBL)

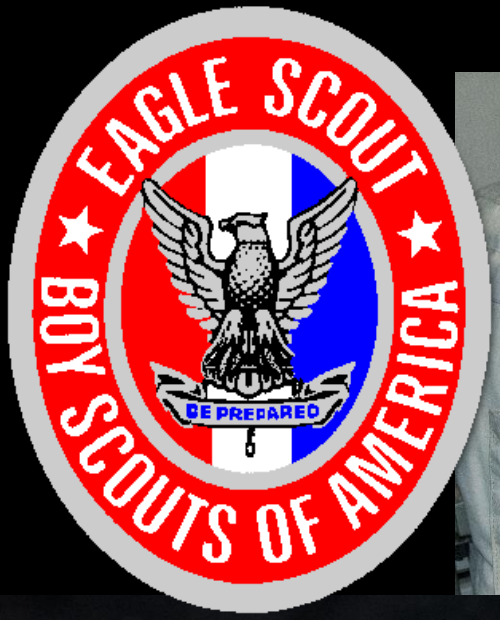


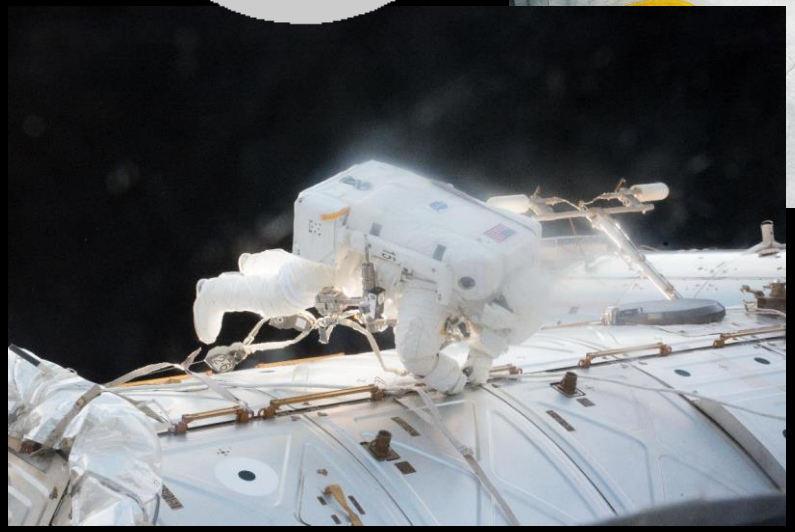
NBL Video

NBL training Will show video
from 4:45 -6:30

- Videos
- EVA 30 real-time
- https://www.youtube.com/watch?v=26QWMMT1c8Y
- NBL training
- https://www.youtube.com/watch?v=6cwIeHpAUE0
- EVA 32 Kjell
- https://www.youtube.com/watch?v=FWKW0qACcH0
- EVA 32 timelapse
- https://www.youtube.com/watch?v=yD9U89asG4o
- EVA 33 timelapse
- https://www.youtube.com/watch?v=VkcTcy1hrE4

Kjell Lindgren – Eagle Scout/Space Walker





US EVA 32 Kjell Lindgren

Will show video from 0:00-2:00, then 6:40-8:40

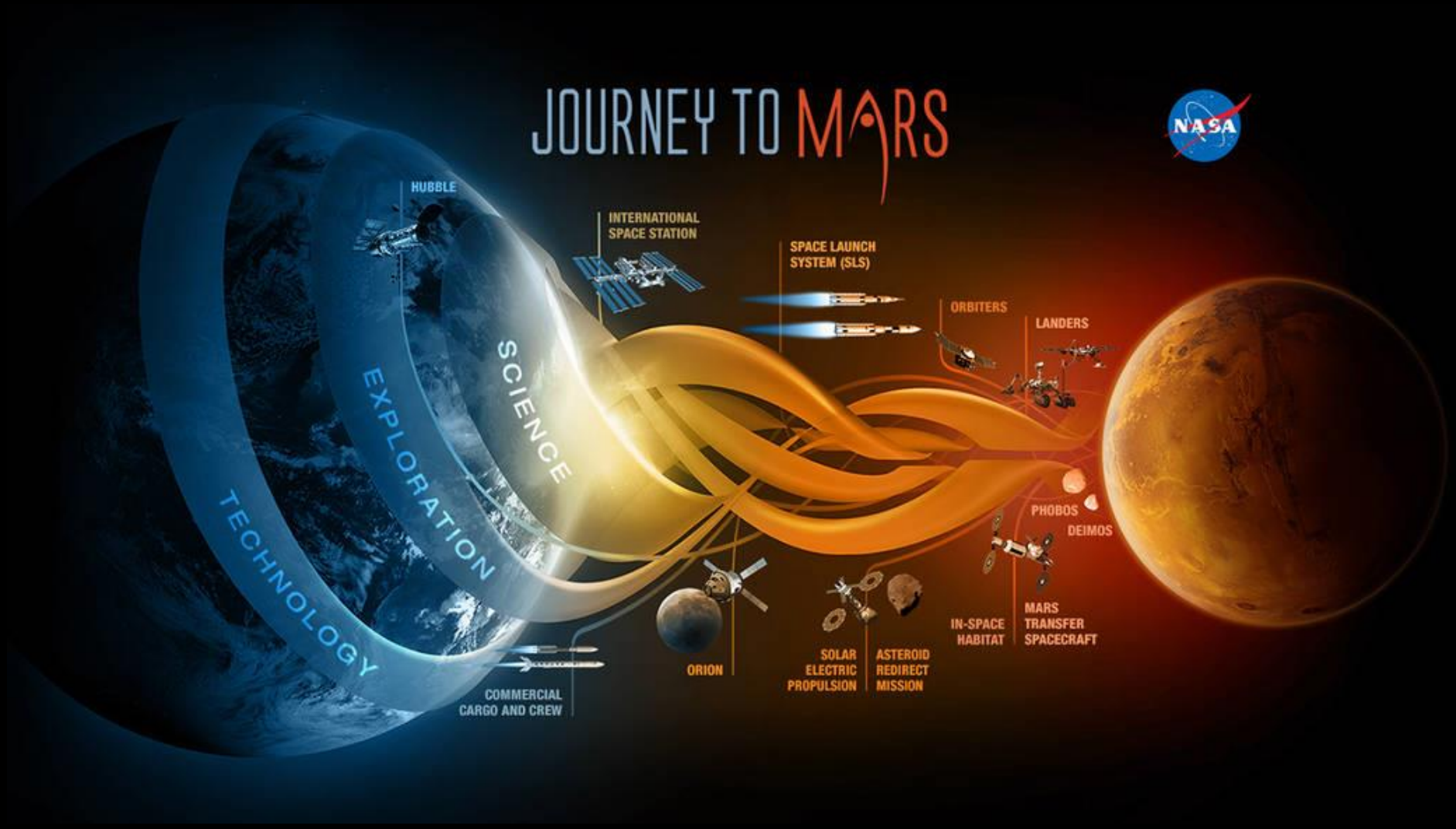
National Aeronautics and Space Administration

Human Deep Space Exploration

What are we doing now to prepare for a Journey to Mars?

www.nasa.gov/exploration

NASA Journey to Mars



MPCV – Multi-Purpose Crew Vehicle “Orion”

- First test flight completed in 2014
- Second test flight in 2018 (SLS)
- First Manned Mission 2021 (SLS)

NASA Heavy Lift Vehicle - SLS

- SLS – Space Launch System
  - Estimated 80-120 metric tons capacity
  - First launch planned for 2018
- 5 Segment Solid rocket test this week

Cargo and Crew Vehicle

Commercial Crew for LEO (Low Earth Orbit)

2 Companies

1. SpaceX Dragon 2
2. Boeing Starliner

Boeing CST-100 Starliner

Atlas V

SpaceX Dragon Capsule

Dragon Interior

Falcon 9 Rocket

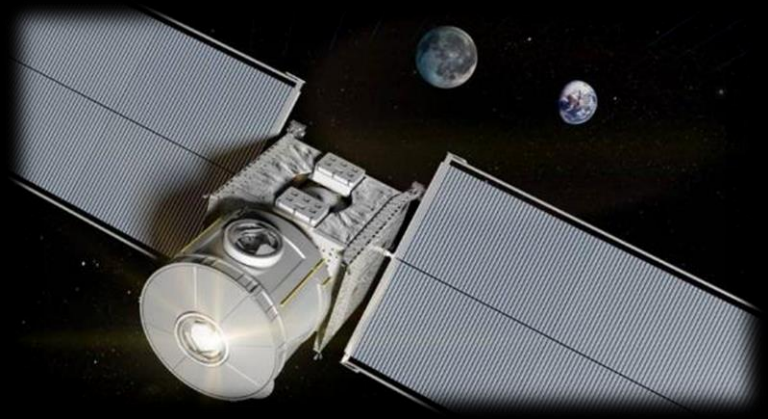
So, What is the Exploration plan?

- Develop strong commercial LEO presence
- Build the exploration vehicles for deep space missions
- Develop the technologies to support these deep space exploration
- Define the path to Mars

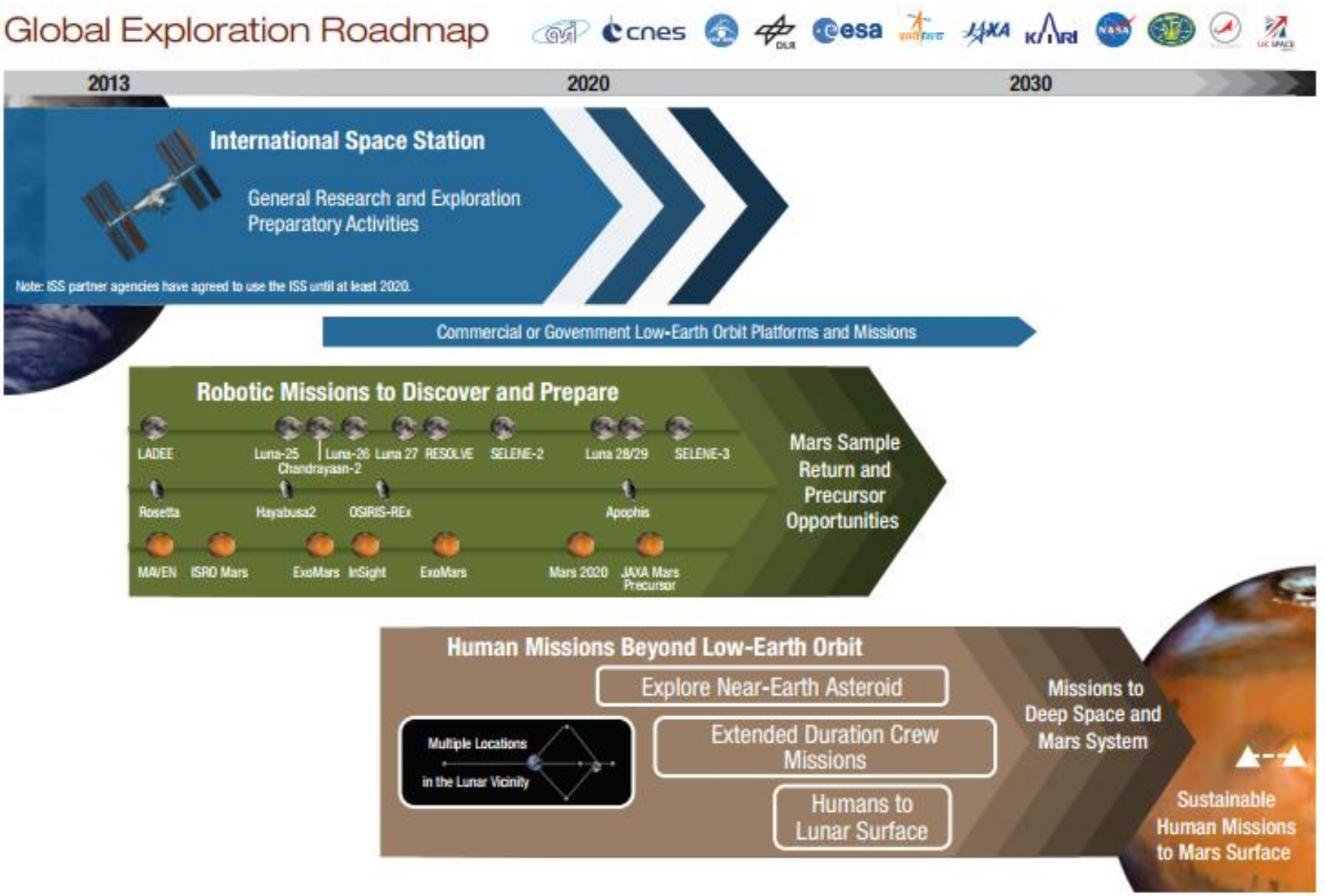
Orion

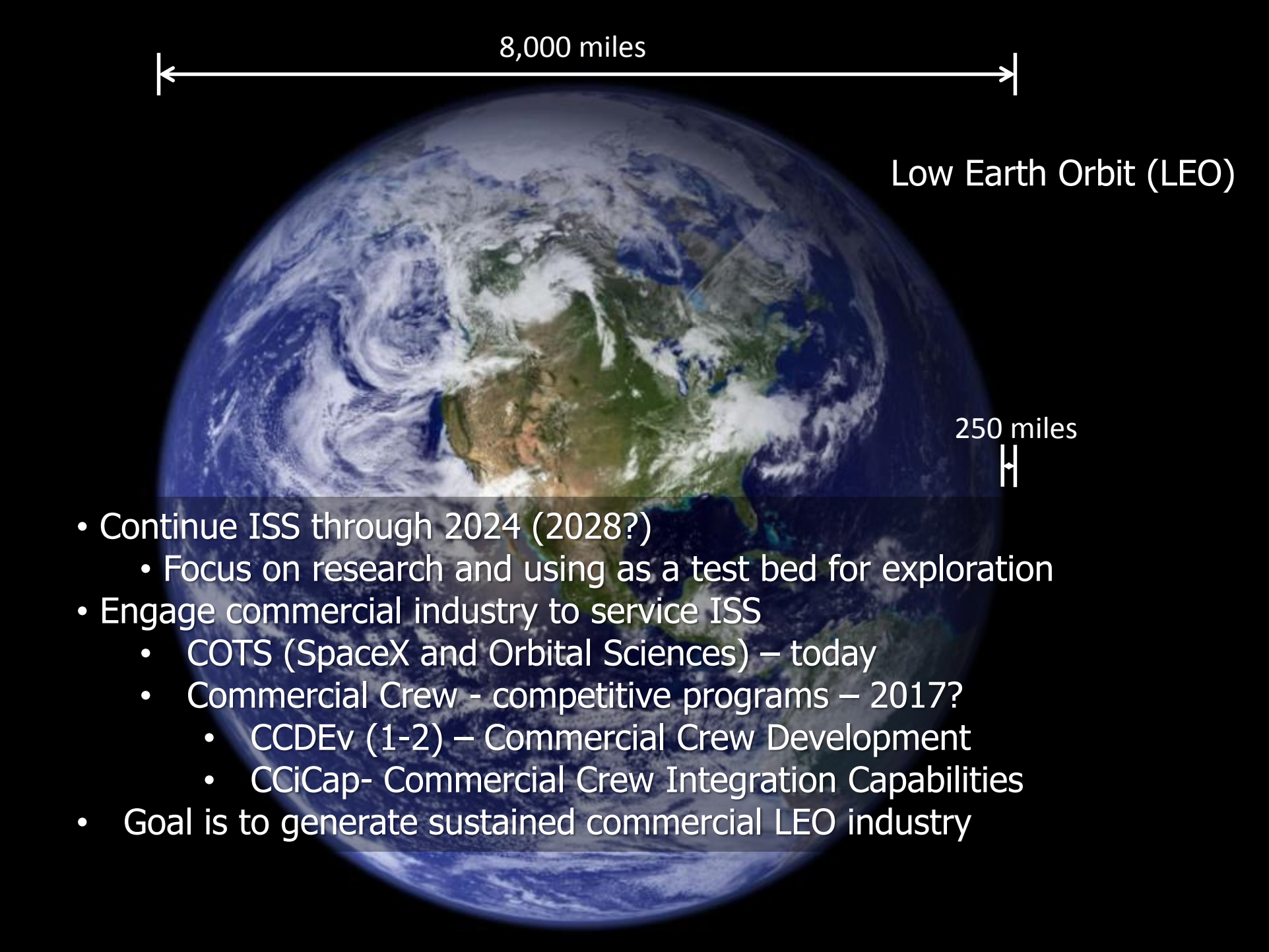
SLS

Deep Space Habitat



Timing for all of these…

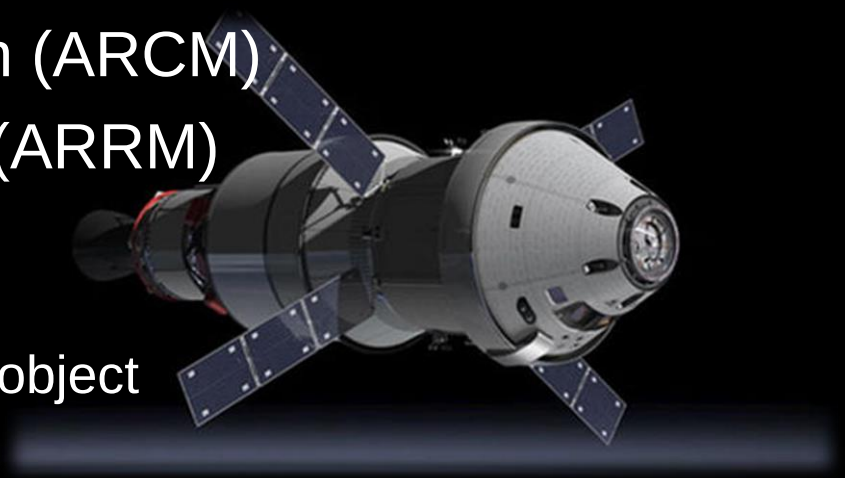




- Continue ISS through 2024 (2028?)
  - Focus on research and using as a test bed for exploration
- Engage commercial industry to service ISS
  - COTS (SpaceX and Orbital Sciences) – today
  - Commercial Crew - competitive programs – 2017?
    - CCDEv (1-2) – Commercial Crew Development
    - CCiCap- Commercial Crew Integration Capabilities
- Goal is to generate sustained commercial LEO industry

Proposed Mission - Asteroid Redirect Mission

- Asteroid Redirect Return Mission (ARCM)
- Asteroid Redirect Crew Mission (ARRM)
  - Possible Lunar orbit or use of L2 (Lagrange point)
  - Science collection from deep space object
  - Exploration System Technology Demonstration

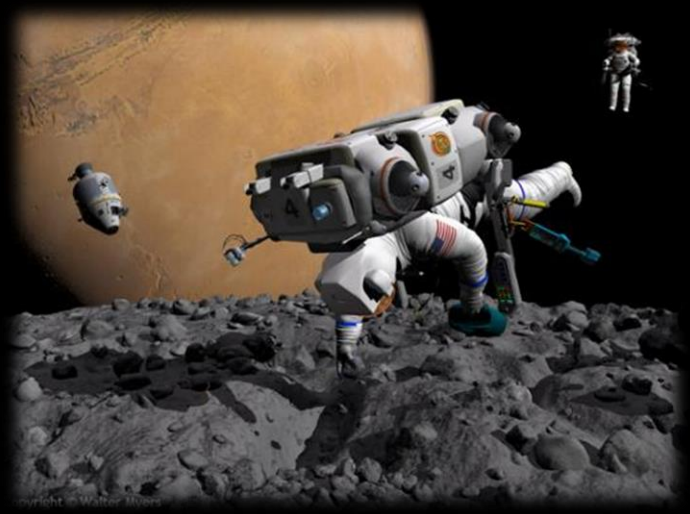


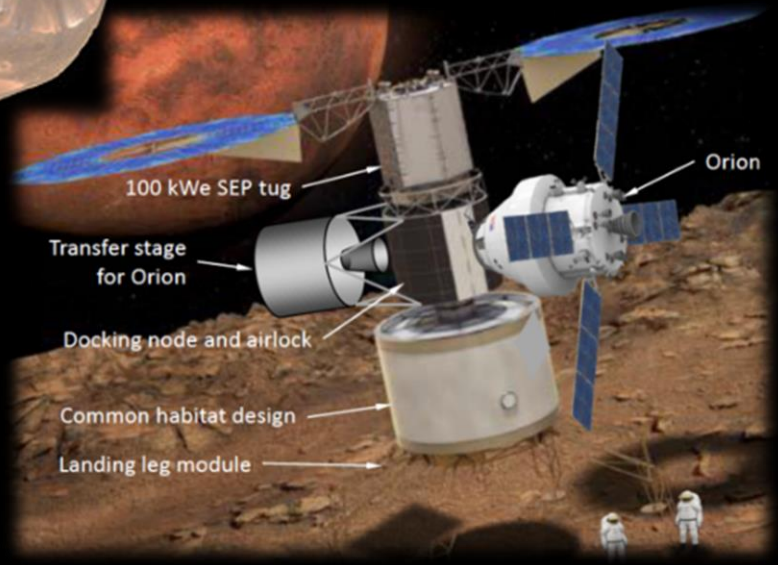
Proposed Mission - Cise Lunar Missions

- 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

Proposed Mission - Mars Orbital Mission- Phobos (Mars Moon)

- Possible first trip to Mars
- Technology gap not as big
- Proof of concept for long range mission
- More cost affective
- *Worth the trip??*





Proposed Mission - Human Mars Mission

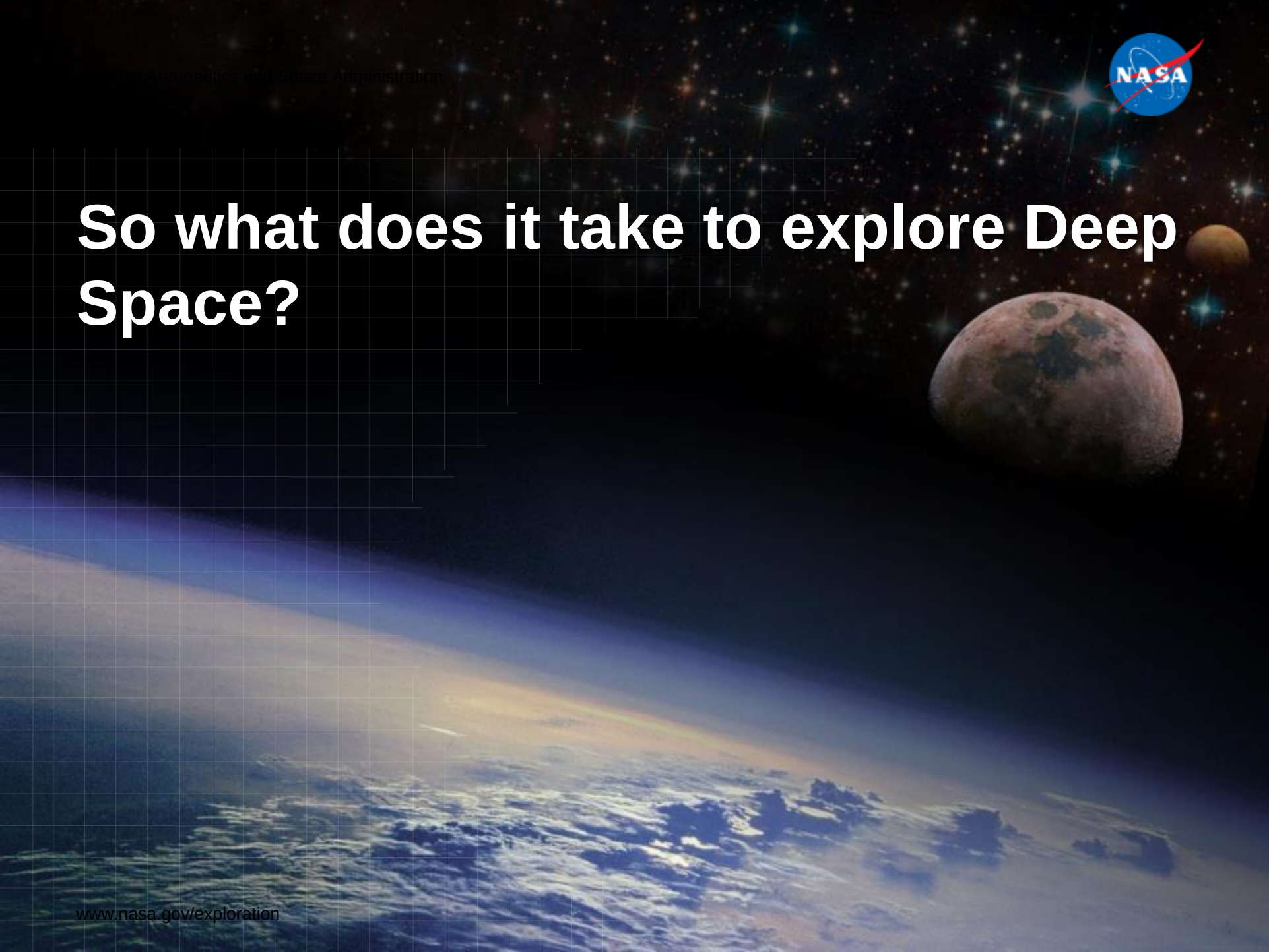
- 2-3 Year Mission
- Large technology gap exists
  - Both for Humans and Systems
- Large infrastructure required
- Will be International involvement
- Would be biggest risk, also biggest reward

Images Credit: The Martian/20th Century Fox

Proposed Mission - Red Dragon

- Red Dragon is a proposed unmanned SpaceX Dragon capsule for low-cost Mars lander
- Missions to be launched using Falcon Heavy rocket(s)
- These Mars missions will also be pathfinders for the much larger SpaceX Mars colonization architecture that will be announced in September 2016
- Certain level of engagement with NASA via Space Act Agreement

SpaceX's Red Dragon Mars Mission in Images



So what does it take to explore Deep Space?

Space Exploration Challenges…

- Who would you need on a deep space mission?

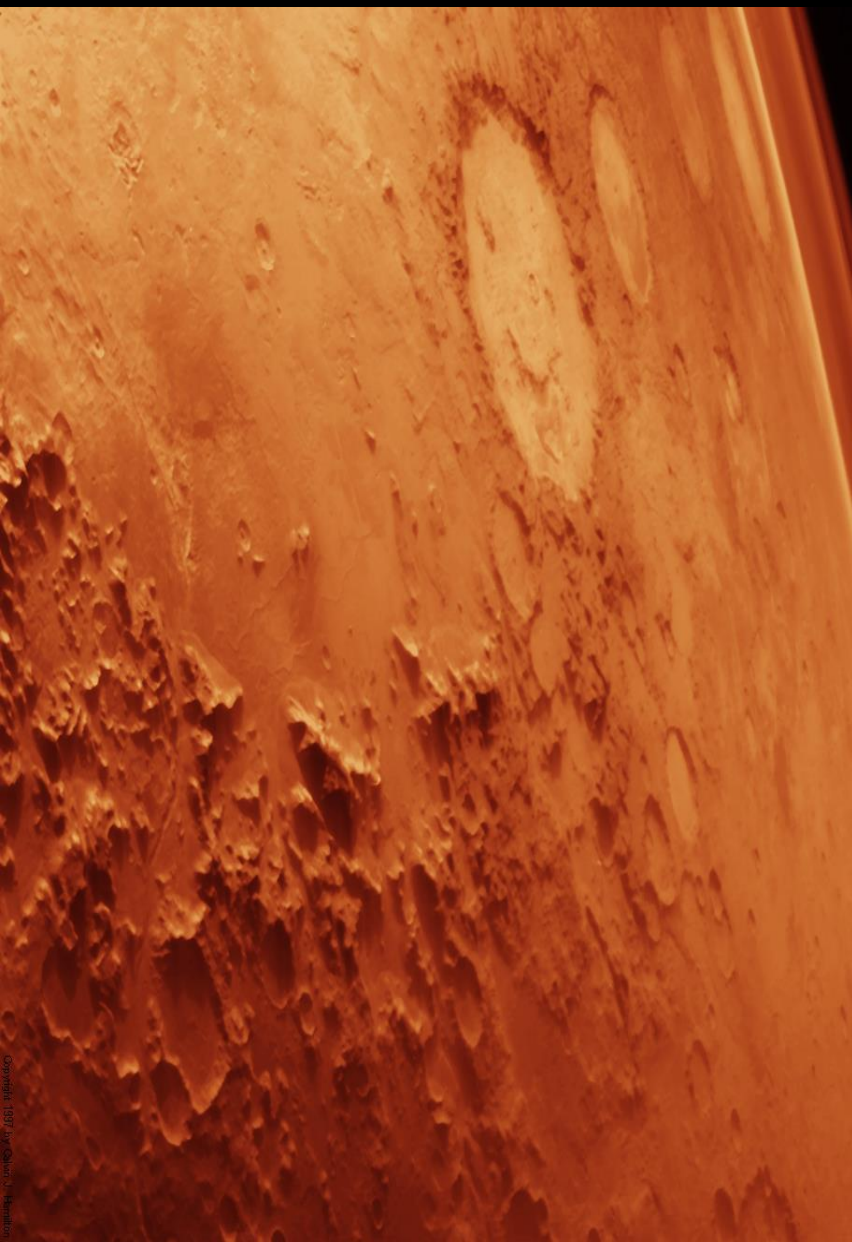
Standard for LEO today
- Pilot
- Scientist
- Engineer

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

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

20+ People???

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

Next Extraterrestrial Footprints – 2030?

- We left a lot of Human footprints on the moon…

Who will make that first human foot print on Mars?

Next Extraterrestrial Footprints – 2030?

Could be one of you!!

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

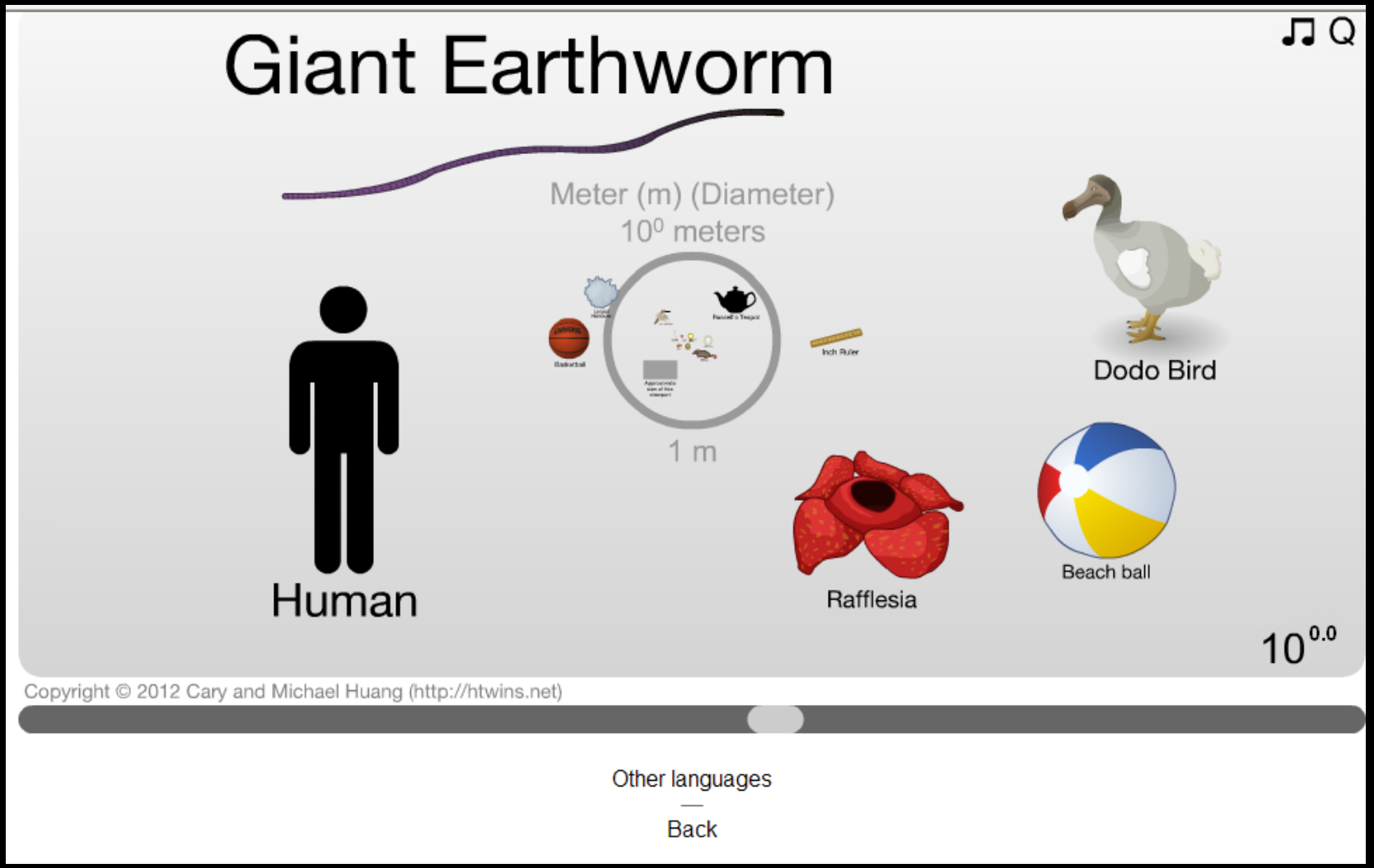
  http://htwins.net/scale2/?bordercolor=white
- ISSLive
  - http://spacestationlive.jsc.nasa.gov/
- Distance Learning Network
  - NASA DLN Website: http://www.nasa.gov/offices/education/programs/national/dln/index.html
  - Toolkit with Material and Templates: http://communications.nasa.gov/OCP/Communications%20Tool%20Kit/Presentation%20Templa

JPL – Eyes on the Solar System

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

Perspective -

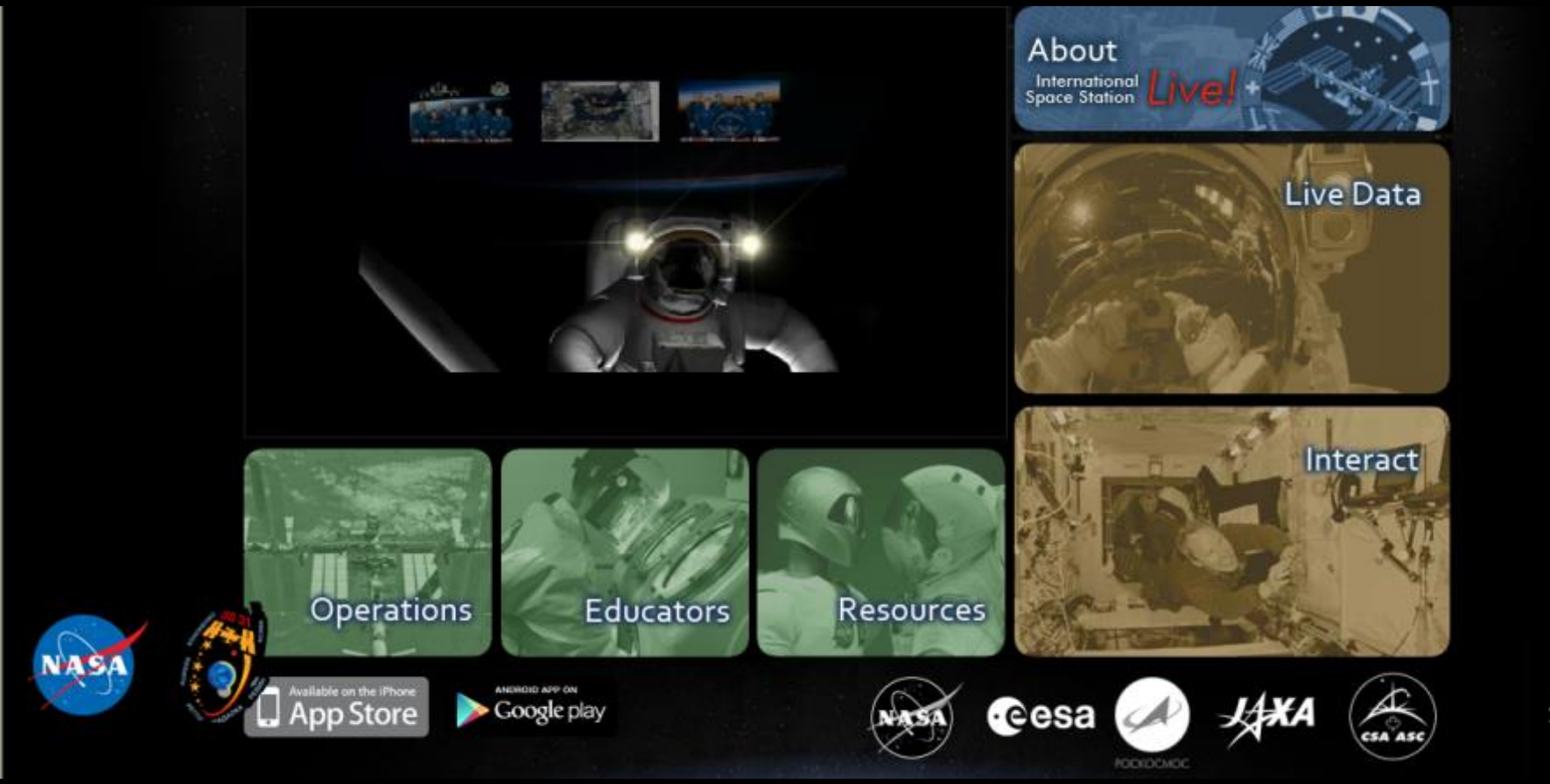
http://htwins.net/scale2/?bordercolor=white



ISS*Live*

ISSLive

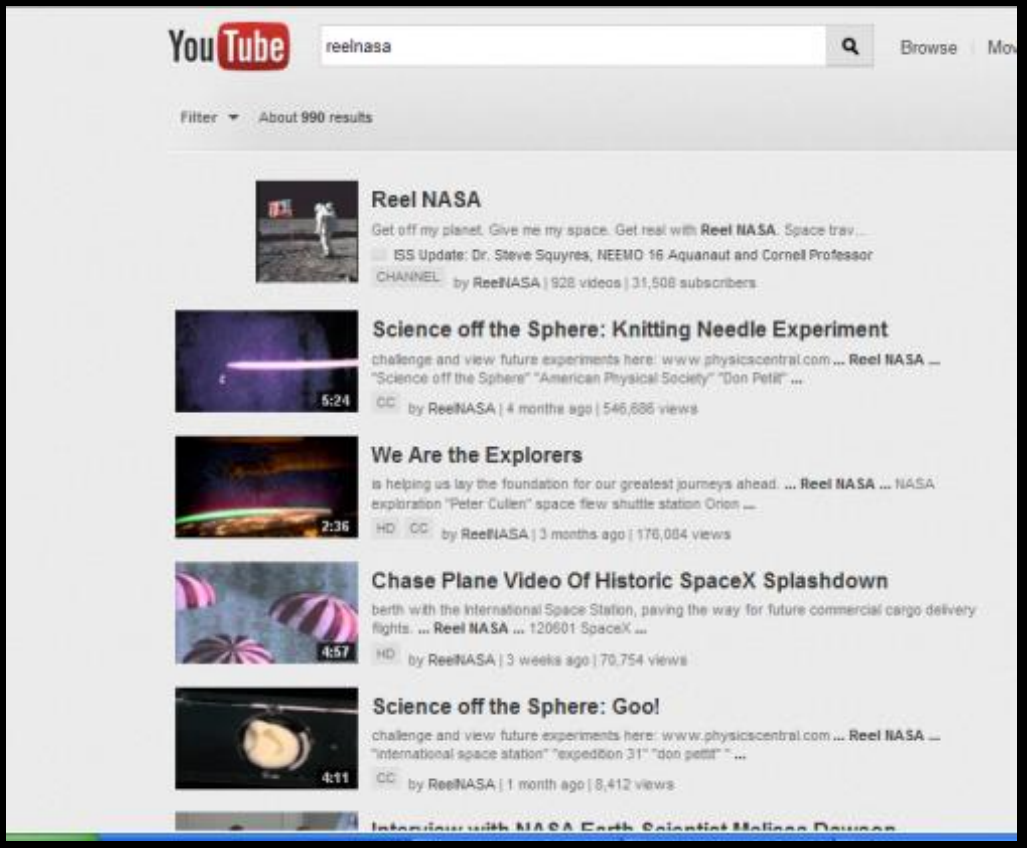
http://isslive.com/



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

NASA Exploration Technologies

High-Efficiency Space Power Systems: This project develops technologies to provide low-cost, abundant power for deep-space missions, including advanced batteries and regenerative fuel cells for energy storage, power management and distribution, solar power generation, and nuclear power systems. A major focus will be on the demonstration of dual-use technologies for clean and renewable energy for terrestrial applications.

Human Robotic Systems: This project develops advanced robotics technology to amplify human productivity and reduce mission risk by improving the effectiveness of human-robot teams. Key technologies include teleoperation, human-robot interaction, robotic assistance, and surface mobility systems for low-gravity environments. Early demonstrations will focus on human teams interacting with multiple robotic systems. Longer-term demonstrations will focus on enabling operations in remote, hostile environments with limited support from Earth.

› About Robonaut, NASA's dexterous humanoid robot

In-Situ Resource Utilization: This project will enable sustainable human exploration by using local resources. Research activities are aimed at using lunar, asteroid, and Martian materials to produce oxygen and extract water from ice reservoirs. A flight experiment to demonstrate lunar resource prospecting, characterization, and extraction will be considered for testing on a future robotic precursor exploration mission. Concepts to produce fuel, oxygen, and water from the Martian atmosphere and from subsurface ice will also be explored.

› About in-situ resource utilization (ISRU) field testing in Mauna Kea, Hawaii

Life Support and Habitation Systems: This project develops technologies for highly reliable, closed-loop life support systems, radiation protection technology, environmental monitoring and control technologies, and technologies for fire safety to enable humans to live for long periods in deep-space environments.

Lightweight Spacecraft Materials and Structures: This project develops advanced materials and structures technology to enable lightweight systems to reduce mission cost. Technology development activities focus on structural concepts and manufacturing processes for large composite structures and cryogenic propellant tanks for heavy lift launch vehicles, and on fabric materials and structural concepts for inflatable habitats.

http://www.nasa.gov/exploration/technology/

NASA Exploration Technologies

Advanced In-Space Propulsion: This project develops concepts, technologies, and test methods for high-power electric propulsion and nuclear thermal propulsion systems to enable low-cost and rapid transport of cargo and crew beyond low Earth orbit.

Autonomous Systems and Avionics: This project develops and demonstrates integrated autonomous systems capable of managing complex operations in space to reduce crew workload and dependence on support from Earth. Technologies will address operations in extreme environments, efficient ground-based and on-board avionics systems and operations, and cost-effective human-rated software development.

Cryogenic Propellant Storage and Transfer: This project develops technologies to enable long-duration storage and in-space transfer of cryogenic propellants. Technology development includes active cooling of propellant tanks, advanced thermal insulation, measurement of propellant mass, liquid acquisition devices, and automated fluid couplings for propellant transfer between vehicles.

Entry, Descent, and Landing (EDL) Technology: This project develops advanced thermal protection system materials, aerothermodynamics modeling and analysis tools, and concepts for aerocapture and atmospheric entry systems for landing large payloads safely and precisely on extra-terrestrial surfaces and returning to Earth.

› Read about the Mars Science Laboratory Entry, Descent, and Landing Instrument (MEDLI) Suite

Extravehicular Activity Technology: This project develops component technologies for advanced space suits to enable humans to conduct "hands-on" surface exploration and in-space operations outside habitats and vehicles. Technology development includes portable life support systems, thermal control, power systems, communications, avionics, and information systems, and space suit materials.

http://www.nasa.gov/exploration/technology/

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