

# US Spacewalks – Past, Present and Future of American EVAs

Sandy Fletcher  
ExtraVehicular Activities (EVA) Operations Branch  
Johnson Space Center  
New England Fall Astronomy Festival  
17 October 2014



# The Beginning

April 12, 1961 – Yuri Gagarin, first spaceflight

May 5, 1961 – Alan Shepard, 1<sup>st</sup> American suborbital flight

May 25, 1965 – President Kennedy addresses Congress:

"I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to Earth."

The Mercury flights demonstrated that humans could survive and function in microgravity.

Gemini flights demonstrated capabilities needed for the Moon Landing program – long duration flight, rendezvous, docking and EVA

# Mercury Flight Suit

- Modified US Navy high altitude pressure suit
- Worn for entire flight (15min – 34 hours)
- Inner Layer of Neoprene-coated nylon
- Outer layer – aluminized nylon
- Helmet, gloves and boots were separate.



# Gemini Flight Suit

- Modified US Air Force high altitude pressure suit
- Worn for entire flight (10 hours – 14 days)
- More layers for thermal and micrometeoroid protection
- Gold visor for UV protection
- Helmet, gloves and boots were separate.



NASA-S-65-4970

# GEMINI EXTRAVEHICULAR SPACE SUIT



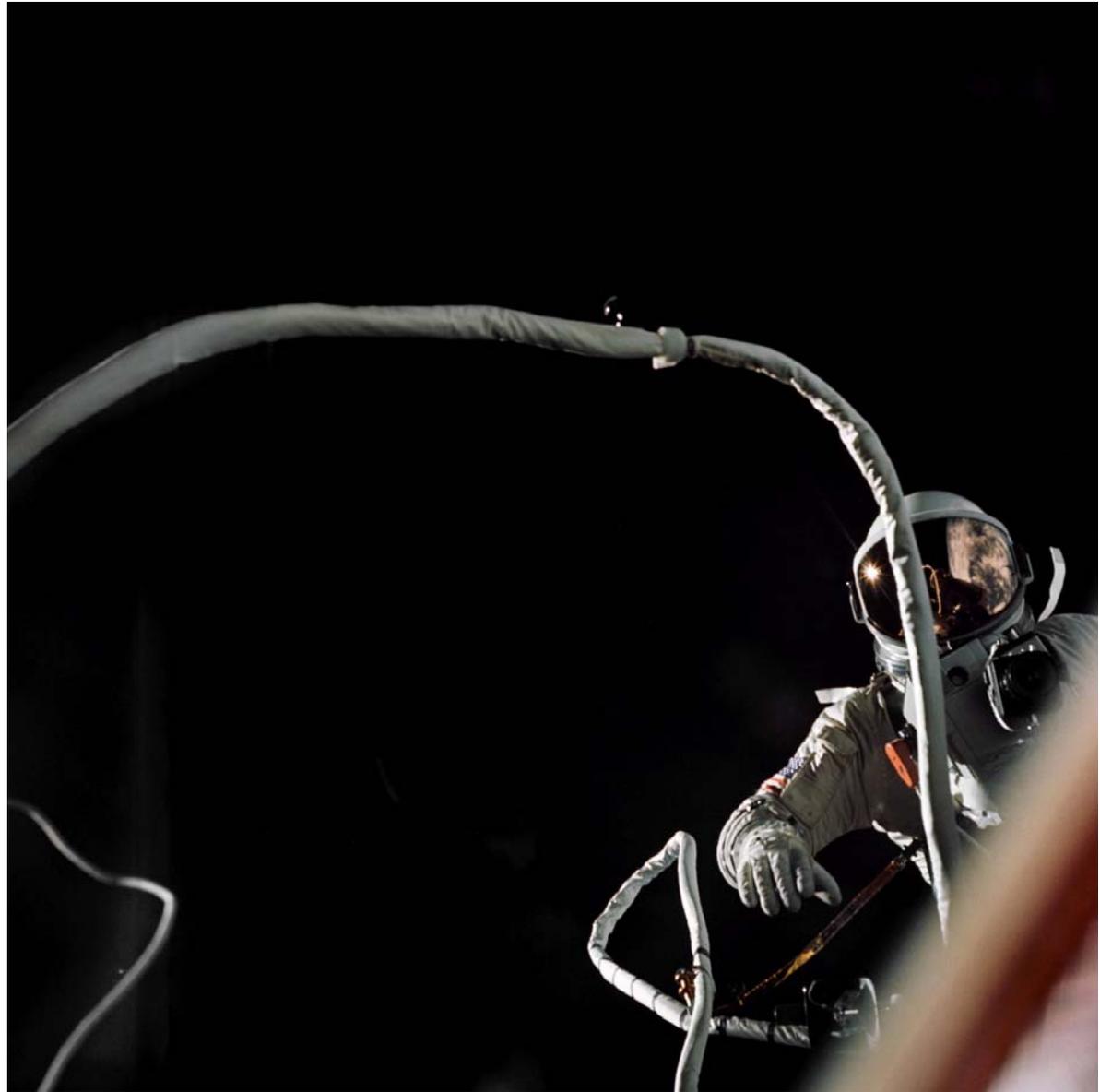
# First Spacewalks

- March 18, 1965 – Alexei Leonov, 1<sup>st</sup> spacewalk
  - Duration 24 minutes
- June 3, 1965 – Ed White, 1<sup>st</sup> American Spacewalk
  - Gemini 4 Crew: James McDivitt, Ed White
  - Spacewalk duration: 36 minutes
  - Depressurized entire Gemini capsule
  - Life support provided by 25 foot umbilical, also comm and biomed data
  - Also contained a load-alleviating tether
  - Hand-Held Maneuvering Unit providing 20 seconds of compressed oxygen as propellant



# Gemini IX

- Tom Stafford, Gene Cernan
- June 5, 1966
- EVA Duration: 2:09
- Had extreme difficulties with the tether, fighting to maintain body position
- Overheated, helmet fogged so badly he couldn't see
- Found out later he had torn his spacesuit down to the last pressure layer.
- Lead to pool training for all future EVAs.



# Gemini 10 – John Young, Michael Collins

- Two EVAs
  - One Stand-up EVA for color photographs (0:49)
  - One EVA to translate between two non-docked spacecraft (0:39)
    - Use of antifog material for both crews' helmets
- Collins' feedback:

“without some sort of handholds or restraining devices, a large percentage of the astronaut's time is. . . devoted to torquing his body around until it is in the proper position to do some useful work.”
- Young's feedback:

“There was no way if anything happened to somebody going outside a Gemini that you could get them back in.” The seat was too narrow and the pressure suit too stiff to put an EVA astronaut into the cockpit without his cooperation.

# Gemini XI

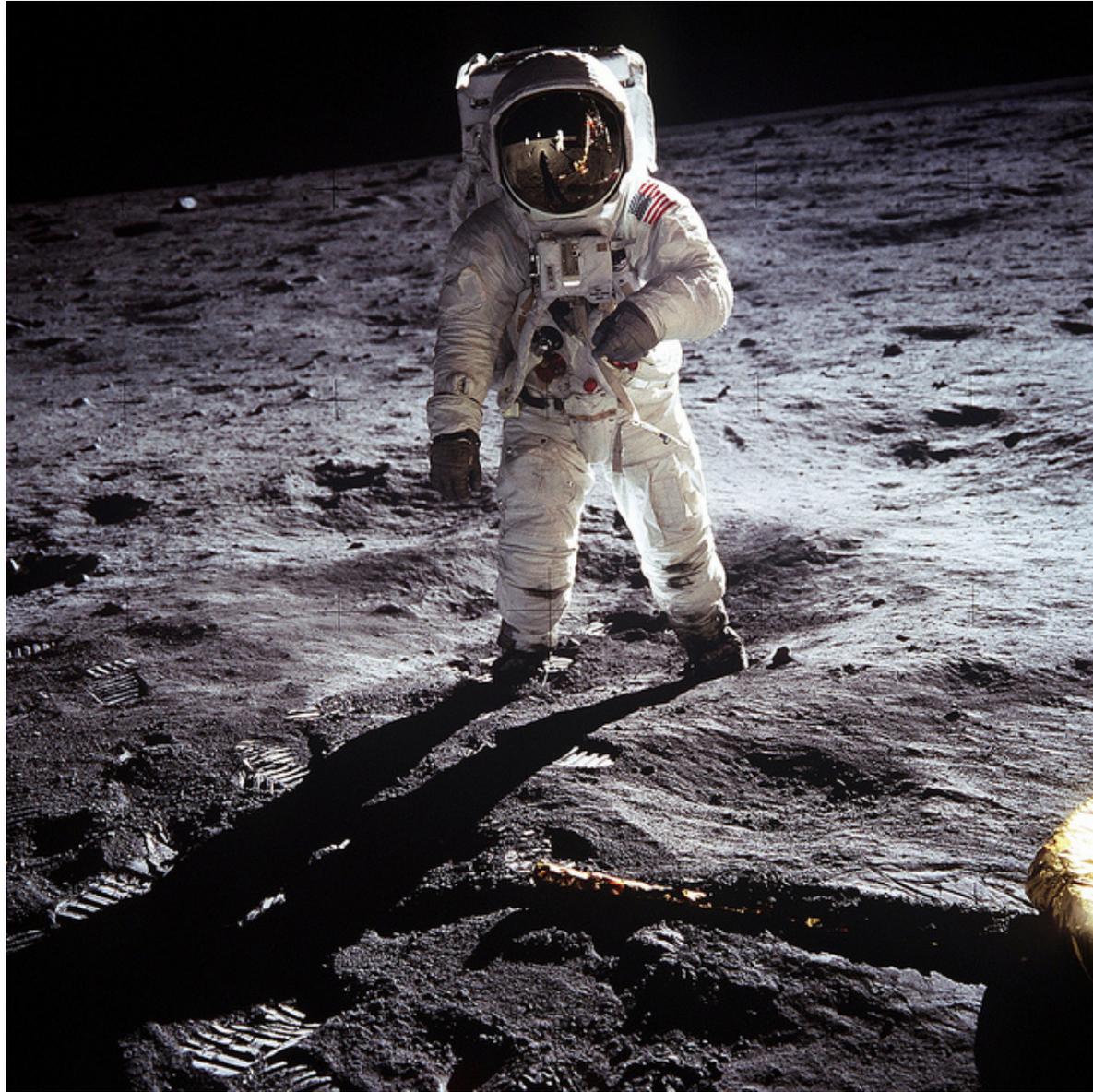
- Pete Conrad, Dick Gordon
- September 13, 1966
- EVA Duration: 0:38
- Overheated prior to EVA
- September 14, 1966
- EVA Duration: 2:08
- Astronomy/Earth photography
- No issues



# Complex EVA Success – Gemini XII

- Jim Lovell, Buzz Aldrin
- 12 November 1966
- EVA Duration: 2:18
- Astronomy and Earth photography
- 13 November 1966
- EVA Duration: 2:09
- Fluid and electrical connectors, tightened bolts
- 14 November 1966
- EVA Duration: 1:11
- Astronomy photography





# Moonwalk Training

- Apollo EVAs were fundamentally different than Gemini
  - Used legs for locomotion – required more waist, hip, knee flexibility
  - 1/6<sup>th</sup> Earth's gravity- items would drop not float away
  - Lunar dust is abrasive and sticks to everything
  - Higher metabolic rates
- Still used pool, vacuum chamber
- “Rock Pile” at Manned Space Center to mimic lunar surface
- Trained full duration EVAs in suits using lunar tools to build endurance



# Apollo 11 - 18

- Twelve men walked on the Moon between 1969 - 1972
- 15 lunar EVAs
- 3 EVAs to retrieve external camera film
- 160 hours on the lunar surface
  - Longest EVA was 7:37
- Difficulties encountered
  - Drink bags failed to dispense
  - Fingertip pain
  - Significant hand fatigue
  - Excessive spinal growth in microgravity led to suit fit issues



# Skylab

- 1973 - 1974
- First Space Station Repair – deploying the second solar array.
- 10 EVAs, totaling 41 hours



# Space Shuttle Suits



Advanced Crew Escape Suits



ExtraVehicular Mobility Unit (EMU)

# Space Shuttle EVAs

- Depress Shuttle to 10.2 psia
- Mixed nitrogen/oxygen environment
- EMUs pressurized to 4.3 psid
- 6-7 crew, so had specialist astronauts
- EV crew would develop their EVAs
- Extensive practice in pool facilities, train right up to launch



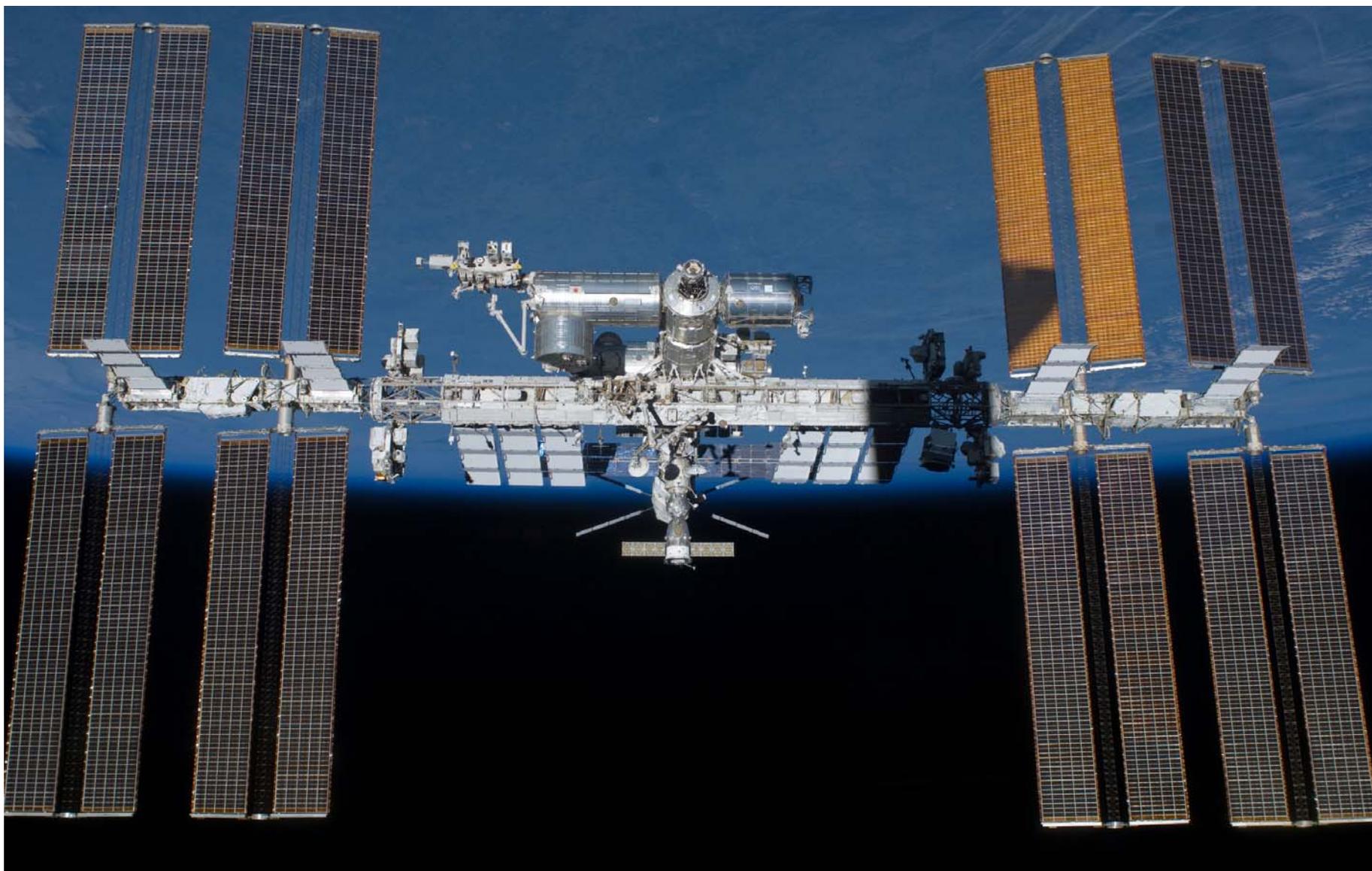


# 5 Hubble Servicing Missions

- STS-61 – 5 EVAs
- STS-82 – 5 EVAs
- STS-103 – 3 EVAs
- STS-109 – 5 EVAs
- STS-125 – 5 EVAs



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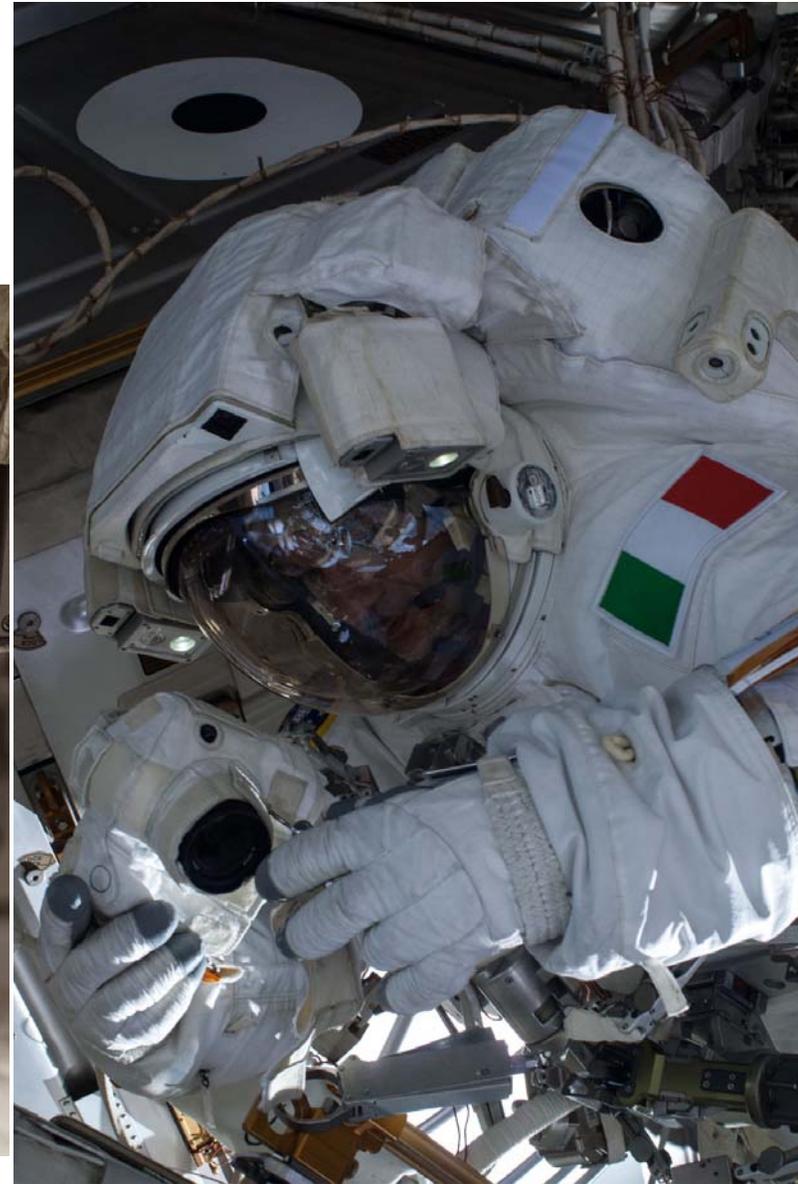


# Expedition/ISS EVAs – A New Approach

- Training changed from specific Tasks (end-to-end planned EVAs) to generic skills based.
- No longer have specialized EVA crew. ISS crews are 3 people, 6 on orbit at a time. All crew must be trained how to perform repair EVAs.
- All crew undergo extensive training in the US and Russia, with additional training in Canada, Japan and Europe.
- EMUs are no longer flying up/down on Shuttle. They remain on ISS for up to 6 years and have to be maintained and/or repaired on orbit.

# US EVA 23

## Cassidy and Parmitano



# What Did We Learn?

- Water behaves very differently in microgravity than expected
  - The EMU fan was not strong enough to push the water from the back of the helmet across the visor and down into the suit – instead the water pooled.
  - The airflow within the helmet was insufficient to overcome the surface tension between water and skin.
- Nothing in the EMU data indicating the severity of the situation
- EMU failure history may be misleading because using the suits in a new way – leaving them on orbit for extended periods of time rather than refurbishing them after each Shuttle mission
- The EVA community devised troubleshooting plans to determine the cause and crew on orbit were able to replace hardware components with little/no ground training.

## Upcoming ISS EVAs

- Just completed two EVAs, with additional EVAs anticipated in early 2015.
- Several EVAs coming up over the next few years to prepare ISS for commercial vehicle docking and to replace hardware, including the ISS Batteries which store any excess solar energy
- Always prepared for EVA response to ISS failures

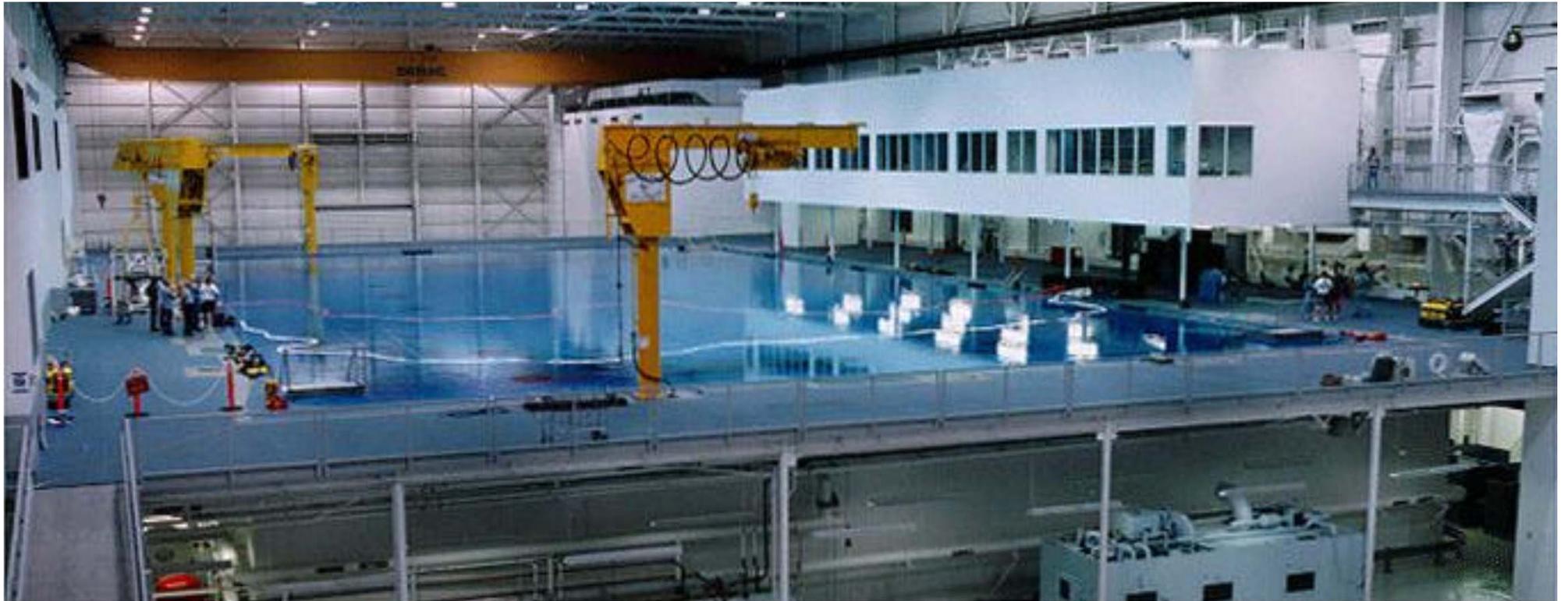
## Longer Term Future

- Evaluate effects of extended reduced ambient pressures to minimize prebreathe.
- Suit development should consider repair/replacement of parts.
- Current suit cooling only functional at vacuum – won't work on Mars.

# The Next Generation SpaceSuits are in Work



# Neutral Buoyancy Laboratory (NBL)



# Space Vehicle Mockup Facility (SVMF)









# Additional Sources

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    - Barton Hacker, James Grimwood
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- *Last Man on the Moon* by Eugene Cernan
- *Carrying the Fire* by Michael Collins