Extravehicular Activity (EVA) 101

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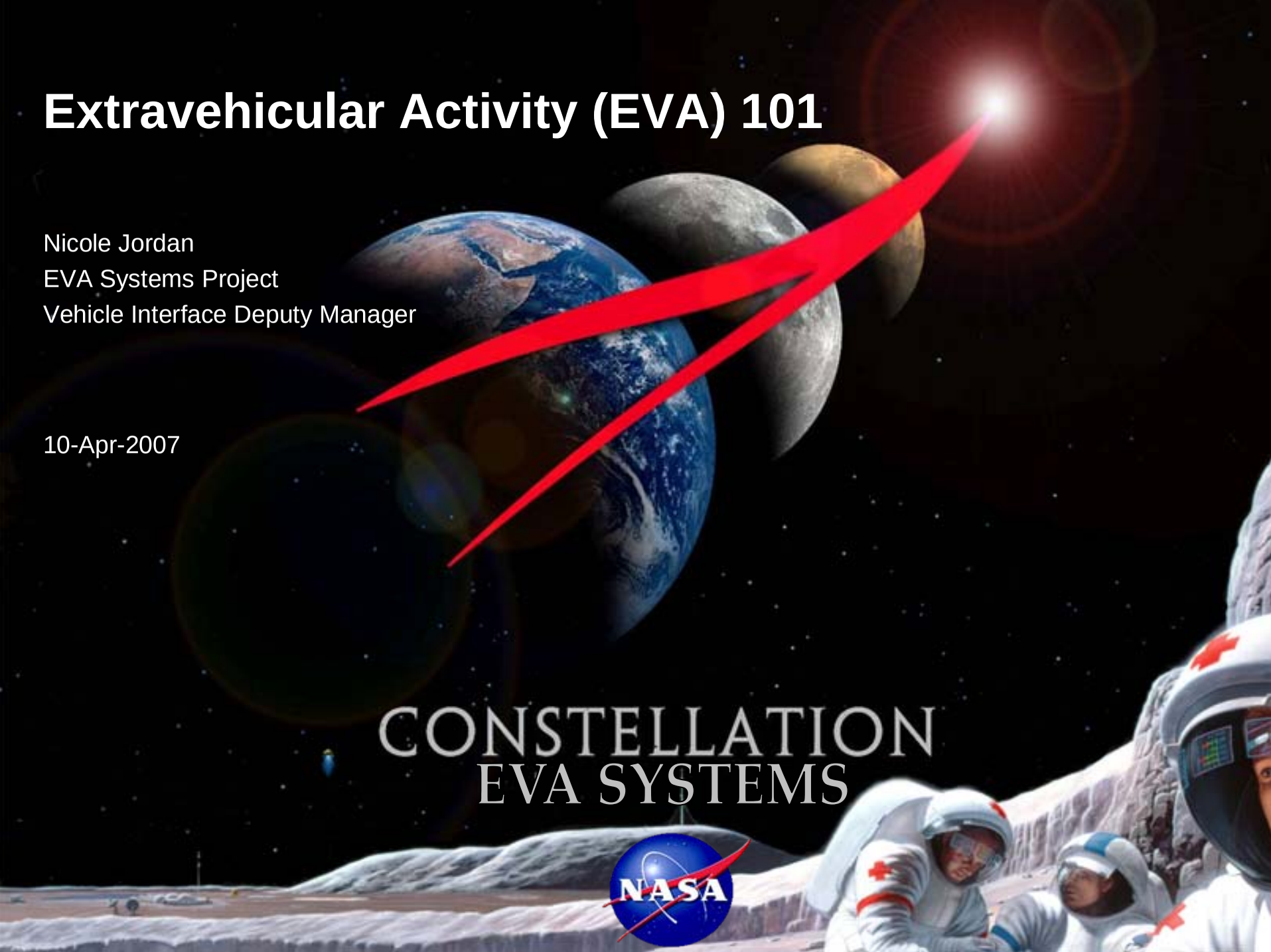
10-Apr-2007



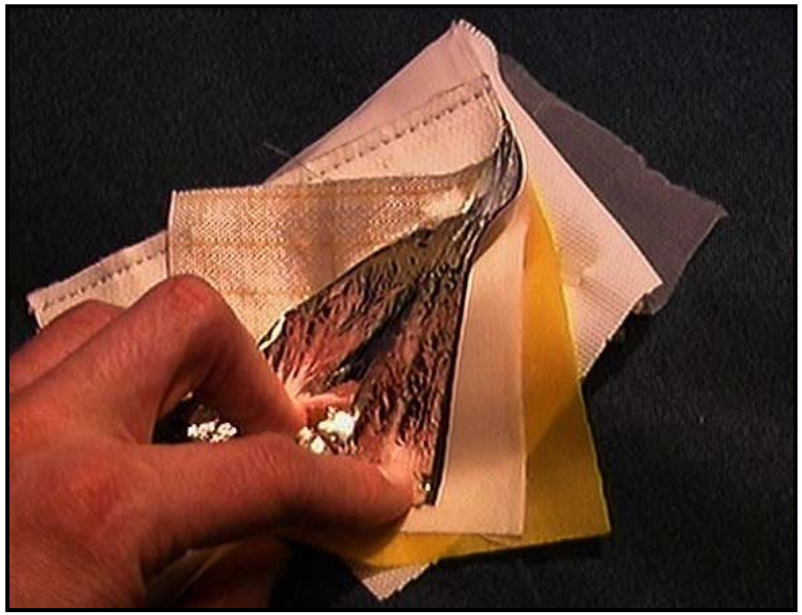
Agenda

- **Introduction to space suits and crew survival**
- **Brief history of space suits and EVA**
- **Overview of the Constellation EVA System**
- **Opportunities for students and faculty to work with NASA**

Why do we need space suits?

- **Sustain the life of the crewmember**
  - Protection from the environment
  - Life support (metabolic & cooling)
  - Hydration, nutrition, & medication
  - Waste management
- **Mobility / Dexterity**
  - Transition to/from the worksite
  - Stabilize at the worksite
  - Perform necessary tasks (w/gloved hand or tools)
- **Visibility / Communication**
  - Ability to get ‘eyes on’
  - Communication of voice and data

Protection From the Environment



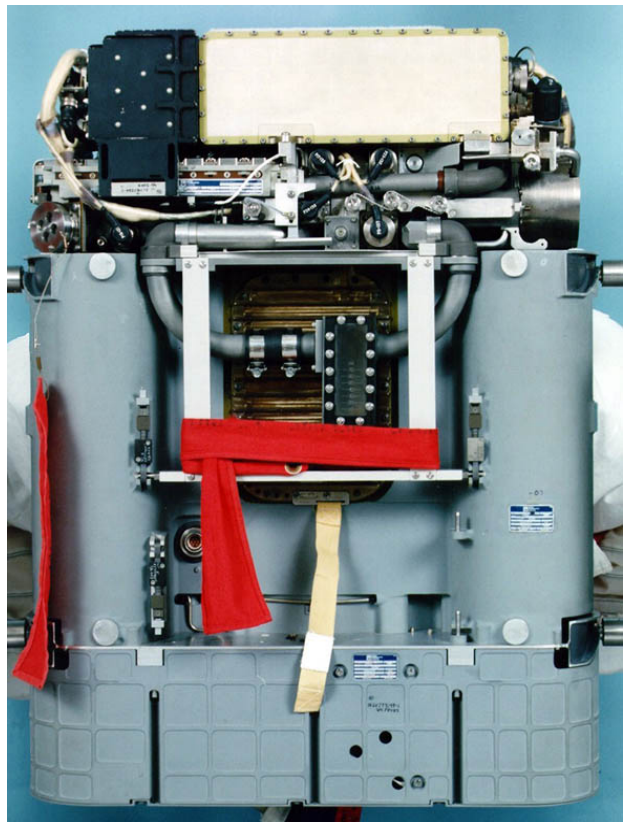
Innermost

Outermost

- **Pressure Garment Bladder**
- **Pressure Garment Cover-Restraint**
- **Thermal Micrometeoroid Garment (TMG) Liner**
- **TMG Thermal Insulation**
- **TMG Cover**

Primary Life Support System (PLSS)

- Provides primary and emergency oxygen
- Suit pressurization
- Carbon Dioxide removal
- Cooling Water
- Power (battery)



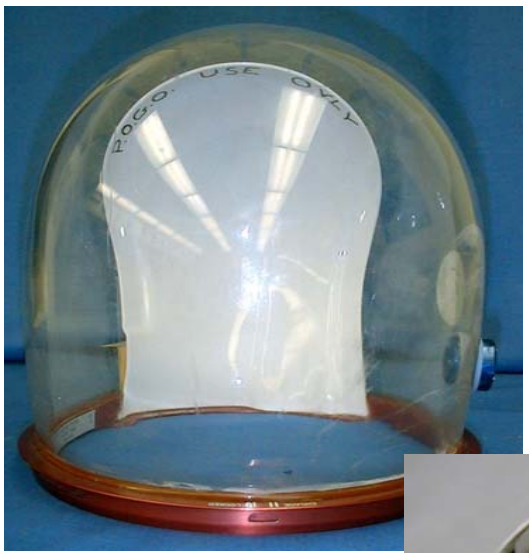
Thermal Control

- **Liquid Cooling and Ventilation Garment (LCVG)**
- **Conformal garment to maintain body temperature**
- **Ethylene vinyl acetate tubing woven through spandex restraint cloth**

Communications

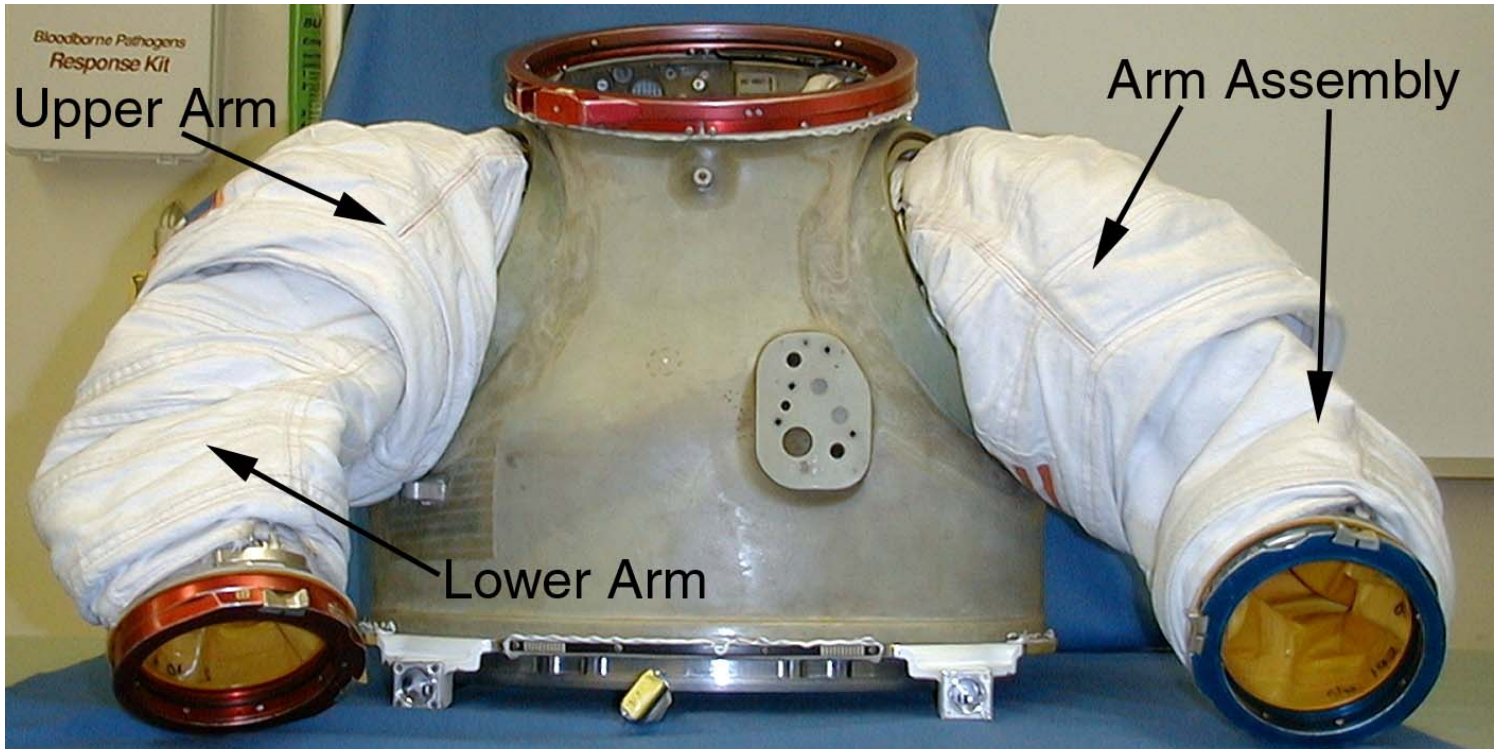
- **Communications Carrier Assembly (CCA) aka “Snoopy Cap”**
- **Contains redundant microphones and headphones for communication and caution and warning tones**

Helmet and Extravehicular Visor Assy



- **Pressure vessel for the head**
- **Visor provides visual, thermal, impact, and micrometeoroid protection in space**

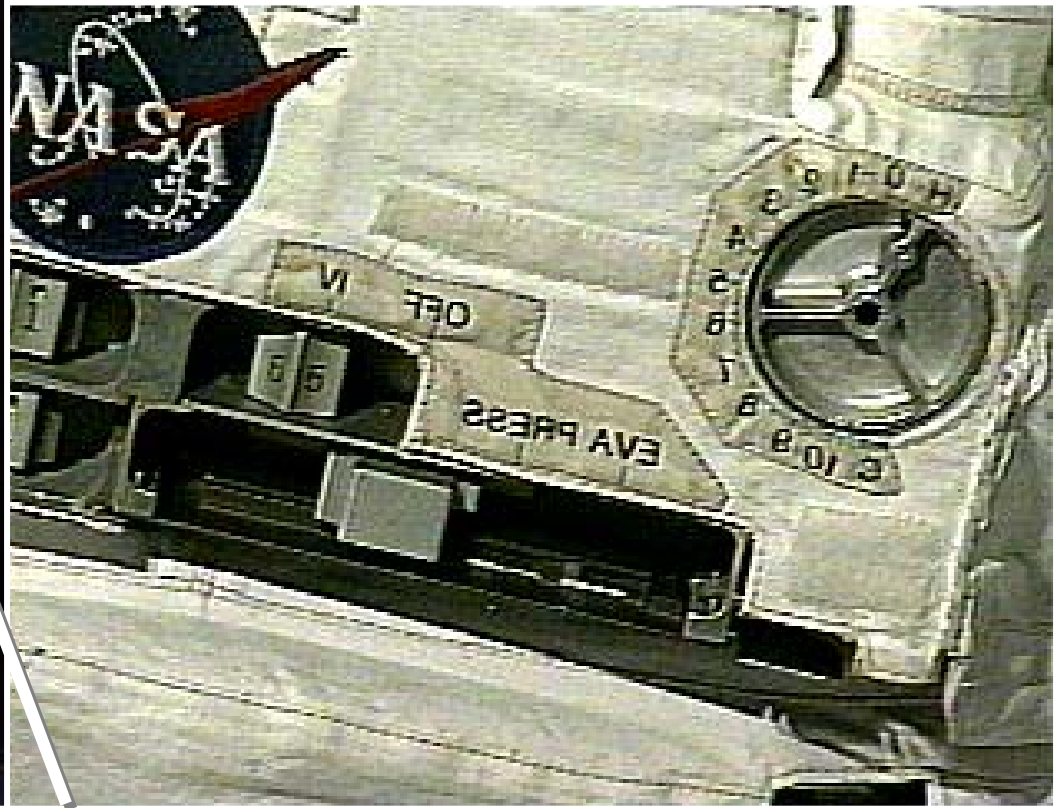
Hard Upper Torso (HUT) and Arm Assy



- **Structural mounting interface**
- **Contains shoulder joints, upper arm bearings, elbow joints, and wrist bearings permitting joint mobility**

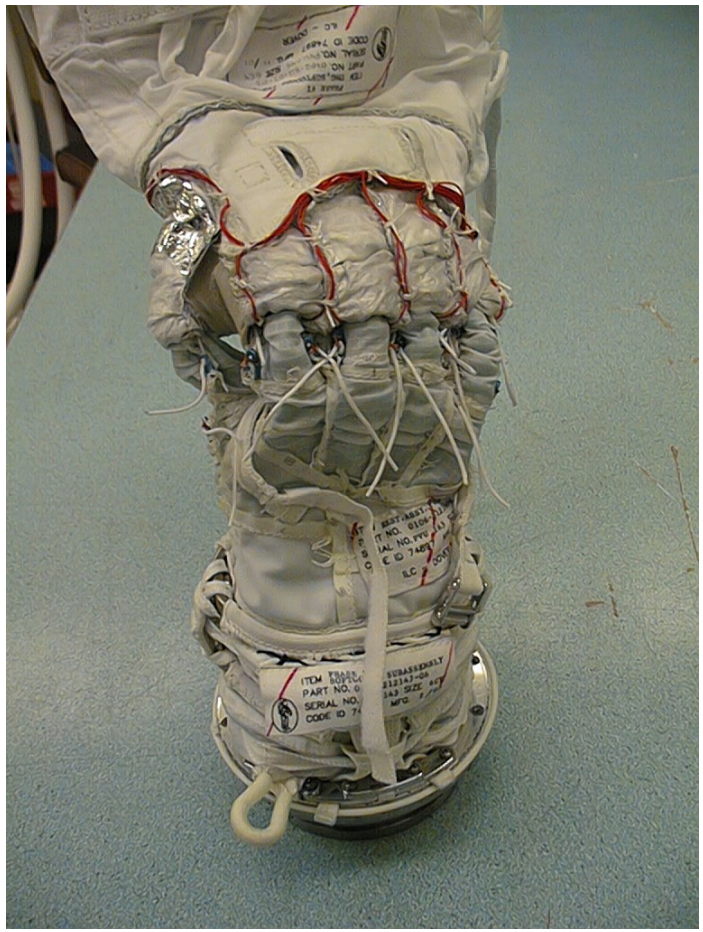
Display and Controls Module (DCM)

- **Electrical and mechanical controls for EVA crewmember to operate EMU**

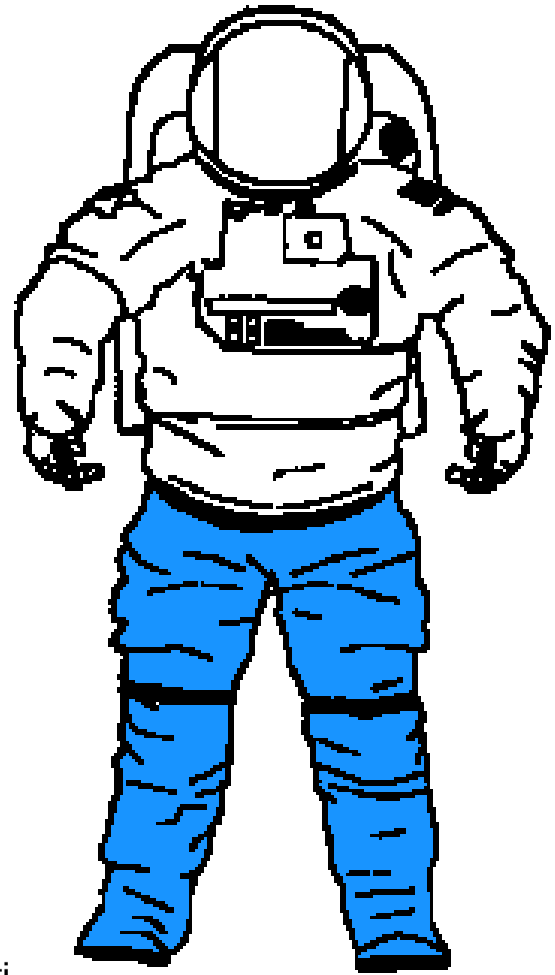


Gloves

- **Active interface between crewmember and work being performed**



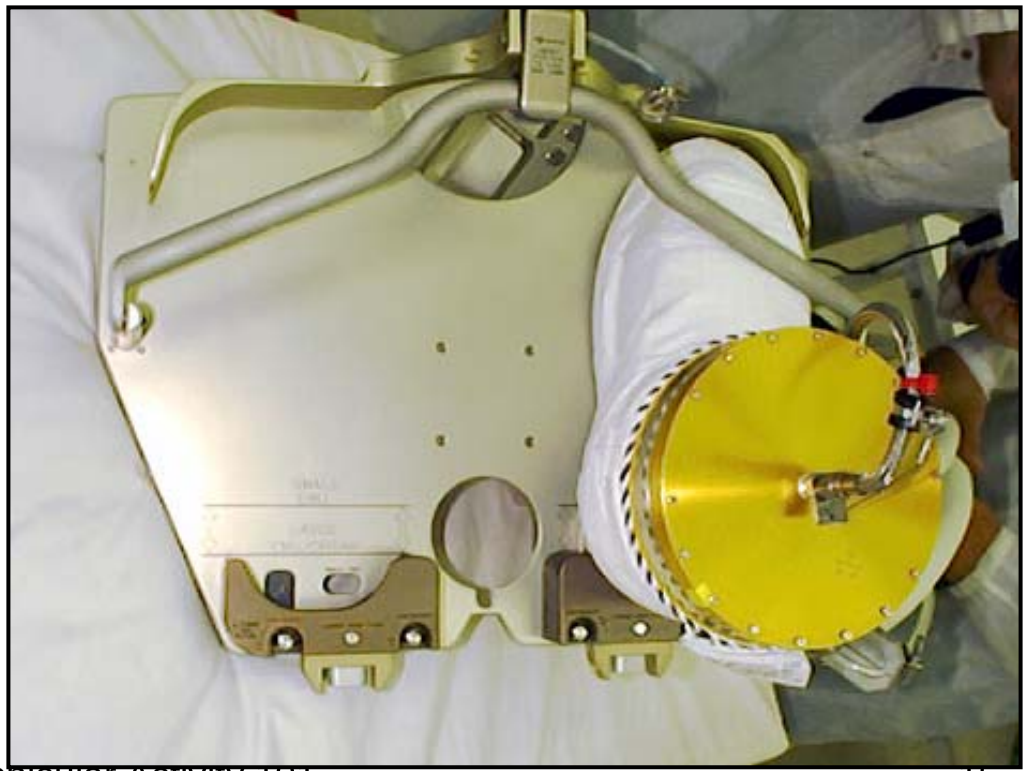
Lower Torso Assembly (LTA)



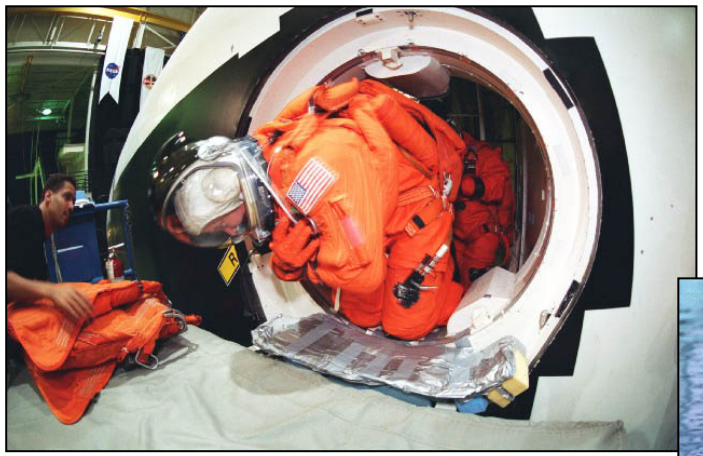
What Size Do You Need?

Boot and Sizing Insert

Boot Heel Clip and Foot Restraint



Crew Escape Suit



- Used during launch and landing

Advanced Crew Escape Suit

- **Crew Escape Functions**
  - Cold Water Protection
  - Occupant Protection
  - Bailout
  - Fire and Chemical Protection
  - Pressure Protection

Nominal & Off-Nominal Landing

- **Nominal landing scenario is on land with full assistance by ground ops recovery forces**
  - Crew would likely stay suited through transport (cooling services provided)
- **Off-nominal scenarios:**
  - Land-landing not at the designated site
  - Water-landing

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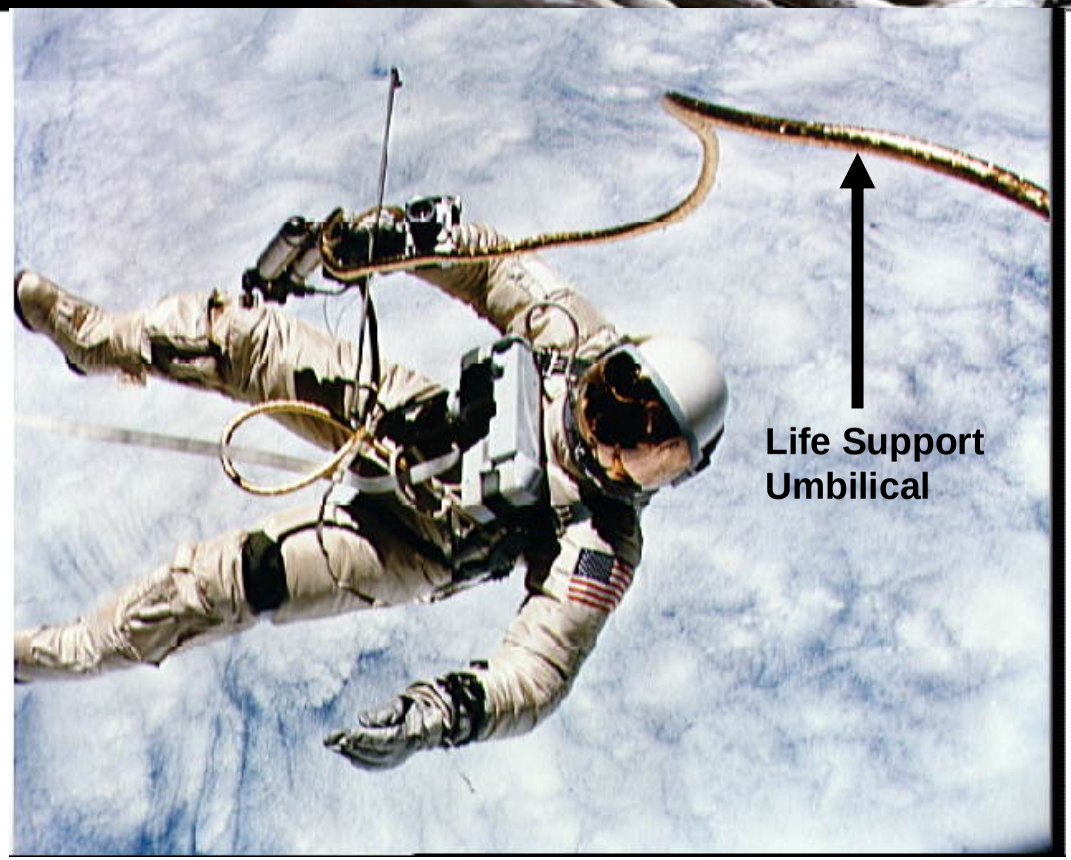
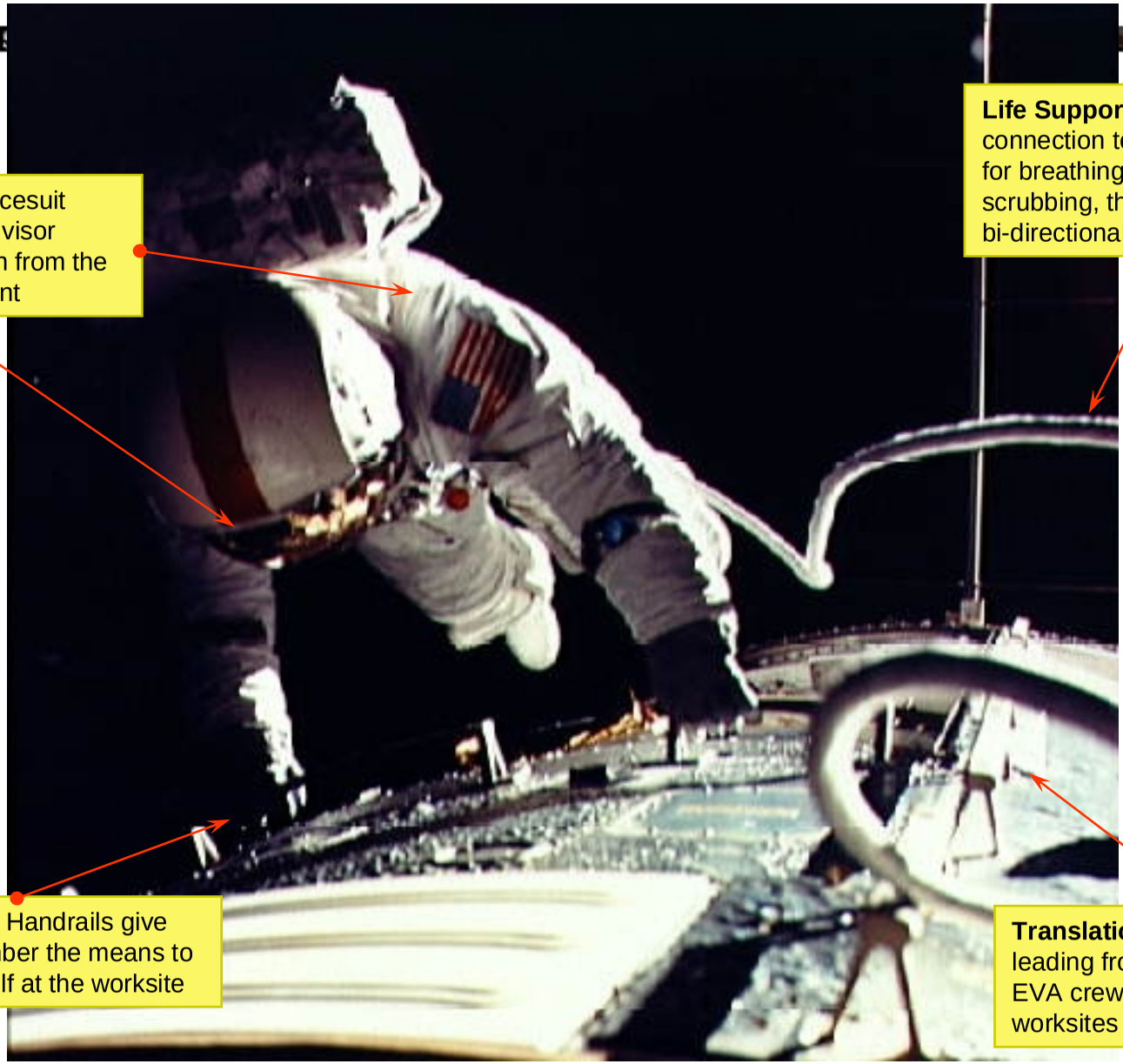
Gemini Program (mid-1960s)

- **Umbilicals provided O2 for breathing, suit pressurization, & ventillation (cooling and CO2 removal)**
- **Also provided power, comm, & biomedical sensor wiring, and a restraint tether.**
- **~25 feet in length.**
- **Problem: O2 purge flow cooling was inadequate for keeping the astronaut cool during EVA activity. Also, hard to manage the umbilical length during EVA and re-stowage.**



Astronaut Ed White makes the first US EVA during Gemini IV on June 3, 1965 on umbilical flow (36 minute EVA duration).

Apollo EVA on Service Module



Protection: Spacesuit TMG and helmet visor provide protection from the space environment

Life Support: Umbilical connection to spacecraft ECLSS for breathing gas supply, CO2 scrubbing, thermal control, and bi-directional data/voice

Stabilization: Handrails give EVA crewmember the means to stabilize himself at the worksite

Translation Path: Handrails leading from the hatch allow EVA crewmember safely reach worksites

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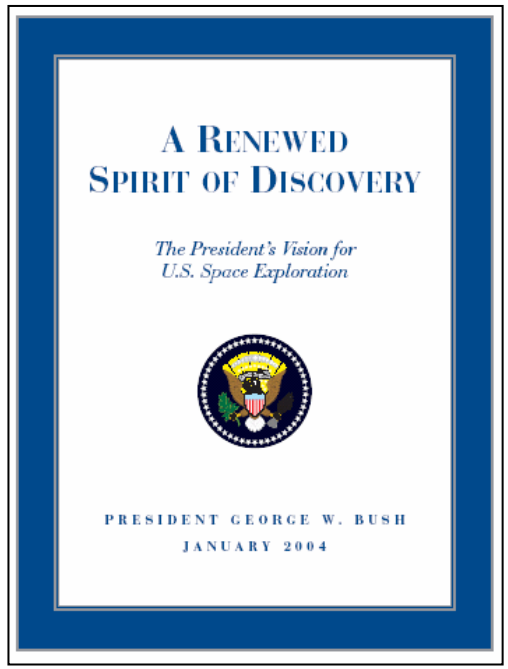
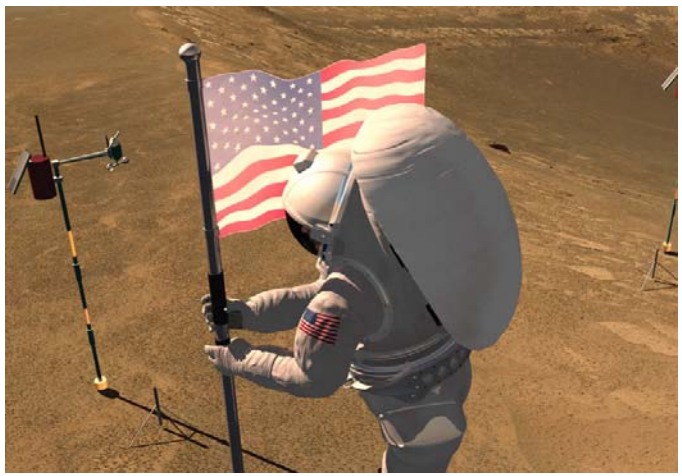
A Bold Vision for Space Exploration, Authorized by Congress

- **Complete the International Space Station**
- **Safely fly the Space Shuttle until 2010**
- **Develop and fly the Crew Exploration Vehicle no later than 2014**
- **Return to the Moon no later than 2020**
- **Extend human presence across the solar system and beyond**
- **Implement a sustained and affordable human and robotic program**
- **Develop supporting innovative technologies, knowledge, and infrastructures**
- **Promote international and commercial participation in exploration**





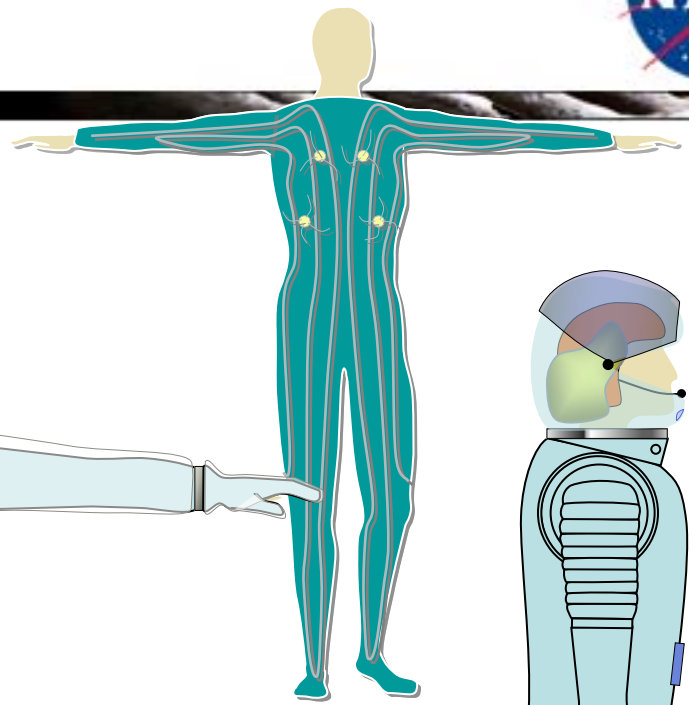
NASA Authorization Act of 2005

The Administrator shall establish a program to develop a sustained human presence on the Moon, including a robust precursor program to promote exploration, science, commerce, and U.S. preeminence in space, and as a stepping stone to future exploration of Mars and other destinations.

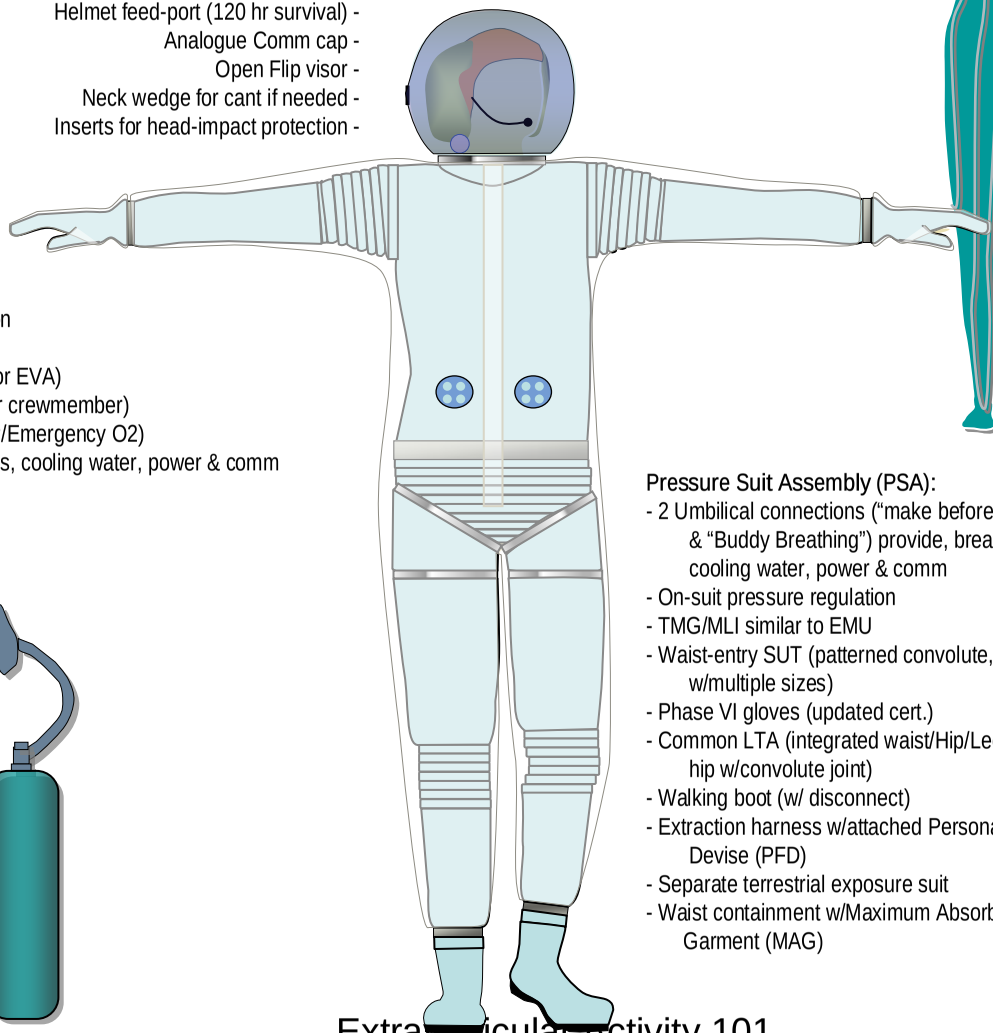
EVA System Missions

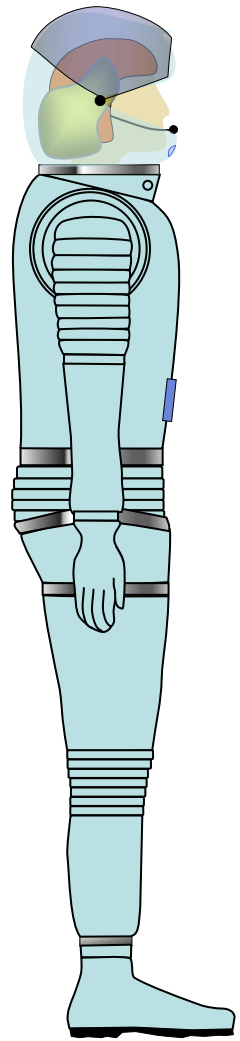
- **Launch / Entry / Abort**
  - Nominal launch operations (suit-up, transfer to pad, vehicle ingress, launch through post-insertion, rndz/dock)
  - Launch aborts (on the pad, in-flight)
  - Orbit operations (crew suits up as precaution for dynamic phases of flight)
  - Survival in an unpressurized cabin (up to ~120 hours)
  - Post-landing operations (nominal, off-nominal, water/land)
- **Microgravity EVA**
  - Contingency & Unscheduled EVA in LEO, LLO or in-between
- **Surface EVA**
  - Outpost Build-up
  - Exploration
  - Science

Configuration 1
LEA/0-g

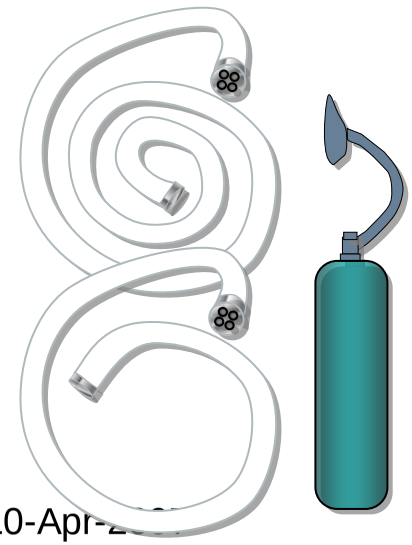


Enhanced Helmet hardware:
TMG (Cont. EVA) -
Helmet feed-port (120 hr survival) -
Analogue Comm cap -
Open Flip visor -
Neck wedge for cant if needed -
Inserts for head-impact protection -





Umbilicals & SOP:
- Universal Umbilical connectors on Umbilicals & vehicles
- Long, Closed-loop Umbilical (2 for EVA)
- Short, Closed-loop Umbilical (per crewmember)
- Secondary Oxygen Supply (SOP/Emergency O2)
- Umbilicals provide breathable gas, cooling water, power & comm
- Umbilical provide tether function



Pressure Suit Assembly (PSA):
- 2 Umbilical connections ("make before break" & "Buddy Breathing") provide, breathable gas, cooling water, power & comm
- On-suit pressure regulation
- TMG/MLI similar to EMU
- Waist-entry SUT (patterned convolute, BSC w/multiple sizes)
- Phase VI gloves (updated cert.)
- Common LTA (integrated waist/Hip/Leg - bearing hip w/convolute joint)
- Walking boot (w/ disconnect)
- Extraction harness w/attached Personal Floatation Devise (PFD)
- Separate terrestrial exposure suit
- Waist containment w/Maximum Absorbency Garment (MAG)

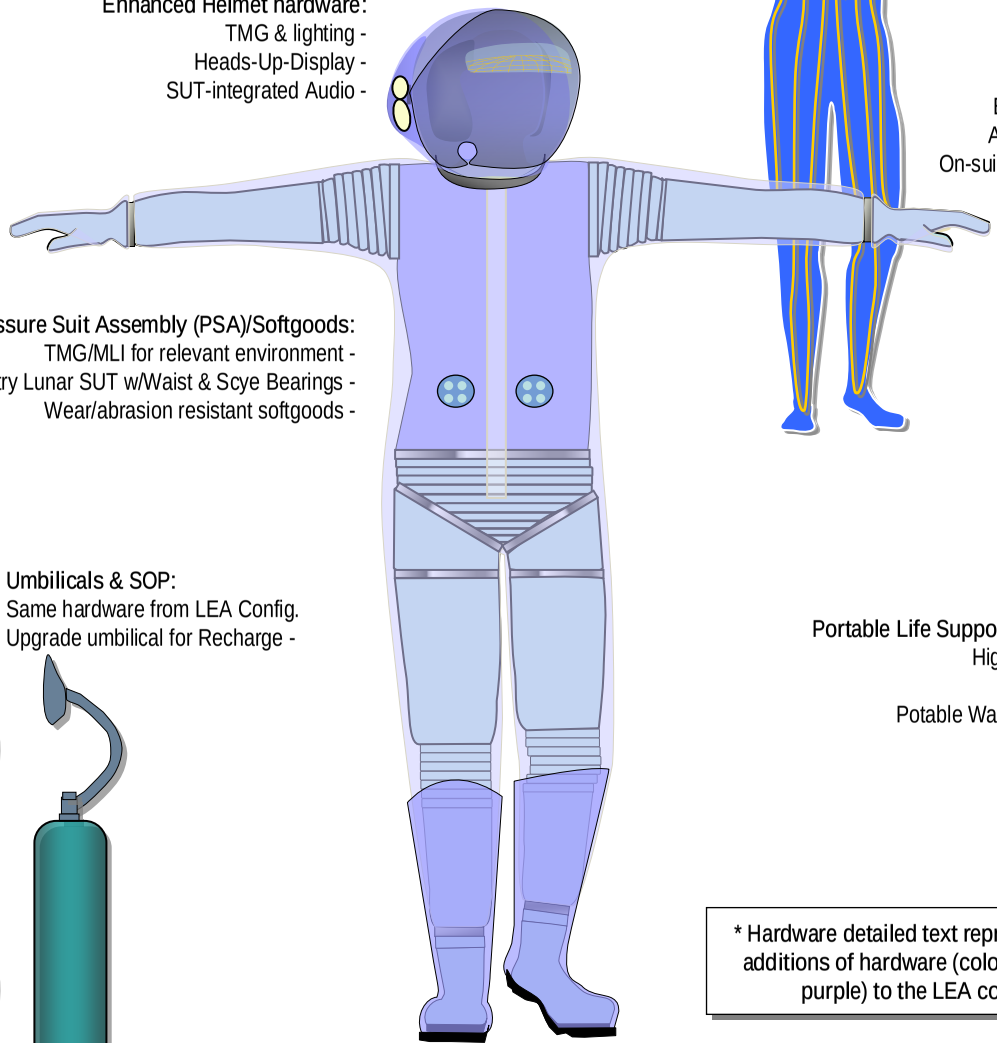
Configuration 2
Lunar Sortie

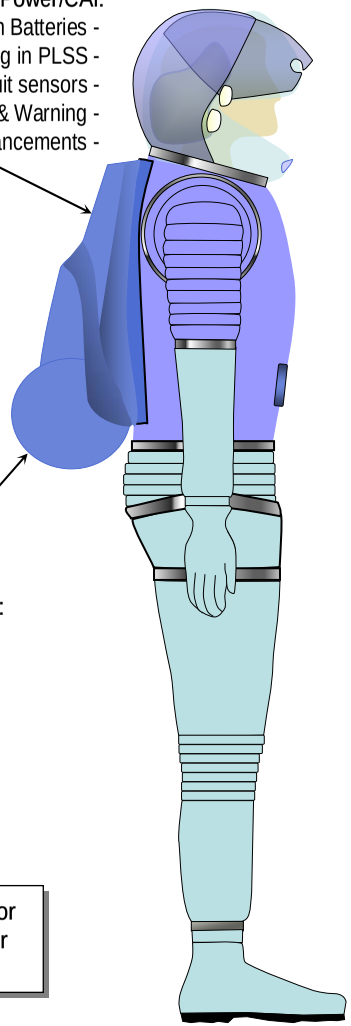
Enhanced LCG & Bio-Med Sensors

Enhanced Helmet hardware:
TMG & lighting -
Heads-Up-Display -
SUT-integrated Audio -

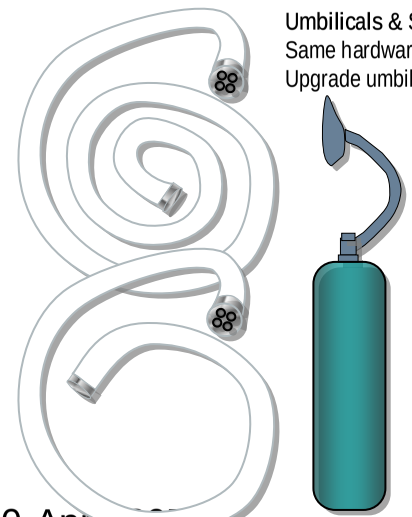
Power/CAI:
Lithium Ion Batteries -
C3I Processing in PLSS -
Expanded set of suit sensors -
Advanced Caution & Warning -
On-suit Productivity Enhancements -

Enhanced Pressure Suit Assembly (PSA)/Softgoods:
TMG/MLI for relevant environment -
Rear Entry Lunar SUT w/Waist & Scye Bearings -
Wear/abrasion resistant softgoods -





Umbilicals & SOP:
Same hardware from LEA Config.
Upgrade umbilical for Recharge -



Portable Life Support System (PLSS):
High Pressure GOX -
SWME/RCA -
Potable Water in PLSS Tank -

* Hardware detailed text represents changes or additions of hardware (colored darker blue or purple) to the LEA configuration.

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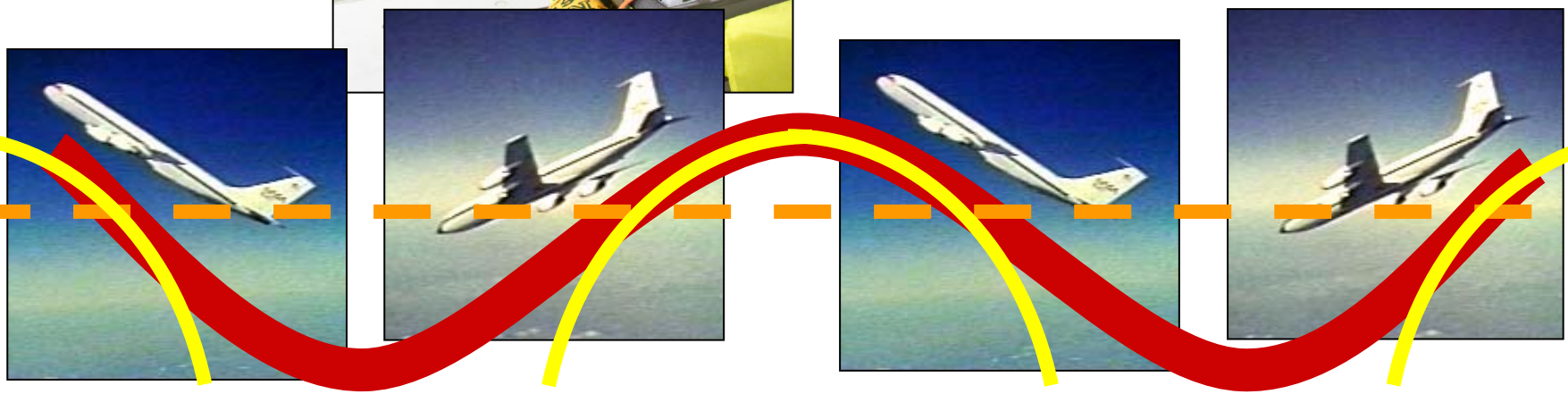
Reduced Gravity Program

KC-135



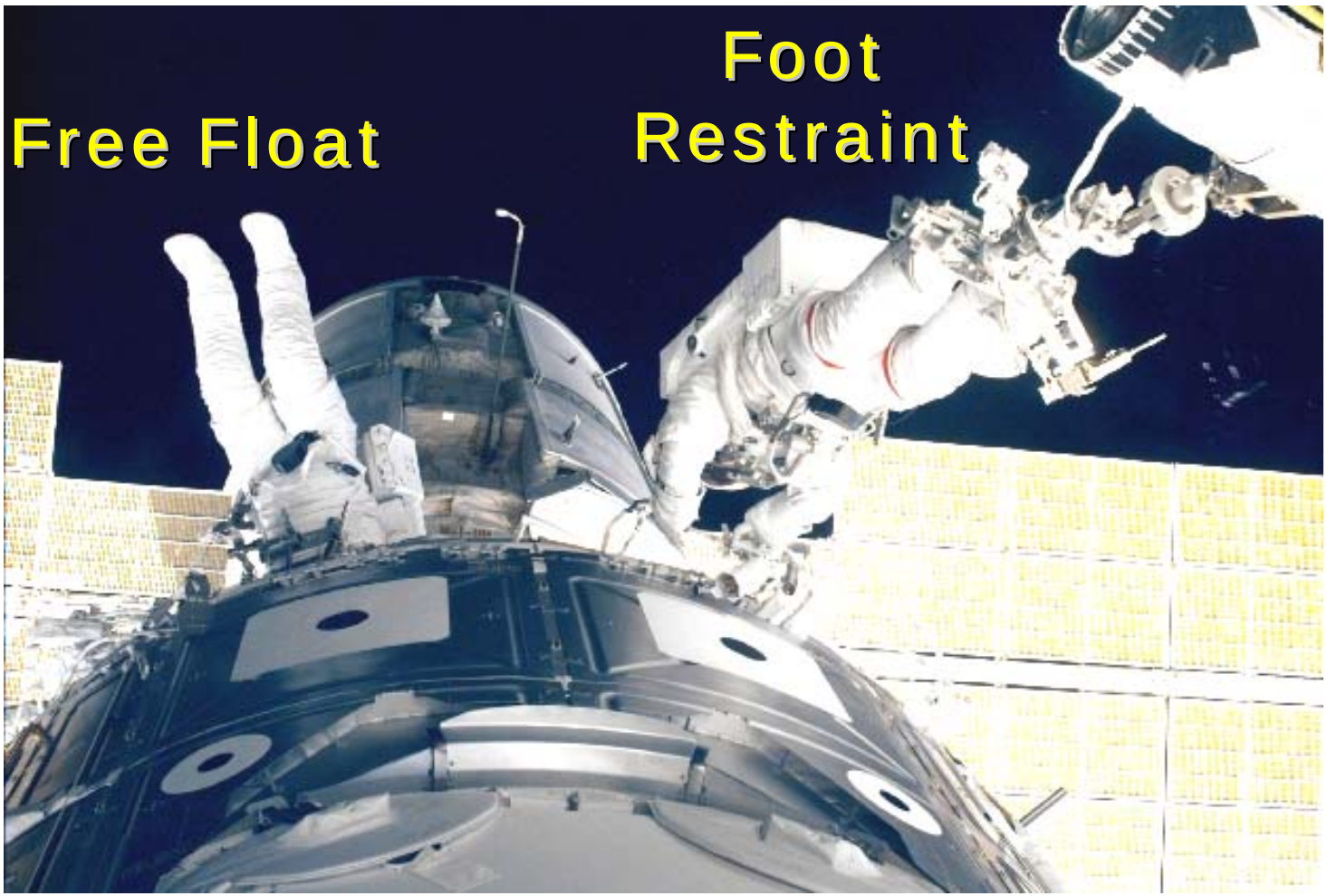
Parabola

Other Opportunities

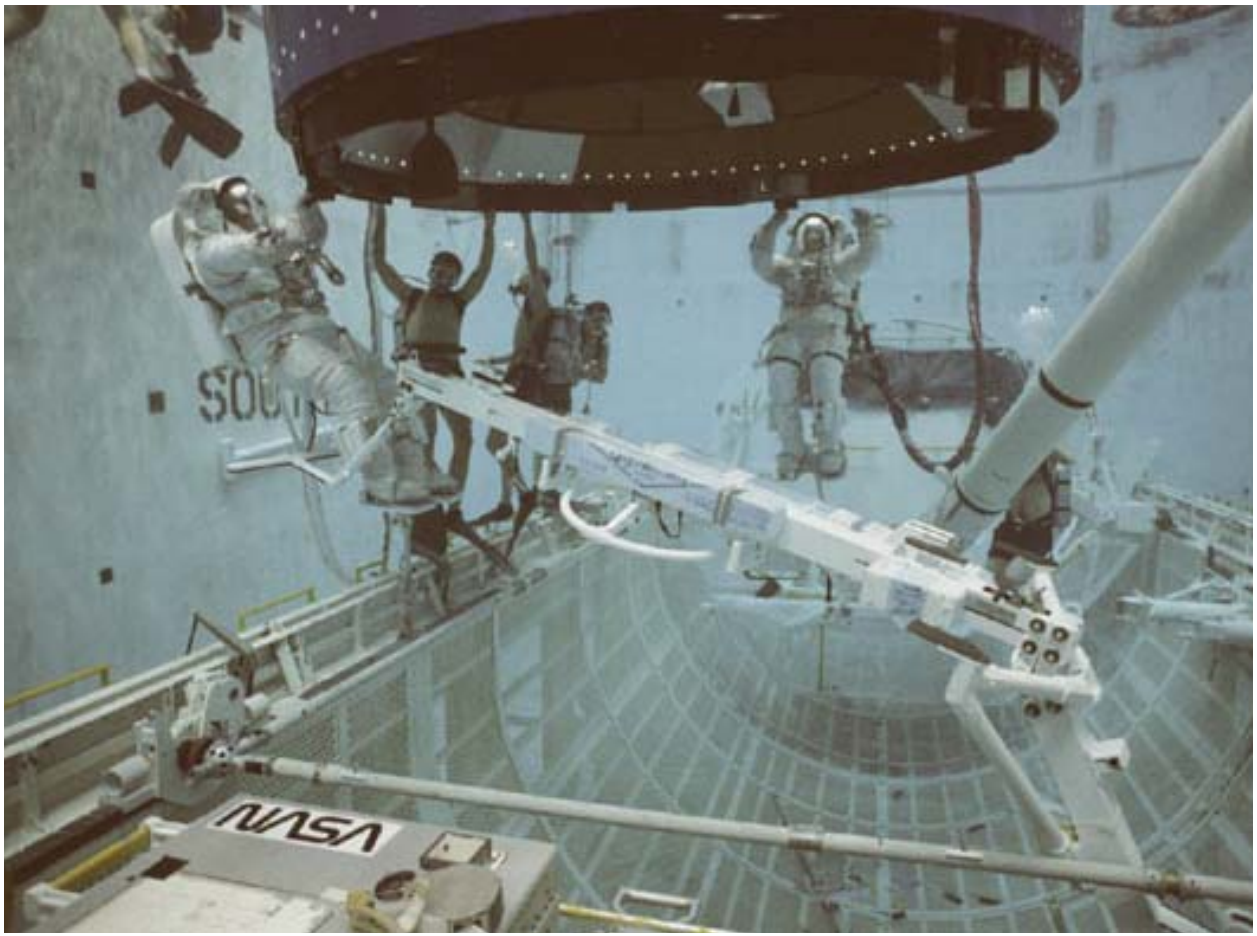
- **Co-op Program (coop.jsc.nasa.gov)**
  - Undergraduate
    - US Citizen
    - Completed 30 semester hours
    - Min GPA of 3.0
    - Complete 3 tours, at least 1 during a semester
  - Graduate
- **STTR**
- **Summer Internships**
- **Graduate Fellowship Program**

Back-up Slides

Extravehicular Activity (EVA)



Neutral Buoyancy Laboratory (NBL)



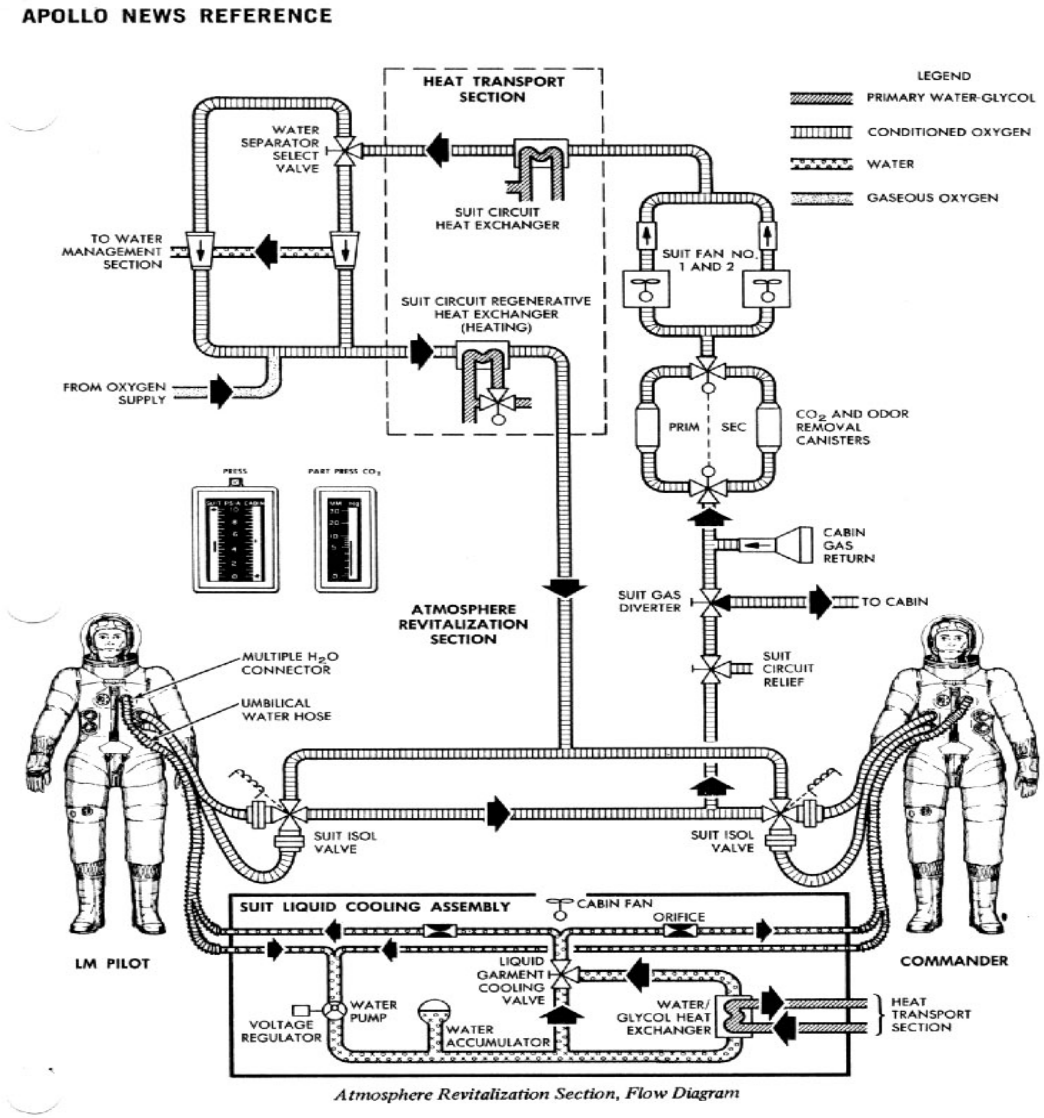
Advanced Space Suit

What they do:

- **Provide connections to the vehicle (space shuttle, CEV, etc.) life support system to provide basic life support functions (breathing gas, suit pressure, cooling, CO2 removal, communications, biomedical sensor lines) while in a pressure suit (either EVA or IVA). This is important during emergencies (cabin depressurization for example) and for simple EVA tasks that take place close to the vehicle (eliminating the need for a complex portable life support system).**
- **During EVA, provides a strong tether connection to the vehicle to prevent the astronaut from floating away from the vehicle and to prevent straining of the life support lines. The tether is usually shorter than the life support lines so it absorbs tension forces in the umbilical before the life support lines are stressed.**
- **In some cases, the umbilical is also used to recharge life support consumables such as cooling water in a Portable Life Support System (PLSS). The PLSS allows the astronaut to move freely without being encumbered by an umbilical during EVA and to roam far from the vehicle (for example, walking on the moon) where an umbilical would be impractical.**

Apollo Program (1965-1972)

- **Umbilicals were used for life support inside the vehicles during emergencies and during transition to/from EVA. Also used for recharging the EVA PLSS (portable life support system) water and O2 tanks.**
- **Provided cooling water to the LCVG garment, O2 for suit pressurization and CO2 transport from the suit, power, comm, and biomed.**
- **Used separate lines and hoses which had to be individually mated/de-mated to the suit.**

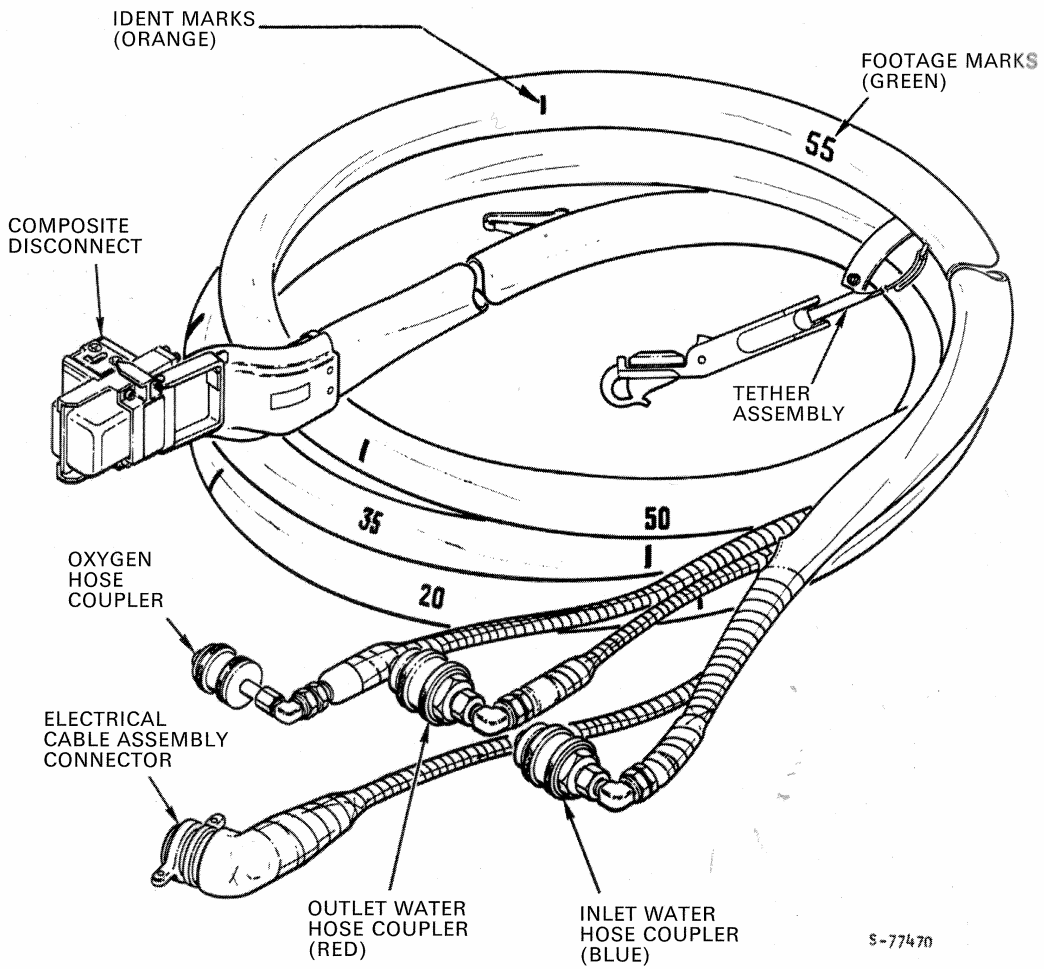


Atmosphere Revitalization Section, Flow Diagram

Life Support Umbilicals

Skylab (1970-1975)

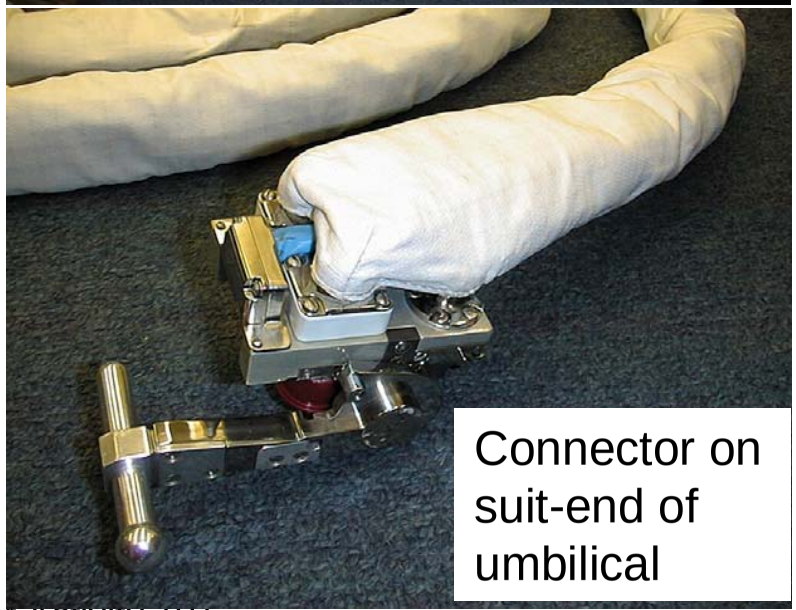
- **60-foot length provided O2 for breathing suit pressurization, cooling water supply return, power, comm, and biomed data lines during EVA outside of Skylab.**
- **Contained a restraint tether (~58 foot length).**
- **Composite connector at suit side allowed for single connection for O2, water, and power by astronaut instead of separate hoses and lines as was the case with the Apollo umbilical.**
- **Stowage and handling were better than th Gemini umbilicals.**



Space Shuttle/ISS

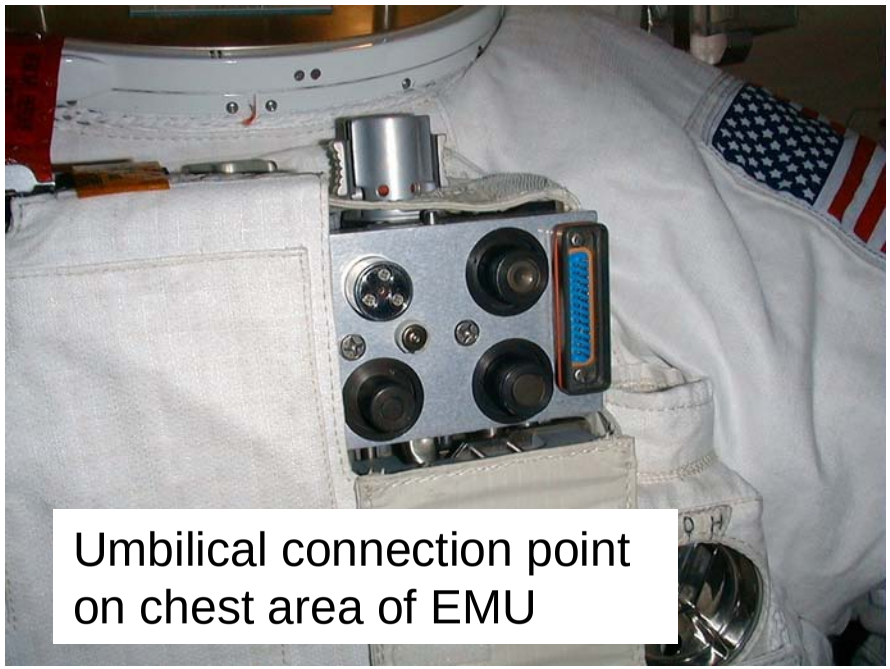
- **Used to recharge the EMU O2 & feed water tanks. Can also recharge the EMU battery. O2 can be recharged while suited and pressurized.**
- **Supplies cooling water flow from the vehicle while suited in the airlock, and supplies power to the suit while in the airlock to save battery power before going outside to perform EVA.**
- **Supplies hard-line comm to the space shuttle or ISS when in the airlock.**
- **Contains a restraint tether.**
- **Allows simple simultaneous connection of all lines to the suit-side connector with one action. On ISS, the vehicle side connection is also a single block for simultaneous connection of all fluid, comm, & power lines.**

Umbilical hoses and outer wrap



Connector on suit-end of umbilical

Space Shuttle/ISS cont.



Umbilical connection point on chest area of EMU

Tether hook

Astronaut connected to ISS life support umbilical in the Space Station Airlock Test Article (SSATA) at JSC

Future Umbilicals

- **The replacement for the space shuttle will require umbilicals to connect the astronaut suits to life support both inside (IVA) & outside (EVA) the vehicle since the vehicle will not have an airlock. The same basic capabilities will be required: gas for breathing & suit pressurization, cooling water, power, comm, and biomedical monitoring.**
- **EVA tasks from the space shuttle replacement vehicle are assumed to be simpler than those on ISS and Shuttle, so EVA on umbilical allows for less complication (no complex PLSS is required) and less mass and volume to be carried on the vehicle – all life support is provided by the vehicle.**
- **Umbilicals will also be required in the lunar lander, the lunar rover, and the equivalent systems to be used on Mars. These allow for recharge of consumables such as O2 and cooling water in the PLSSs, and allow for use of vehicle consumables and cooling during pre-EVA airlock tasks such as pre-breathing.**
- **These umbilicals must be light-weight, low volume, easy to use and stow, and able to survive and function in temperature extremes and the dusty environments of the moon and mars.**