



1.32 Extravehicular Activity (EVA) Operations Overview



**Spaceflight Systems Division
United Space Alliance
Kathy Zubelik - 281.483.0866
David Brashinger – 281.244.8727**

Objectives

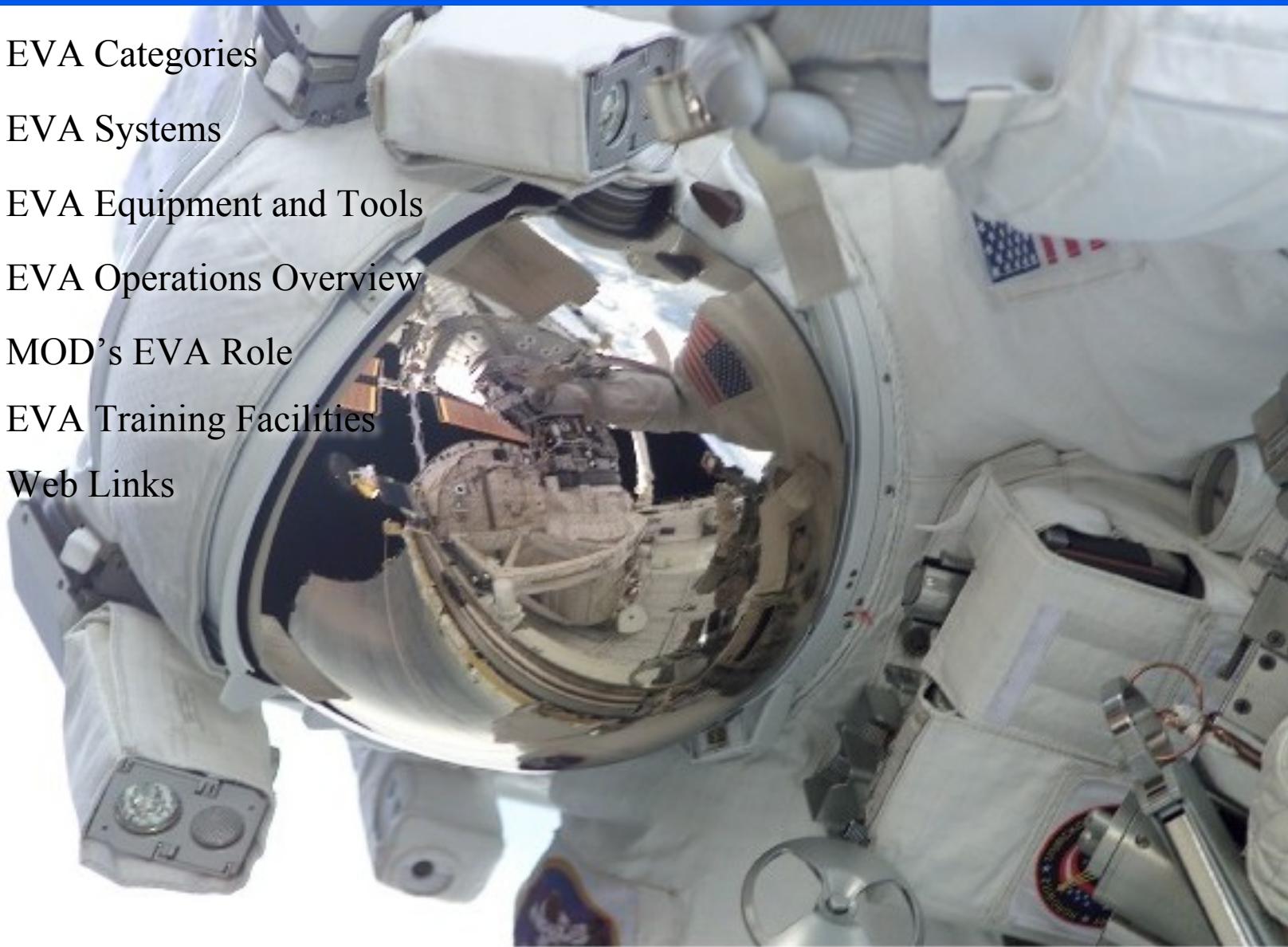
As a result of the Extravehicular Activity (EVA) Operations Overview presentation, students should be prepared to do the following:

- Identify the reasons for conducting an EVA and the role that EVA plays in the space program.
- Identify the types of EVAs that are trained and may be performed on orbit.
- Identify the roles of the Extravehicular Mobility Unit (EMU), Simplified Aid For EVA Rescue (SAFER), Shuttle Airlock, and ISS Joint Airlock.
- Identify the roles that different Space Shuttle and Space Station equipment and tools play during an EVA.
- Identify the methods and procedures of EVA Prep, EVA, and Post EVA operations for Shuttle and Station.
- Define the role MOD plays in the EVA program.
- Define the roles that different training facilities play in EVA training.

NOTE: MOD EVA also has some responsibilities for Russian-based Orlan EVAs. However, this material is beyond the scope of this briefing.

Introduction

- EVA Categories
- EVA Systems
- EVA Equipment and Tools
- EVA Operations Overview
- MOD's EVA Role
- EVA Training Facilities
- Web Links



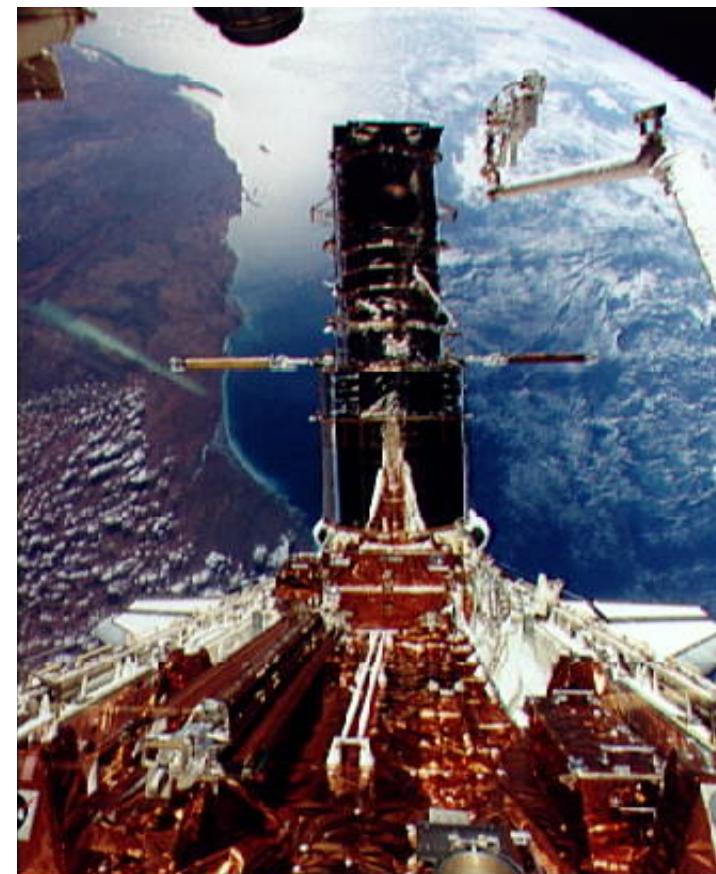
EVA Categories

Extravehicular Activity (EVA)

- Definition: Crewmember leaves the protective environment of a pressurized spacecraft cabin and ventures out into vacuum of space wearing an EMU

- Purpose

- Contingency Repairs
- Mission Success Repairs
- Experiments or Testing
- Spacecraft Servicing (Hubble Space Telescope)
- Space Structure Construction [International Space Station (ISS)]



EVA Categories

ISS vs Shuttle Terminology

Three basic categories of EVA exist:

1. Nominal* or Scheduled EVA:

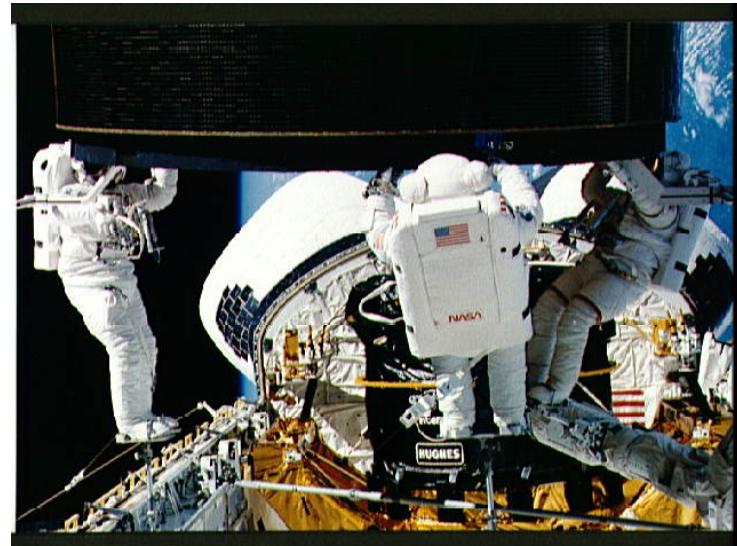
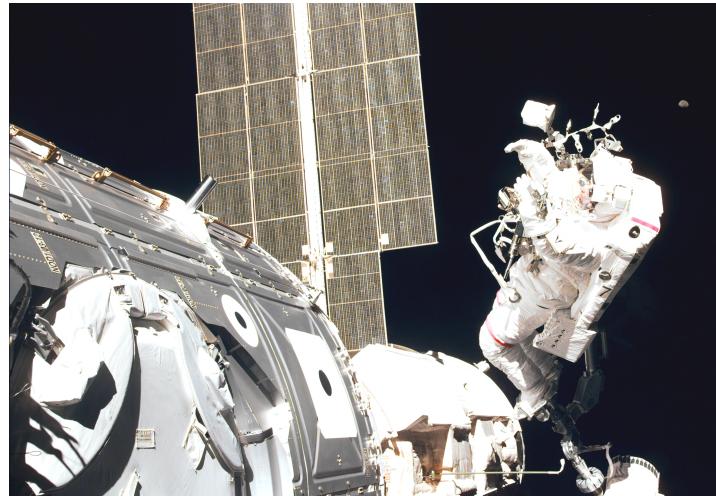
EVA planned prior to launch and included in the nominal mission timeline.

2. Off-Nominal* or Unscheduled EVA:

EVA not included in the nominal 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 (Orbiter or ISS)
(we have performed 0 contingency EVAs)



*Terminology for ISS based EVAs

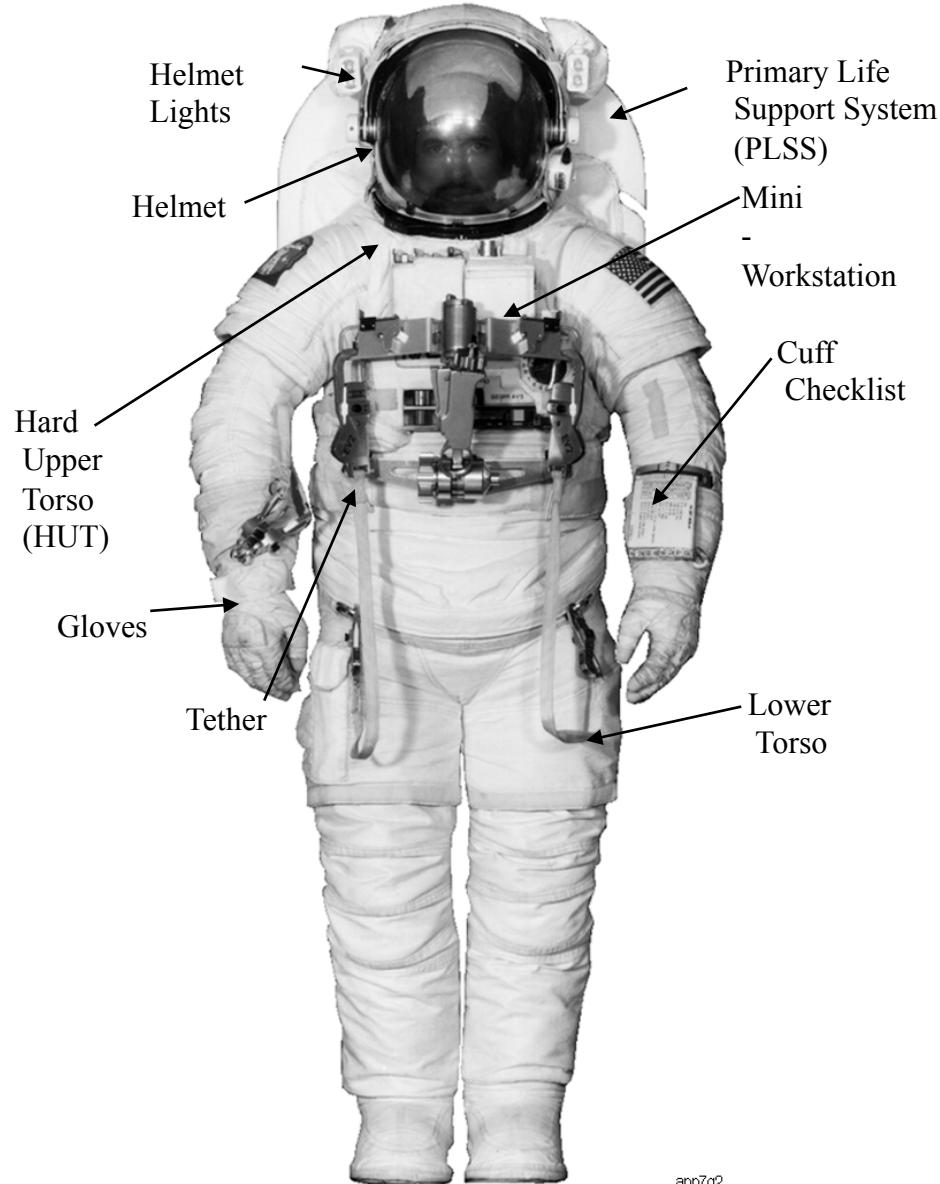
EVA Systems

- Extravehicular Mobility Unit (EMU)
- Simplified Aid For EVA Rescue (SAFER)
- Shuttle Airlock
- ISS Joint Airlock



EVA Systems

EMU



The EMU is an independent system that provides the crewmember with environmental protection, mobility, life support, and communications during EVA.

EMU provides consumables to support an EVA of 7 hours maximum duration.

- 15 minutes for egress
- 6 hours for useful work
- 15 minutes for ingress
- 30 minutes for reserve

EMU is an integrated system consisting of two subassemblies:

- Life Support System (LSS)
- Space Suit Assembly (SSA)

EVA Systems EMU

Two EMUs* are baselined to be flown on each shuttle flight with enough consumables to support 3 two-crewmember (Orbiter contingency) EVAs.

Of these 3 EVAs:

- One 7-hour EVA may be supported.
- Two EVAs of 3-hours and 4-hours respectively may be supported for contingency EVA operations.

- * A third EMU is sometimes flown as a spare on flights with a scheduled EVA or to preserve redundancy on ISS assembly flights.
- * Three or four EMUs can be flown on flights requiring two EVA teams.

EVA Systems

EMU

Life Support System Components:

- Primary Life Support Subsystem (PLSS)
 - Provides breathing O₂, electrical power, comm, cooling
 - Responsible for suit pressure control
 - Circulates O₂ and removes CO₂, humidity and trace contaminants
 - Controls thermal environment
- Secondary Oxygen Pack (SOP)
 - Provides a minimum of 30 minutes of emergency O₂ in open loop purge mode
 - Activated automatically during EVA, if necessary
- Contaminant Control Cartridge (CCC; LiOH Cartridge or METOX Cartridge)
 - Removes CO₂ and trace contaminants

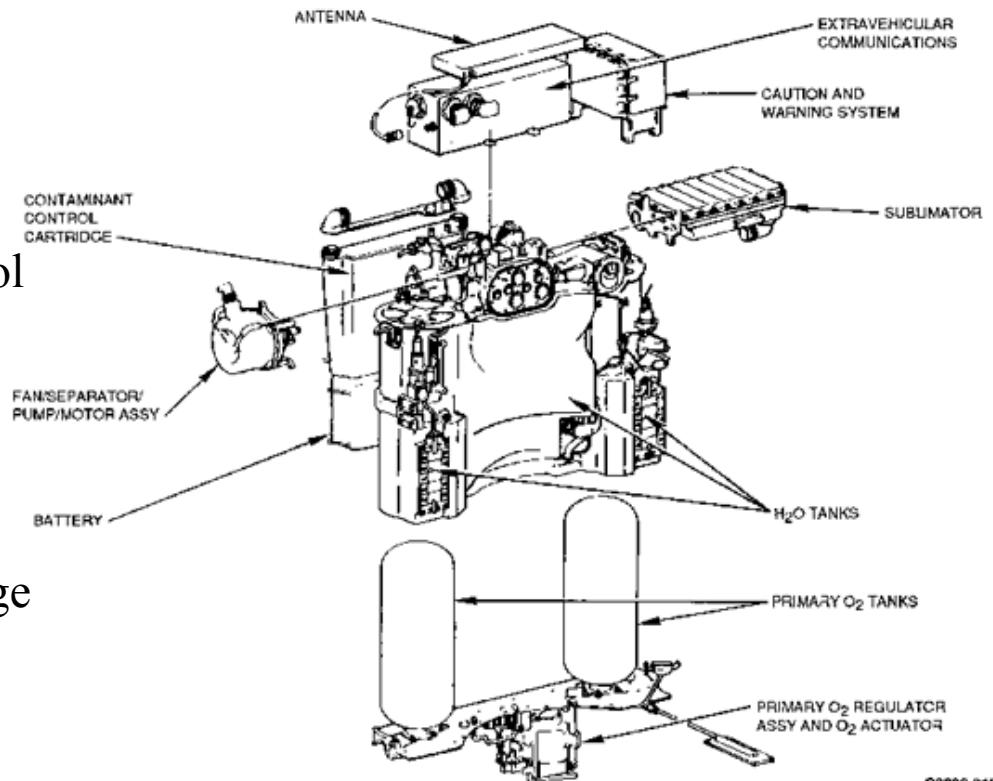


FIGURE 1. PRIMARY LIFE SUPPORT SUBSYSTEM

EVA Systems

EMU

Life Support System Components Continued:

- Battery
- Space to space EMU Radio (SSER; EMU Radio)
- Caution and Warning System (CWS)
- Display and Control Module (DCM)
 - Provides CWS messages, EMU parameters, and EMU controls to crewmember
- Real Time Data System (RTDS)
 - Provides EMU status parameters and biomed data for transmission to Mission Control

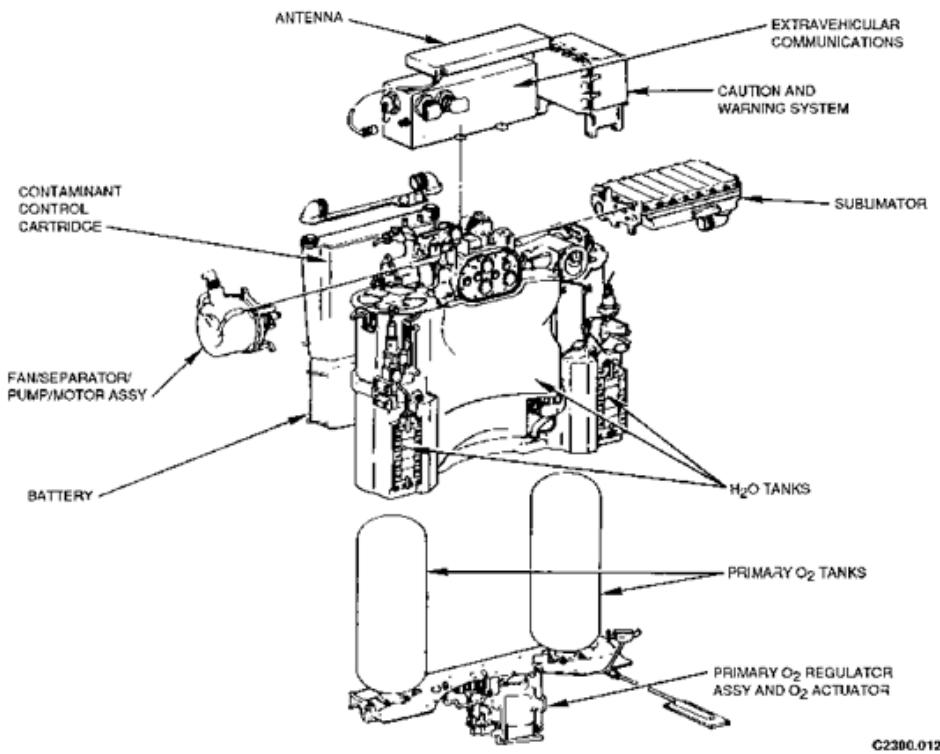


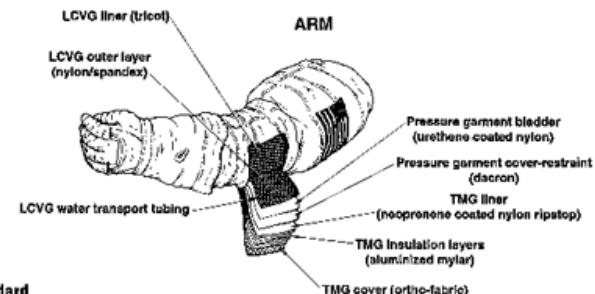
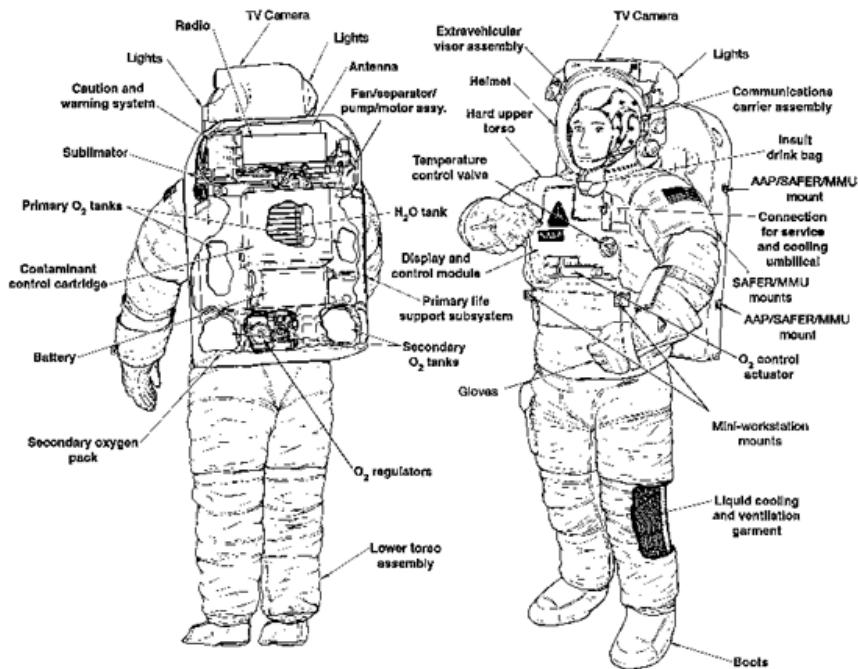
FIGURE 1. PRIMARY LIFE SUPPORT SUBSYSTEM

EVA Systems EMU

Space Suit Assembly Components:

- Hard Upper Torso (HUT)/arms
- Lower Torso Assembly (LTA)
- Extravehicular (EV) gloves
- Helmet/Extravehicular Visor Assembly (EVVA)
- Liquid Cooling and Ventilation Garment (LCVG)
- Operational Bioinstrumentation System (Biomed)
- Communications Carrier Assembly (CCA; Comm Cap)
- Disposable In-Suit Drink Bag (DIDB)
- Maximum Absorption Garment (MAGs)

EXTRAVEHICULAR MOBILITY UNIT

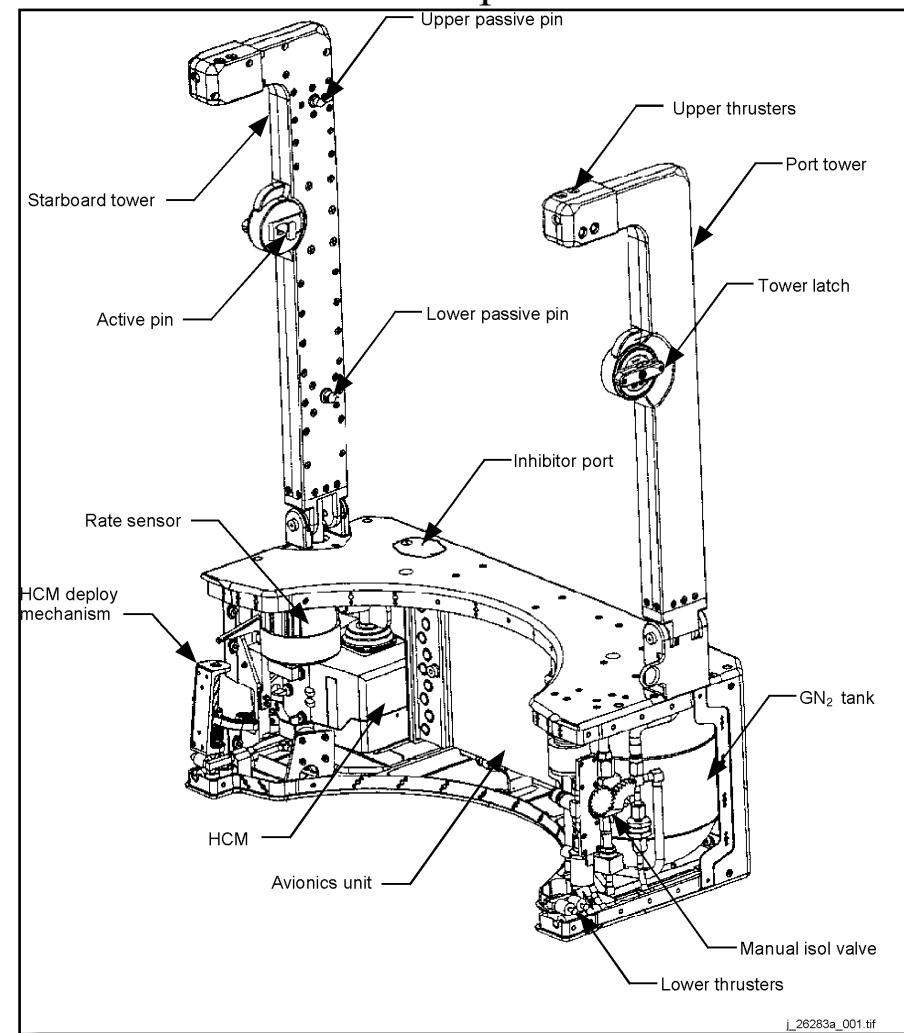


EVA Systems

SAFER (Simplified Aid for EVA Rescue)

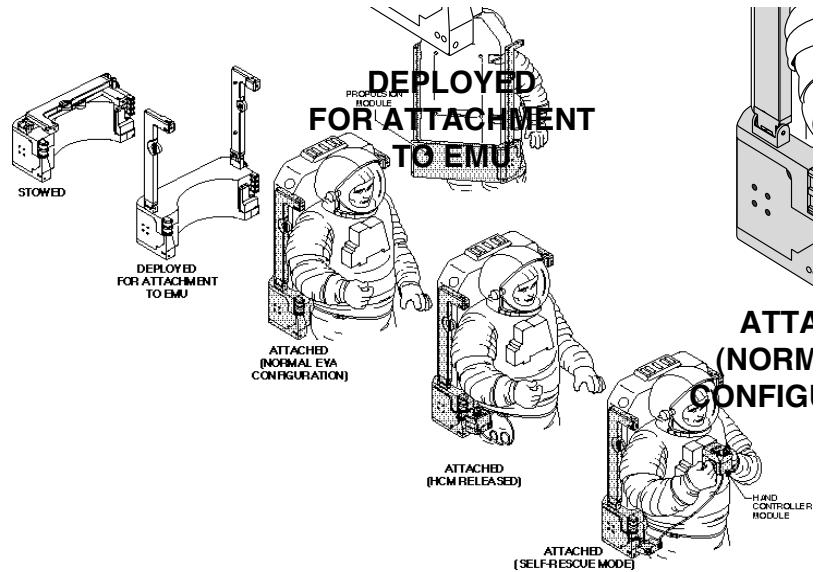
SAFER is a self-contained, propulsive backpack self-rescue system that provides the EV crewmember with self-rescue capability when orbiter is not present or cannot immediately perform EVA rescue.

- Propellant: Pressurized nitrogen gas
- Controlled by a single hand controller
- Stowed in ISS airlock, used on ISS EVAs
- Sufficient propellant and power for one self-rescue (~13 min)
- Test flight on mission STS-64; self-rescue capability on STS-76
- Power up of production model SAFER on STS-86
- Tethered test flight of production model SAFER on 2A and 3A



EVA Systems

SAFER (Simplified Aid for EVA Rescue)

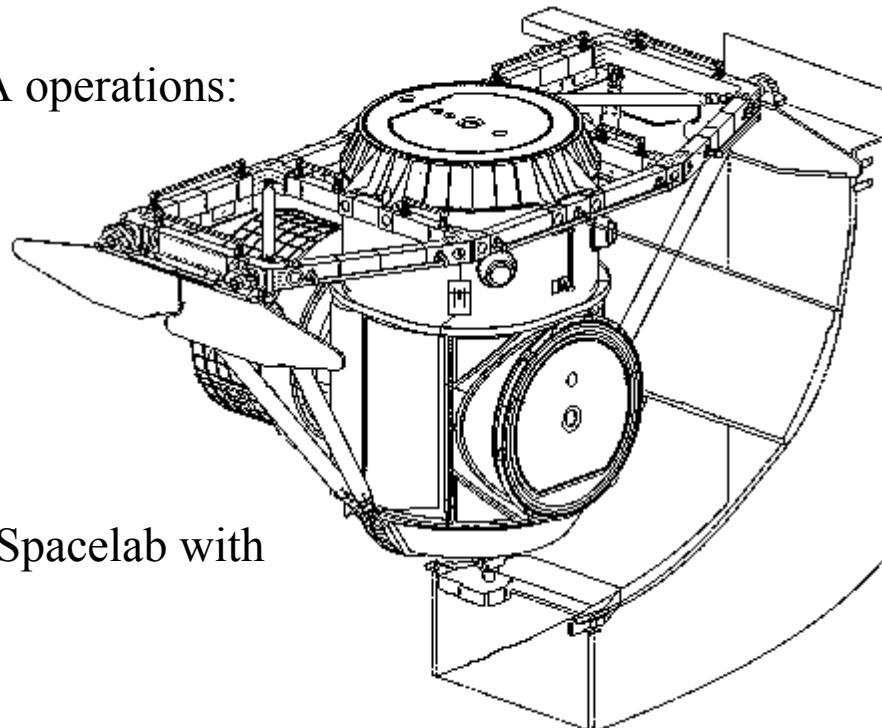


EVA Systems

Shuttle Airlock

The shuttle airlock provides the following:

- The means for a suited EVA crewmember to transfer from the orbiter to the EVA environment without having to depressurize the crew cabin.
- EMU life support during prep/post EVA operations:
 - O₂
 - Power
 - Cooling
- Recharge of EMU consumables:
 - O₂
 - Battery
 - Feedwater
- Ability to move between Space Hab or Spacelab with the attachment of the tunnel adaptor

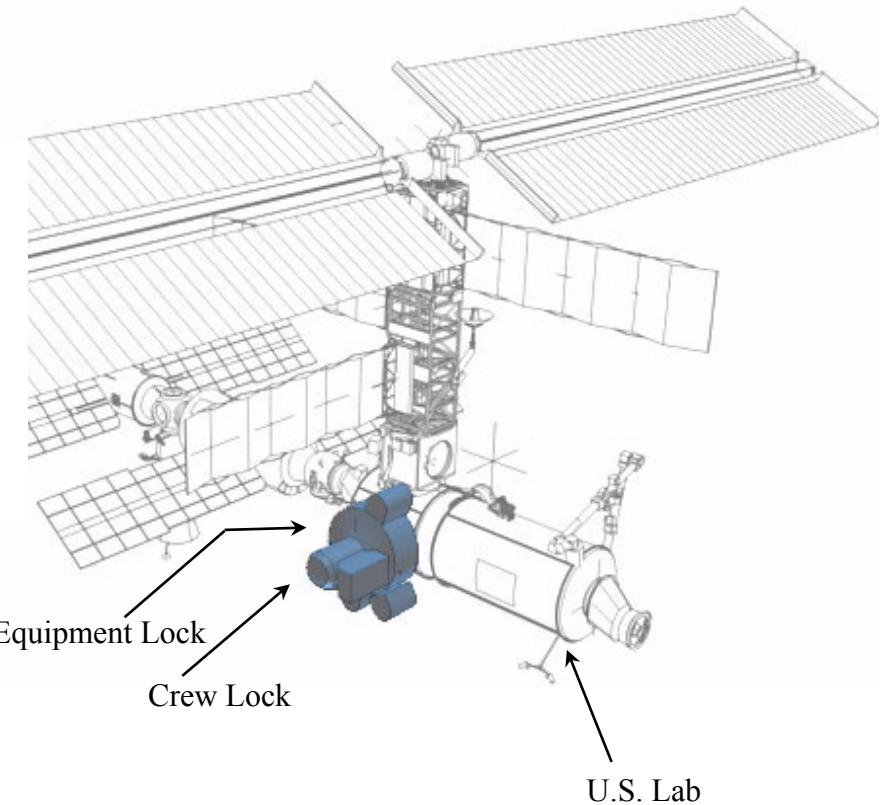


EVA Systems

ISS Joint Airlock

ISS Joint Airlock:

- Primary for US ISS EVAs (both Orbiter and Station based)
- Compatible for use with Russian Orlans
- 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
 - Crew Lock is the volume nominally depressed to vacuum for crew to go EVA



EVA Equipment & Tools

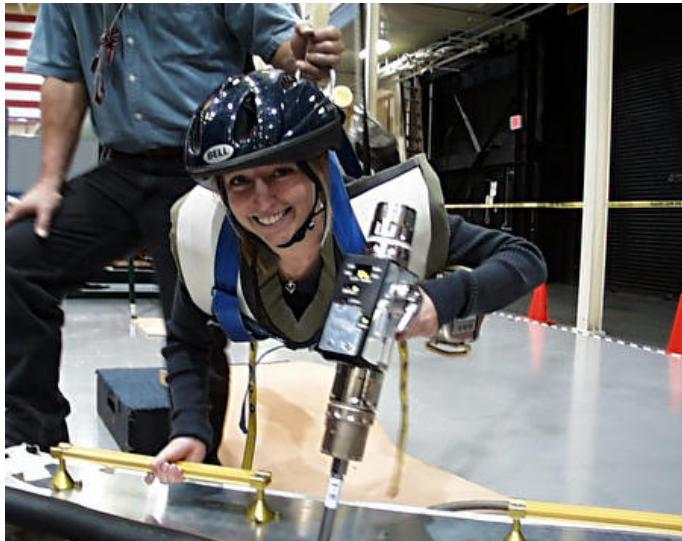
EVA crewmembers use specific tools for each task and this generic equipment:

- Tethers
 - 55' safety tether, 2 waist tethers, wrist tethers
 - EVA tether protocol is that crewmembers and equipment must be tethered at all times
 - **Always make a connection before you break a connection.**
- Mini Workstation (MWS)
 - Attaches to front of the EMU
 - Used to carry small tools
 - MWS end effector and retractable tether provide restraint to EV CM at worksite
- Body Restraint Tether (BRT)
 - Attaches to the MWS
 - BRT end effector provides semi-rigid restraint to EV CM at worksite
 - Requires less time than setting up a Portable Foot Restraint and is more stable than a MWS end effector
 - Also used for translating small objects



EVA Equipment & Tools

- Pistol Grip Tool (PGT)
 - EVA torque wrench (i.e. a bolt turner)
 - Has a programmable torque limiter and turn limiter
 - CM needs to be secured depending on amount of torque required
 - 2ft-lbs to 25ft-lbs of torque available
 - Generally used for ISS assembly missions and maintenance EVAs



← 1-G Testing of the PGT

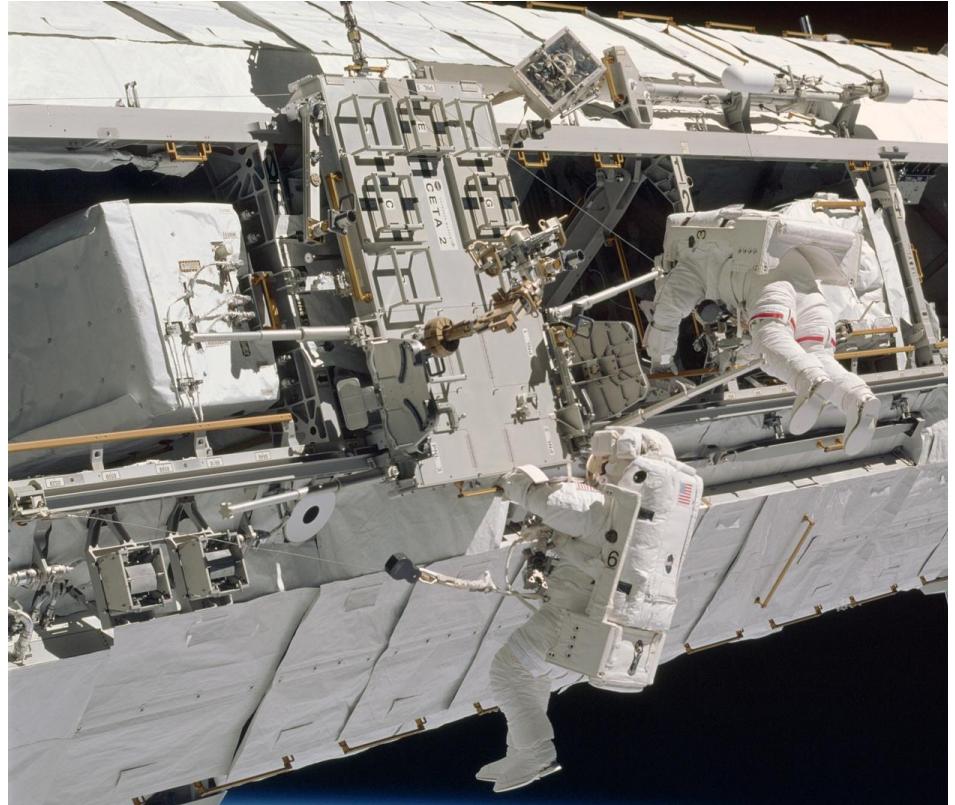
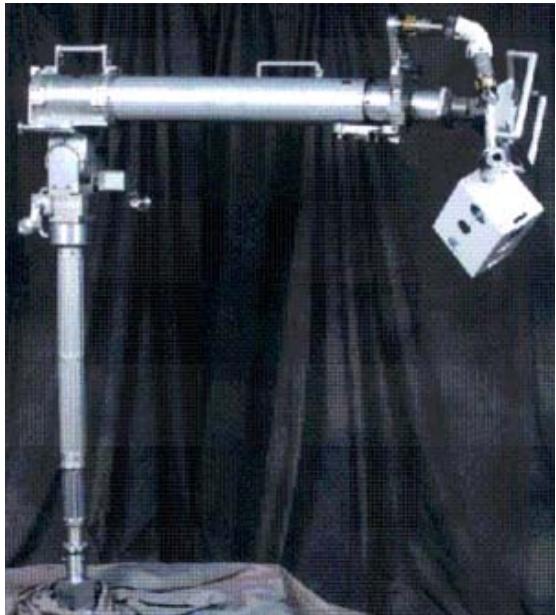
EVA Equipment & Tools

- Foot Restraints
 - Attaches to structure via a socket
 - Provides EV CM rigid restraint at a worksite
 - Different types:
 - Portable foot restraint (PFR) (*Shuttle*)
 - Articulating PFR (APFR) (*US ISS*)
 - Interoperable APFR (IAPFR) (*US & Russian ISS*)
- Tool Stanchion (*no picture*)
 - Attaches to APFR or CETA Cart
 - Levers allow CM to yaw and tilt with respect to APFR
 - Holds tools and provides temp stowage of old ORUs



EVA Equipment & Tools

- Crew and Equipment Translation Aid (CETA) Cart
 - Essentially an EVA equipment cart
 - Translates by CM manually pulling it along truss
 - Use brakes to stop and stay parked
 - Typical use: small ORU replacement on front truss face



- Crane
 - Used to transfer ORUs during maintenance EVAs
 - Pitch and yaw capabilities
 - Telescoping boom (18 feet)
 - Smaller than Russian crane (STRELA)

EVA Operations Overview

EVA operations can be divided into three phases.

Operations to prepare for EVA



EVA Tasks



Operations after EVA



EVA Operations Overview

Operations to prepare for EVA

- Equipment Prep
 - Prepares the airlock and the EMUs to be checked out before EVA. This is normally performed a few days before the EVA or before the Orbiter docks to the Station.
- EMU Checkout
 - Checks all EMU systems. Performed a few days before the EVA or before the Orbiter docks to the Station.
- EVA Prep
 - All steps performed the day of the EVA prior to going EVA, including:
 - EMU Donning
 - Prebreathe with 100% oxygen

EVA Operations Overview

Operations to prepare for EVA

O₂ Prebreathe reduces the risk of Decompression Sickness (DCS)

Protocol	In-Suit	10.2 (12 hr)	10.2 (24 hr)	Exercise
Mask prebreathe time	None	1 hour	1 hour	80 minutes
In-suit prebreathe time	4 hours	75 minutes	40 minutes	1 hour
Ops Overview <i>(Details of EVA Prebreathe protocols are in the Aeromed Flight Rule #B13-107)</i>	Breathe O ₂ in-suit for 4 hours while cabin is at 14.7, go out the door.	Breathe O ₂ on mask while depressing cabin to 10.2, wait 12 hours before in-suit prebreathe, go out the door.	Breathe O ₂ on mask while depressing cabin to 10.2, wait 24 hours before in-suit prebreathe, go out the door.	Exercise on bike for 10 min. at beginning of mask prebreathe, depress airlock to 10.2, breathe in-suit for 1 hour, go out the door.

EVA Operations Overview

EVA Tasks

30 min	Airlock depress
15 min	Airlock egress
6 hours	<p>Worksite operations: Shuttle and ISS-based</p> <ul style="list-style-type: none">– All Shuttle EV crewmembers are trained to perform the following Orbiter contingency tasks (if necessary) for each flight:<ul style="list-style-type: none">• Failed airlock hatch latches or actuator tasks• Failed Remote Manipulator System (RMS) tasks• Manual stowage of radiators or Ku-band antenna• Manual closure of payload bay doors• Installation of payload bay door latch tools• Manual separation of Shuttle from ISS (96 bolt task)– EVA crewmembers assigned to a flight are also trained for scheduled, unscheduled, or contingency tasks.
15 min	Airlock ingress
30 min	Airlock repress

EVA Operations

Operations after EVA

- EMU Doffing
- EMU Maintenance and Recharge
 - O₂ Tank recharge
 - Battery recharge
 - H₂O tank refill
 - METOX regeneration/ LiOH swap
 - Suit cleaning
 - Suit resize (if required)
- Post EVA Entry Prep

MOD's EVA Role

Three EVA Organizational groups at Johnson Space Center

1. EVA Office (XA)
 - Long-range flight planning
 - Purchasing of flight hardware
 - General oversight
2. Engineering (EC5)
 - Development and testing of EVA hardware
3. MOD (DX32, DX35)
 - Operations development
 - Crew training
 - Flight control

EVA Training Facilities

- Shuttle Full-size Mockup Trainers
 - Crew Cabin Trainer (CCT) and CCTII
 - Full Fuselage Trainer (FFT)
- Precision Air-Bearing Floor (PABF)
- EVA Comm Trainer
- Space Station Mockup Training Facility (SSMTF)
Airlock Mockup
- Virtual Reality Lab
- Vacuum chambers
 - 11 foot chamber
 - Environmental Test Article (ETA) chamber
 - Space Environment Simulation Lab (SESL) chamber
 - Space Station Airlock Test Article (SSATA)
- EMU Caution and Warning System (ECWS) Trainer
- Neutral Buoyancy Laboratory (NBL)
- KC-135



WEB Links

- DX32/35 Home page –
<http://mod.jsc.nasa.gov/dx/dx32/evahp.htm>
- EVA History/Advanced suit program –
<http://www.jsc.nasa.gov/xa/advanced.html>
- Hamilton Sunstrand(designers of the EMU) -
[http://www.hssi.com/
Applications/SpaceSuits/](http://www.hssi.com/Applications/SpaceSuits/)
- EC5 Homepage –
<http://ctsd.jsc.nasa.gov/ESS/index.html>