SD2905 Human Spaceflight

Lecture 10, 21-2-2014

ExtraVehicular Activities

References: Norberg ch. 6; ISS FAM TM sec. 11; SCOM sec. 2.11

Lecture outlay

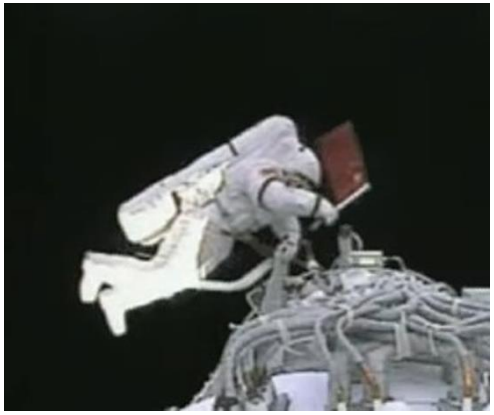
- Some historical notes
- What are needed for EVAs?
- An over-view walk-through of an EVA flow
- Details about EVA suits
- Airlocks
- On-board preparations
- Tools
- Safety
- EVA planning and training
- Future suits

EVA (Space walk) the ultimate human space operation

First ever EVA, 18.3.1965, Alexey Leonov, 24min

A few famous space walks

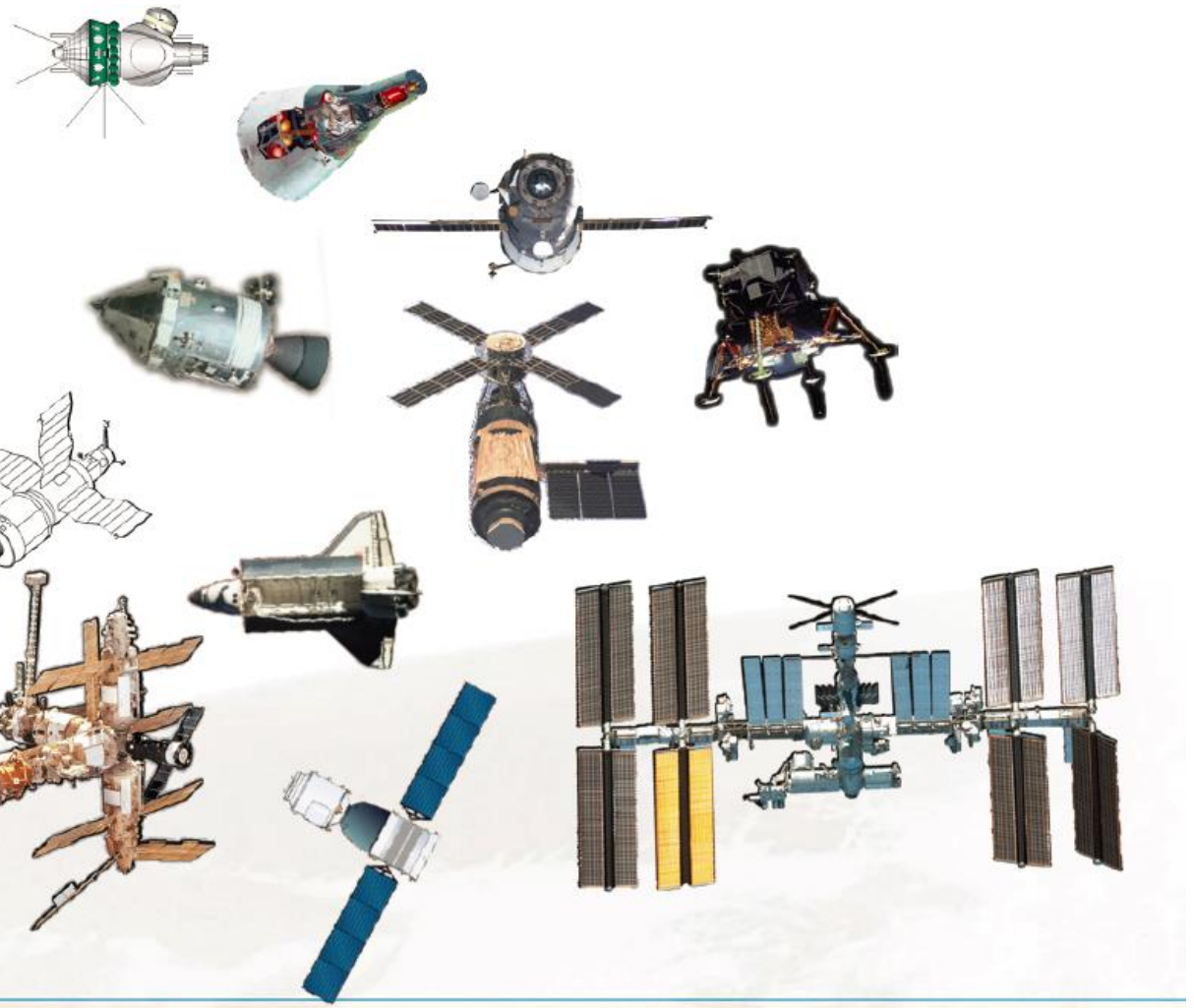
Only ever 3-person EVA. Capture of Intelsat VI in 1992 on STS-49. Pierre Thuot, Richard Hieb, and Thomas Akers.



First Chinese EVA, 7.9.2008, Zhai Zhigang & Liu Boming, 14min

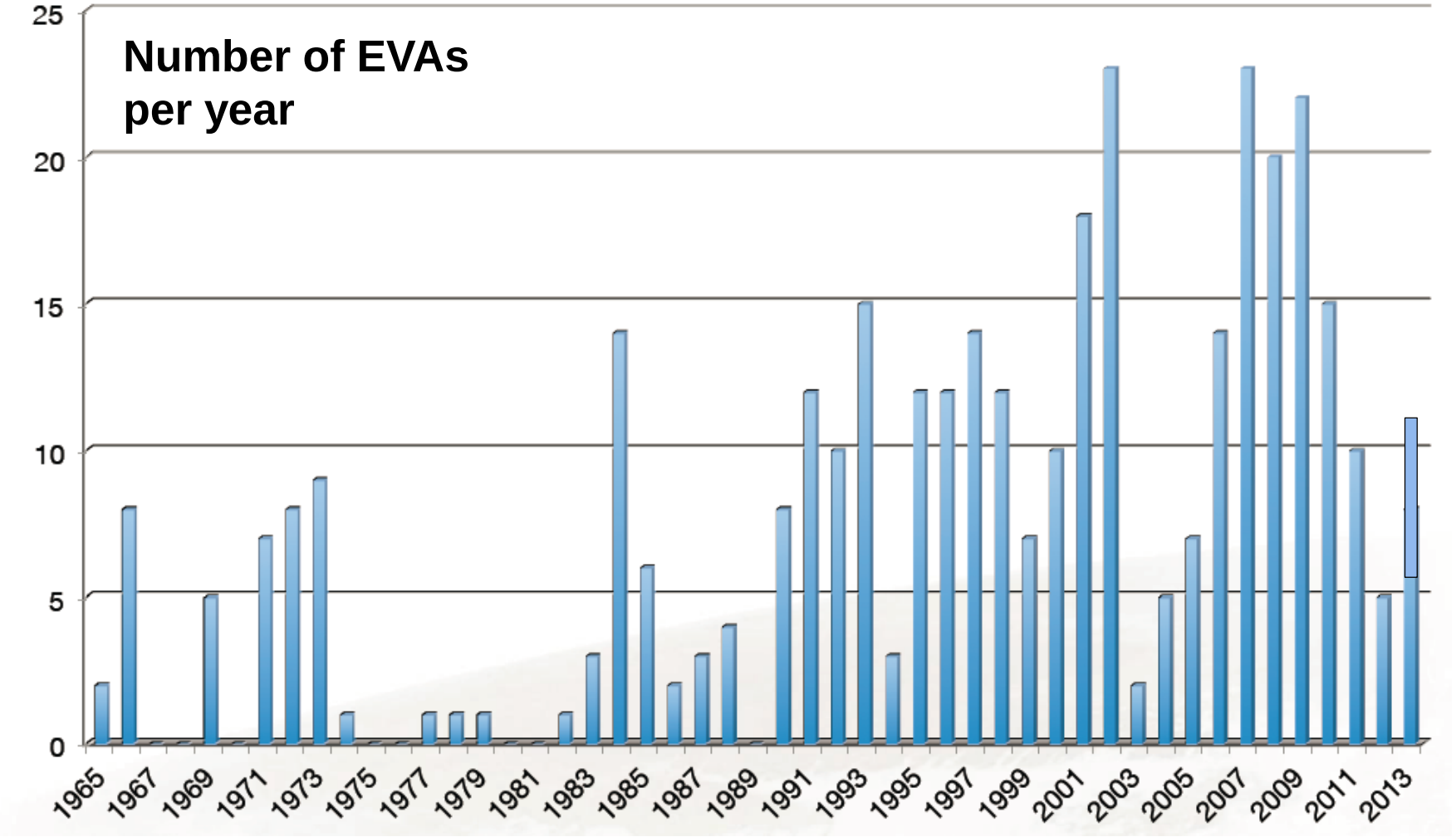
Space crafts from which EVAs have been done

- Voskhod
- Gemini
- Sojus
- Apollo (LM & CM)
- Skylab
- Saljut
- Space Shuttle
- Mir
- ISS
- Shenzhou



Construction (assembly) of ISS required many EVAs!

According to Wikipedia, where all ever EVAs are listed, a grand total of 367 have been performed world (space) wide.



What is needed?

- Space suit
  - Life support system
    - Pressure => Hermetic
    - O_2
    - CO_2 removal
    - Temp control
    - Water (no food)
    - Toilet? => Pamper
  - Communication => Radio
  - Flexibility, dextretious => low pressure => Pure O_2
- Movability
- Vision
  - Big visor
  - sun screen
  - lamps
  - mirror
- Air lock
- Special tools
- Prepare!
  - Planning – in detail
  - Training – in many various ways
- Operations conductor (Somebody on ground or from inside space craft)
- Safety measures
- Work carefully – situational awareness!

You need a space suit
- and be a good friend with it ☺

EMU (NASA) Astronaut (ESA)

Orlan (Russia)

Prepare the suit, the tools, the airlock – takes at least a day

The suit

Tools

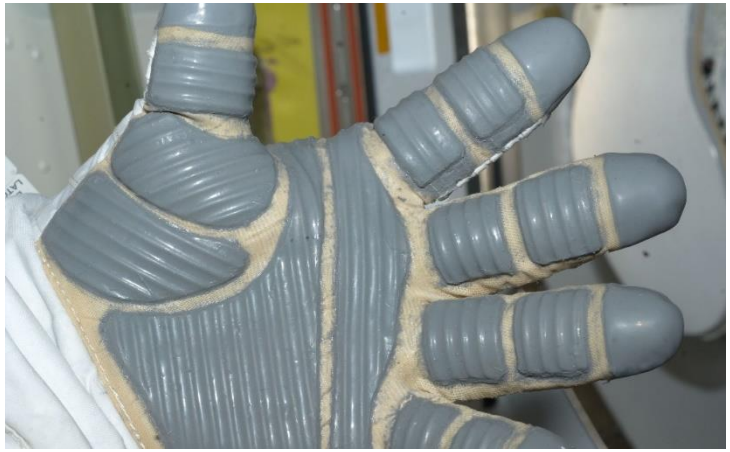
Water

Prepare your body – get rid of nitrogen

Suit up with help of crew mates – and use checklists!

Work carefully – situational awareness – tethers!!

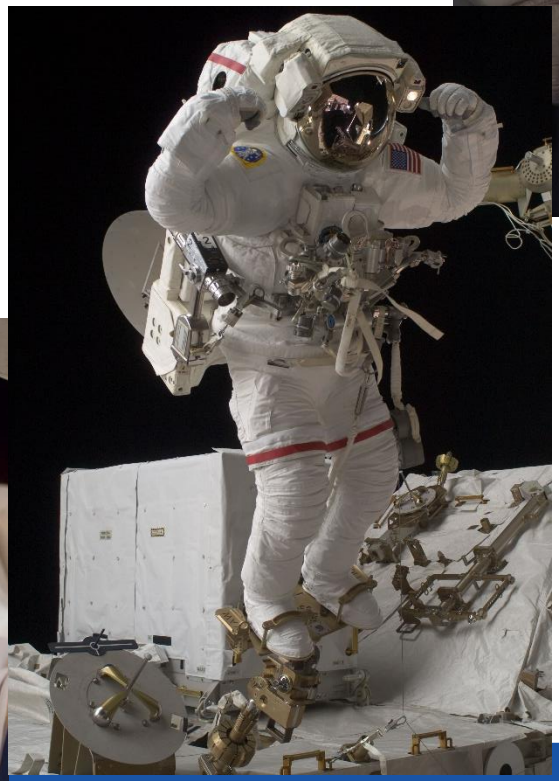
Mirror



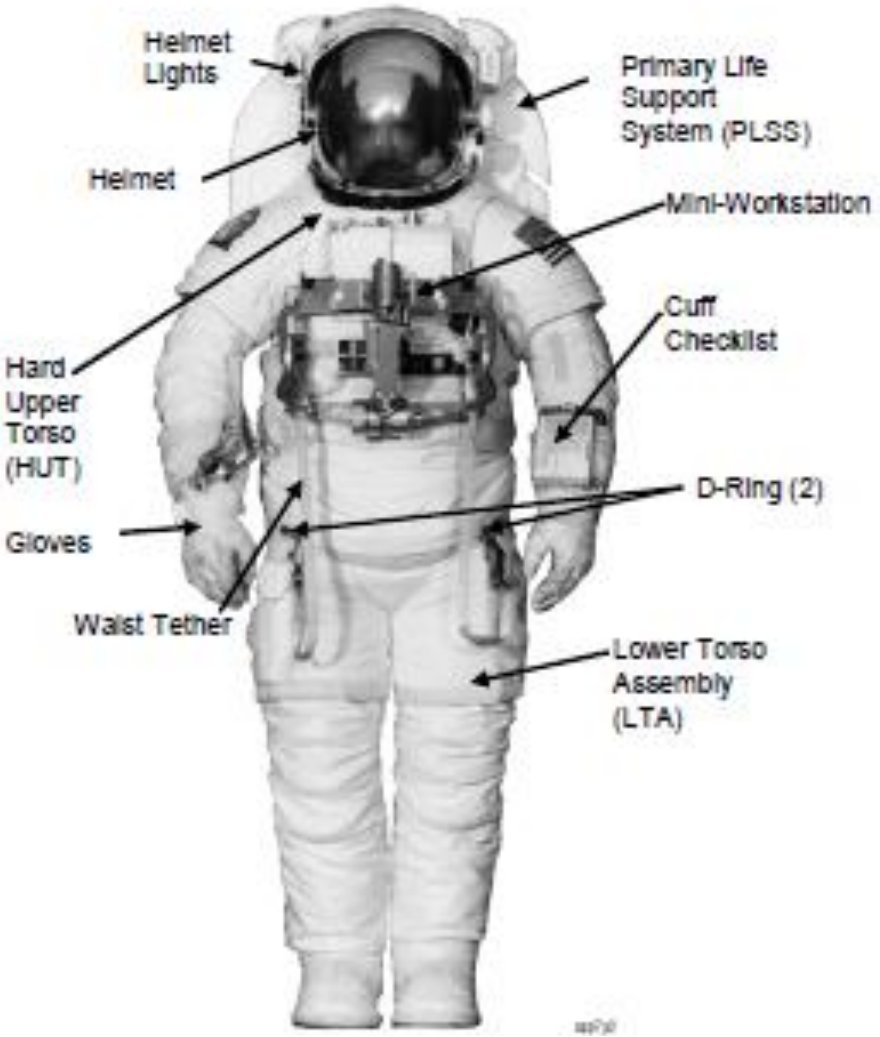
Space ”walk” – but mainly use arms and hands! Handrails everywhere.
Hands gets most tired.
God fit gloves very important!
And check regularly for damages.

Robotic arm operated from inside – good communication important!

But don’t forget to enjoy it also – and take photos!



US current EVA suit:
EMU – Extravehicular Mobilty Unit

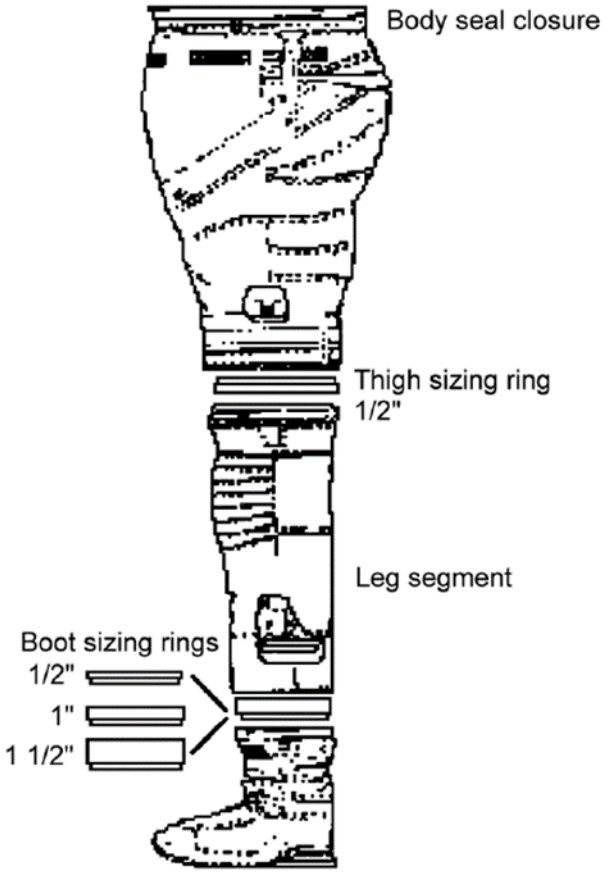


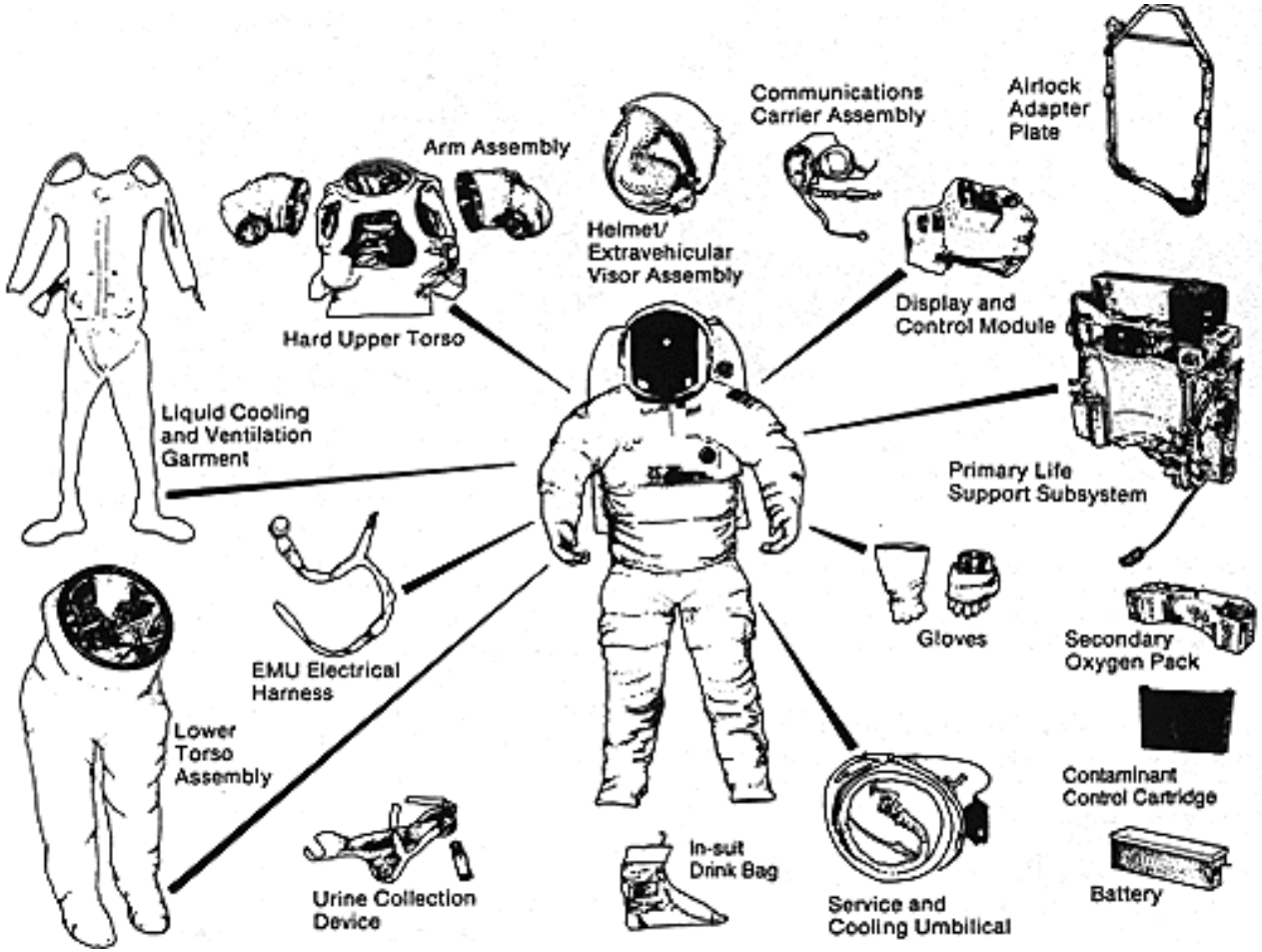
SOME EMU NUMBERS

Suit weight: 55.3 kg
Total equipped weight: 145 kg
Primary life support: 8 hours
Backup life support: 30 min
Pressure: 0.29 atm
Sizing: Modular

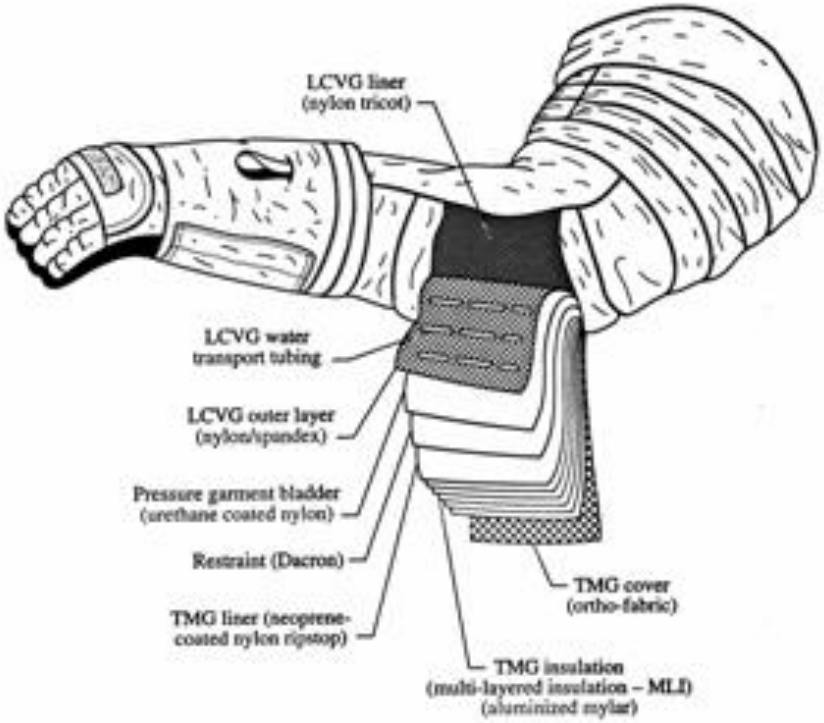
Major pieces of the EMU

For leg sizing

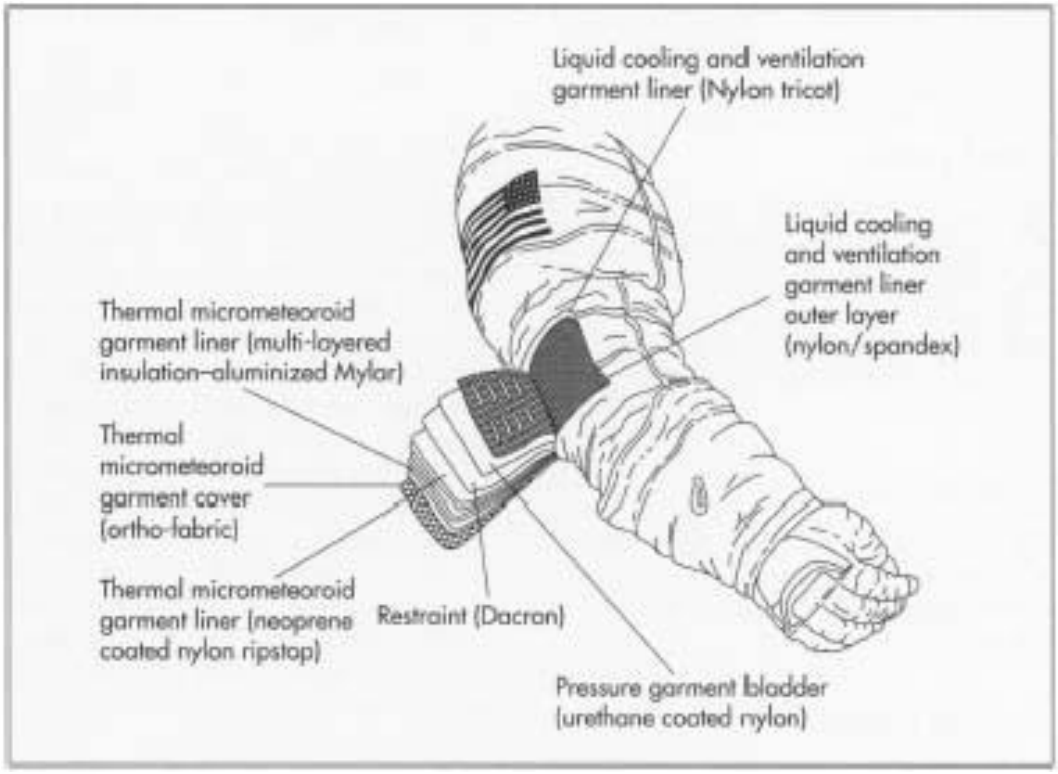




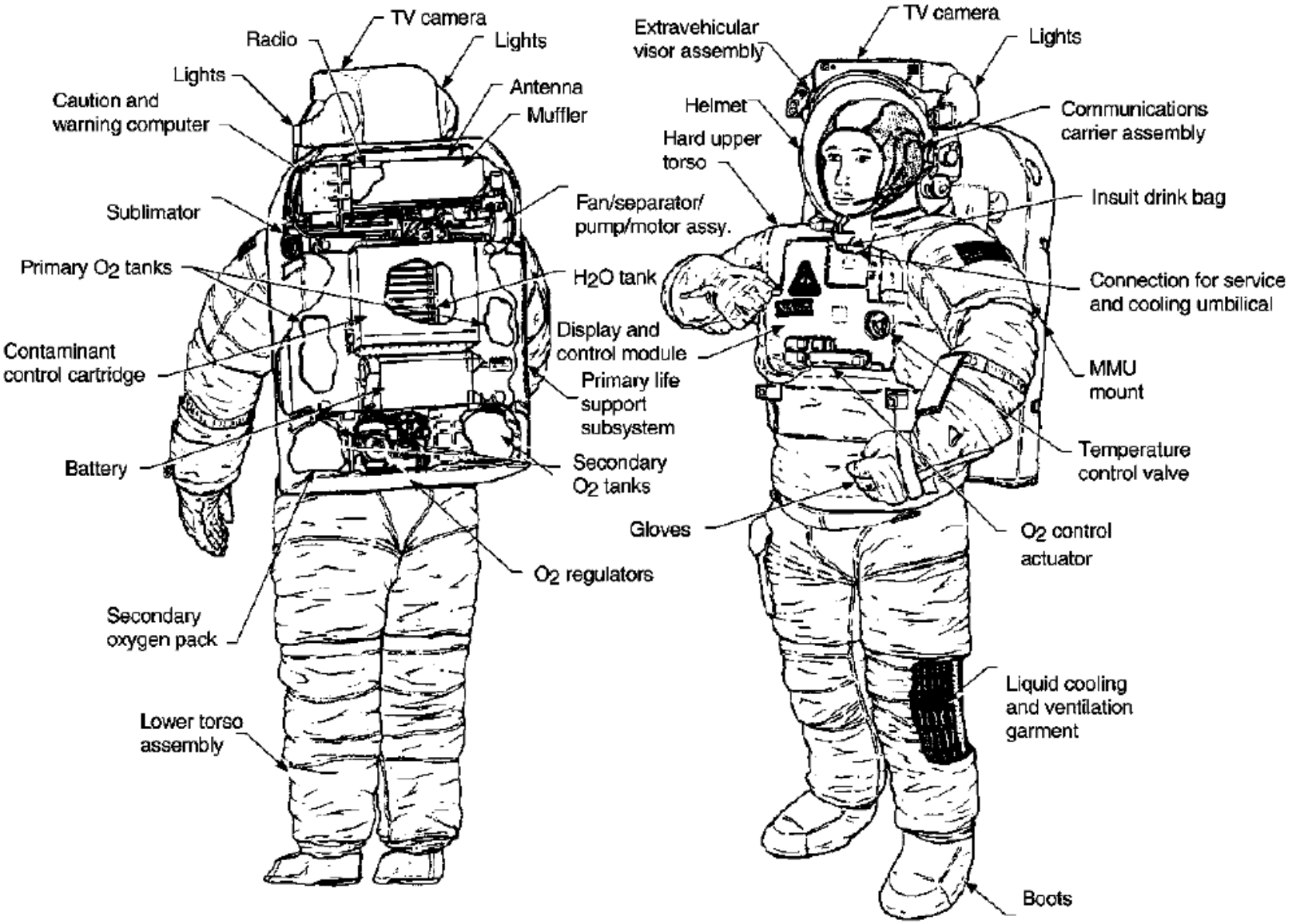
An EMU is made of 14 protective layers. Fabric materials include a variety of different synthetic polymers. The innermost layer is a Nylon tricot material.



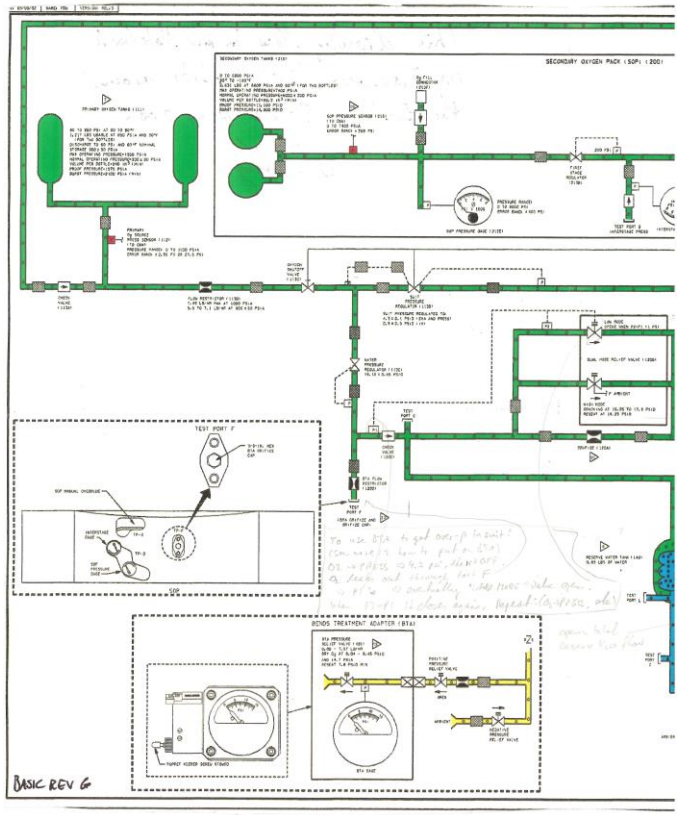
Cross section of material layup used for fabric for the arms and legs of the spacesuit.

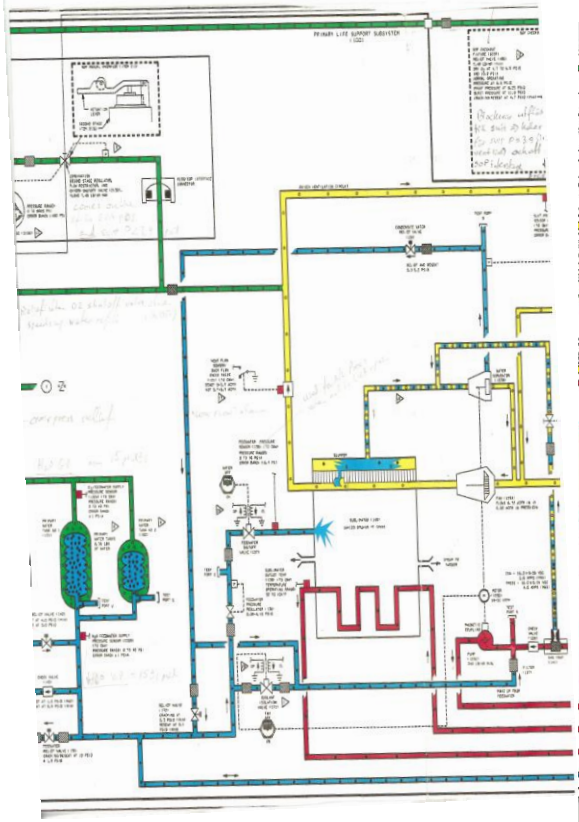


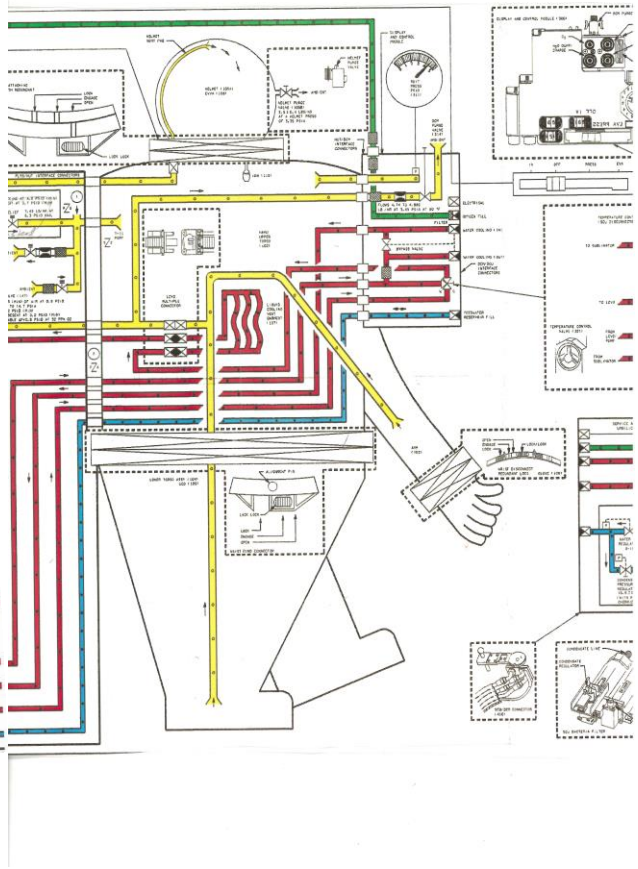
EMU in detail



EMU interior work schematics

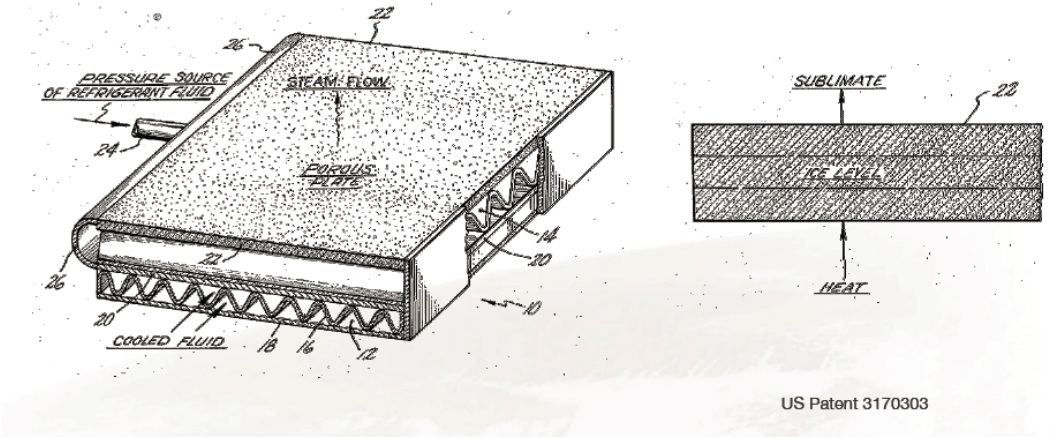






See also paper handout

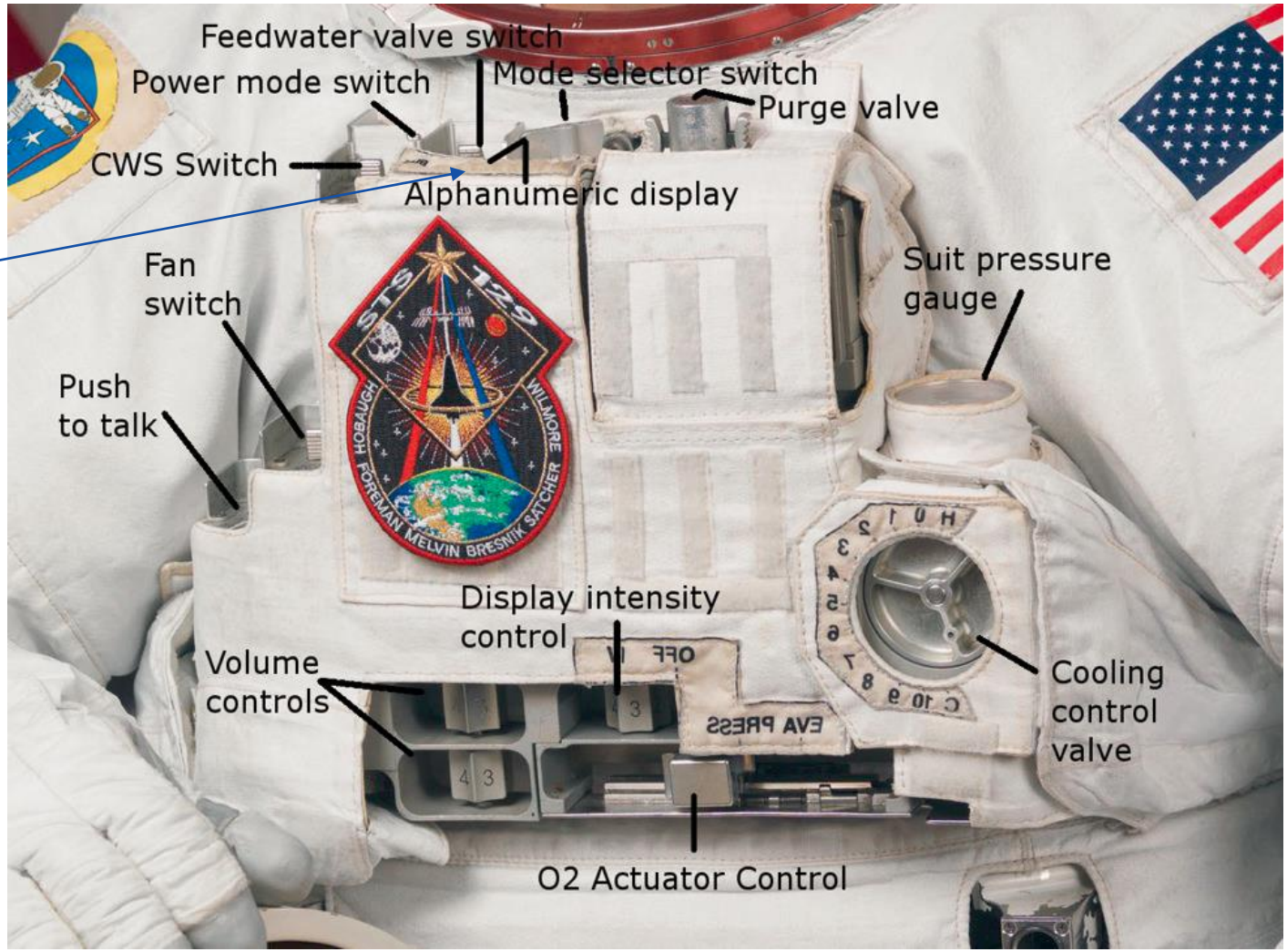
A Sublimator cools the suit (and body)



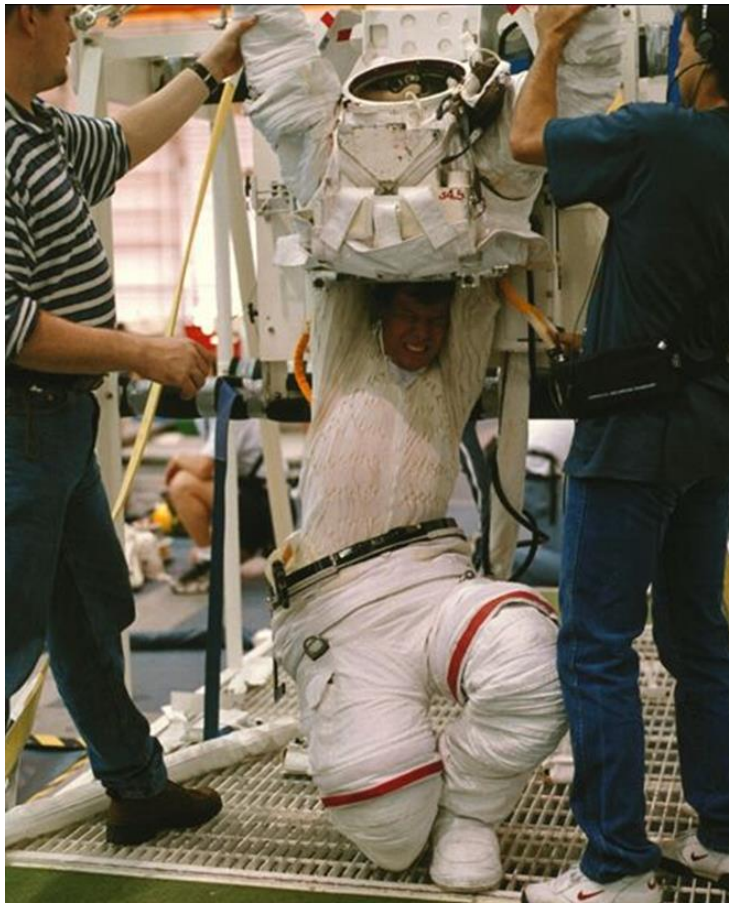
Sublimation is the transition of a substance directly from the solid to the gas phase without passing through an intermediate liquid phase.

The Display and Control Unit

A display shows status of the suit (battery, suit press, O_2 press in tanks and water,...) and gives warning signals

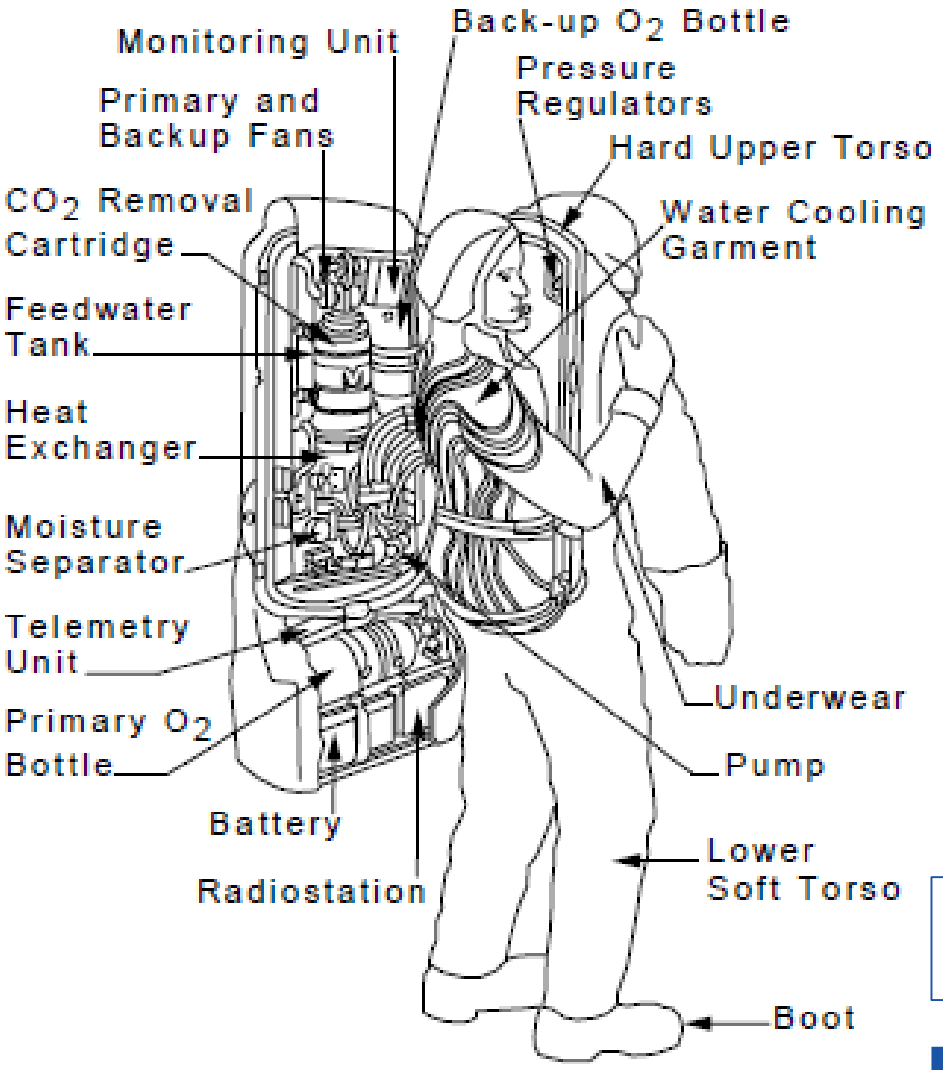


The EMU is hard to don



So you're happy once your in it☺

Russian EVA suit: *Orlan* (= Eagle)



Thomas Reiter w Orlan in Star City 1994

Orlan is easy to don – but less easy to work in. Higher pressure and gloves less good fit.

SOME ORLAN NUMBERS

Suit weight: 120 kg (total)

Primary life support: 7 hours

Pressure: 0.4 atm

Sizing: Somewhat modular

US Airlock: *Quest*

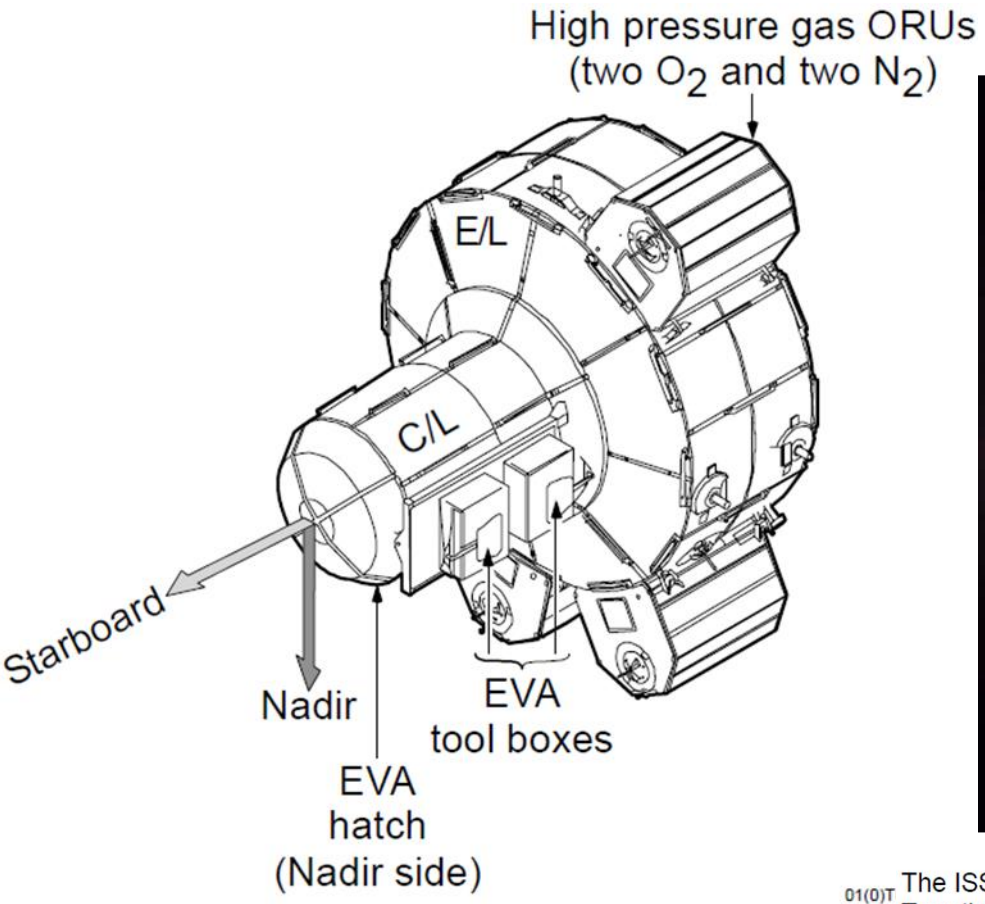
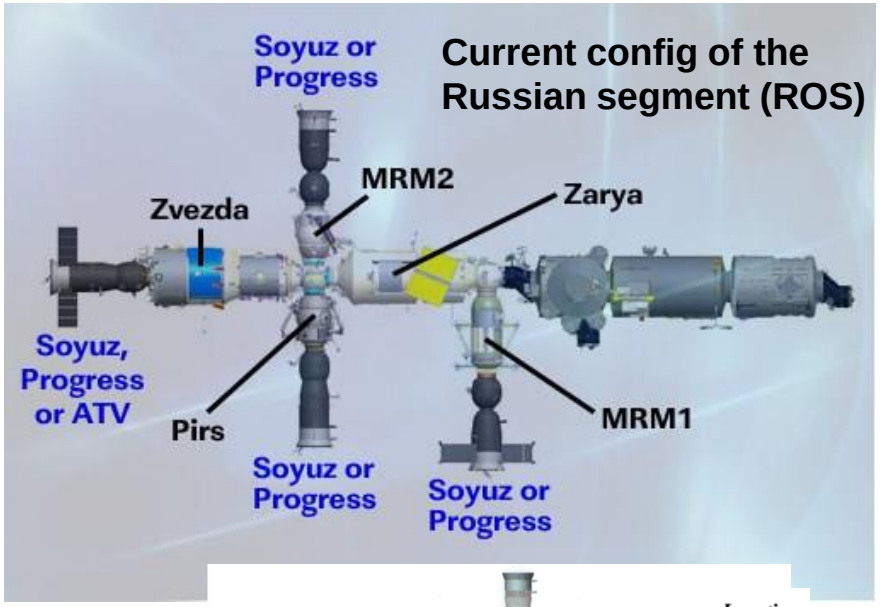
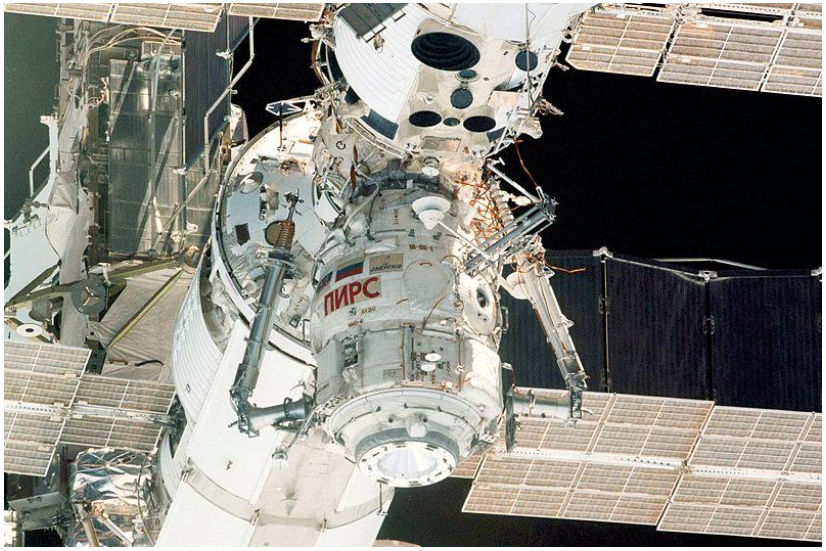


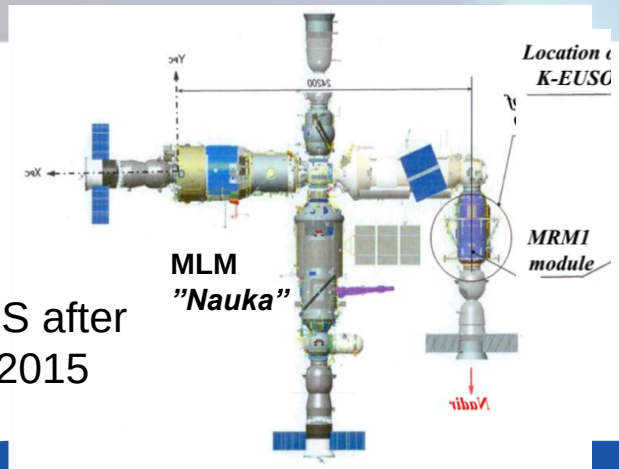
Figure 11-4. Crew lock and equipment lock

01(0)T The ISS Joint Airlock is comprised of the Crew Lock (C/L) and the E/L (Figure 11-4). Together they provide the capability to service, maintain, don/doff, and store EMU and Orlan spacesuits.

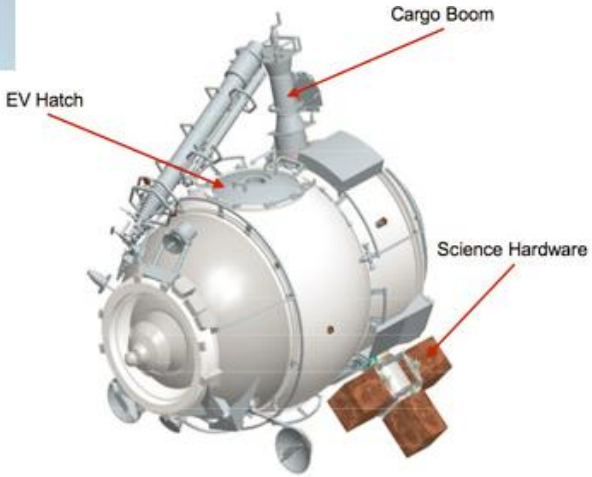
For Orlan-EVA:s currently the airlock is in the *Pirs* module, but later *Poisk* will be used







ROS after ca 2015



The *Poisk* module (a.k.a. MRM-2 Mini-Research Module)

Prepring EVA on-board

Get the EVA suit ready

Find and prepare all tools.

Bring all equipment to the airlock.

Purge your body of N2 (to avoid decompression sickness; similar to divers returning from deep water)

Don the suit

Verify the suit (air tight, fan, pump, communication, cooling,...)

Depressurize the airlock

Open the hatch

AND THEN BE CAREFUL

– BUT ENJOY!

Prep/Post

Table 11-3. Prep/Post EVA procedures

Before an EVA	After an EVA
Airlock Prep This is performed the day before EVA or the day before the orbiter docks to the ISS. The purpose is to configure and activate the airlock	Repress EV crew ingresses and connects to the umbilicals. The IV hatch MPEV is opened to equalize C/L with the E/L. Before the airlock is completely repressed, an airlock pressure integrity check occurs at 5 psi
EMU Checkout These procedures are performed at least 1 day before the EVA. For a series of EVAs, only 1 EMU Checkout would be performed. The purpose of EMU Checkout is to ensure the integrity of the suits EVA Prep This is performed the day of an EVA and includes preparation activities, suit donning, N_2 purge at 14.7, and prebreathe protocol PreBreathe Protocol These procedures have the crewmembers breathe 100% oxygen to eliminate the nitrogen in their bloodstream for the prevention of DCS. There are several different procedures that can be used: campout, 4 hour in-suit, and exercise prebreathe Campout – During "campout," the crew sleeps, or "camps out" in a depressed (10.2 psi) airlock overnight. Prior to camping out in the airlock, a ~1 hr mask prebreathe on 100% O_2 is required. On the day of EVA, the crew performs both a 70 min mask prebreathe and 40 min in-suit prebreathe 4 hour insuit - On the day of EVA, the crew begins EVA Prep, dons the EMU, and breathes 100% O_2 in the EMU for 4 hours Exercise Protocol - On the day of EVA, the crew initiates an 80 min, 100% oxygen mask prebreathe. While on the mask, the crew performs ten minutes of exercise, begins EVA Prep, and then depresses the airlock to 10.2 psi. While at 10.2, the crew will doff their masks, perform EMU Donning, and then repress the airlock back to 14.7psi. This protocol ends with a 40 min in suit prebreathe	Post EVA This is performed directly after repress. EV crew doffs suits at the EDDAs, stows EMU ancillary equipment, recharges O2, cleans the EMU, and temp stows the suit for EMU servicing the next day EMU Servicing This is performed the day after an EVA. Crew recharges batteries, METOX, and EMU feedwater. EMUs should be ready for the next EVA after servicing is complete Airlock Closeout This is performed after the last EVA of a series of EVAs to configure the airlock to a dormant mode until the next scheduled EVA. Airlock equipment is powered down and the racks are secured
Depress EV crew depresses C/L to 2 psi via the depress pump, stopping at 5 psi for a leak check of the EMU. The final depress to vacuum is accomplished by venting the remaining atmosphere through the VAJ via the EVA hatch Emergency MPEV located on the IV hatch bulkhead in the E/L	

Several protocols for prebreathing. More demanding for EMU than Orlan due to lower suit pressure

Execution of EVA led from inside space vehicle, or ground.

- Inside better, since safer communication
- But ground has more resources
- In addition to voice loop, TV-pictures and telemetry on suit status and ECG from astroanuts downlinked
- The EVA conductor has all checklists (EVA-crew can have minor things on a so called cuff lists)

EVA Tools

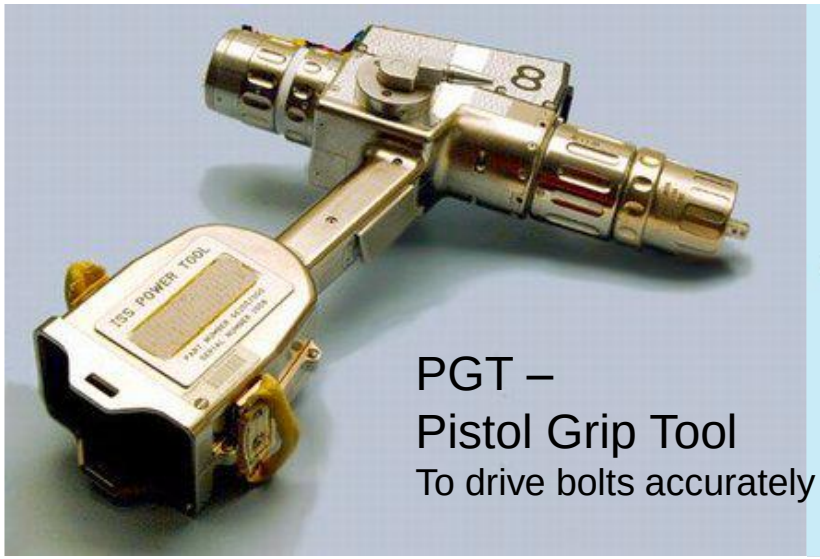
A lot to learn!

Specially designed so can be used with the limited dexterity one has in the suit – in particlar with clumsy gloves

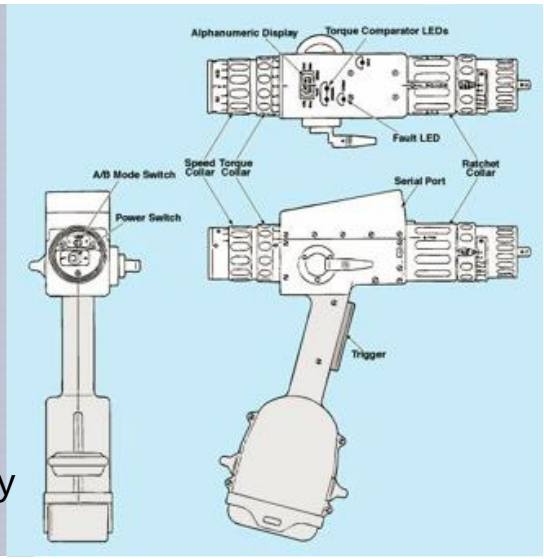
Must be able to function in vaccum.

Tools introduction class at JSC in 2002

Examples
EVA Tools



PGT –
Pistol Grip Tool
To drive bolts accurately



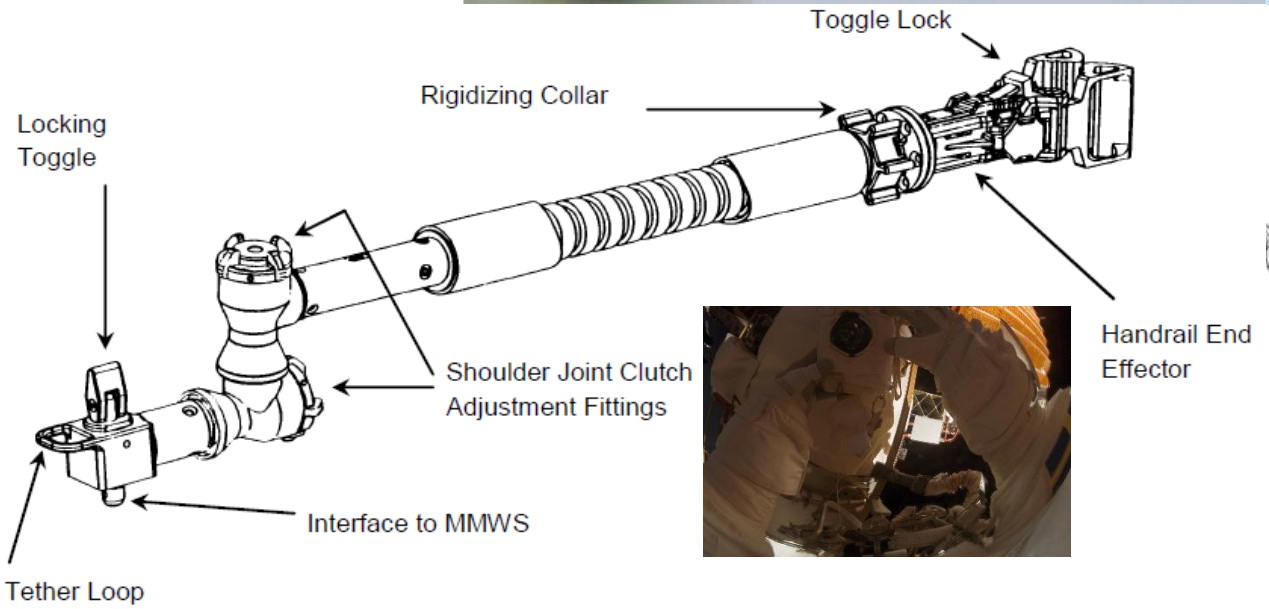


Figure 11-13. Body restraint tether

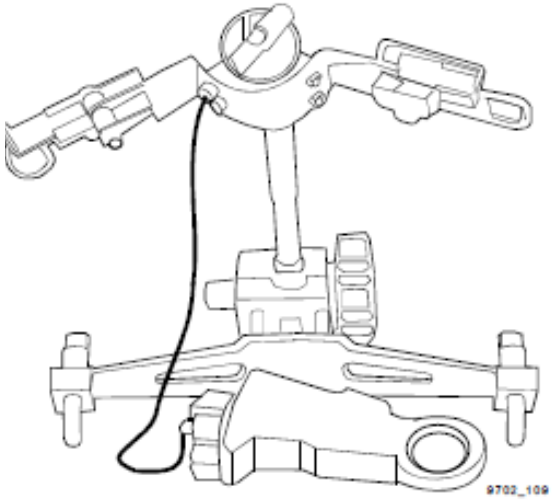
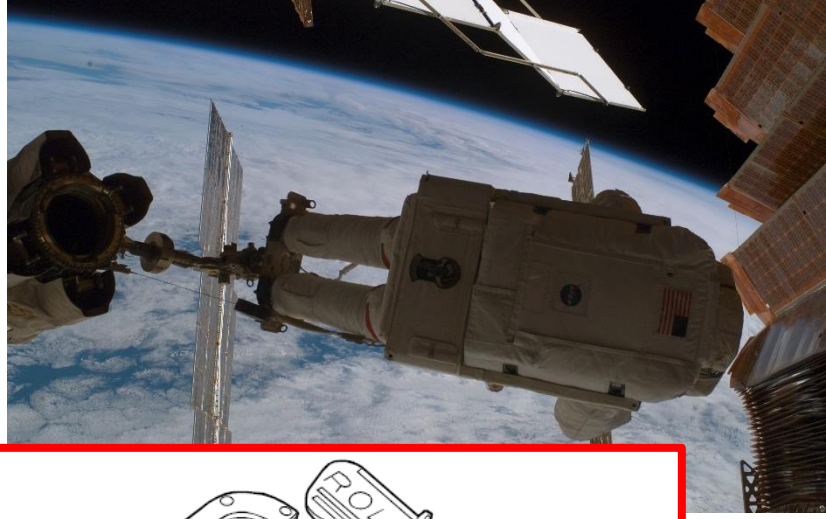


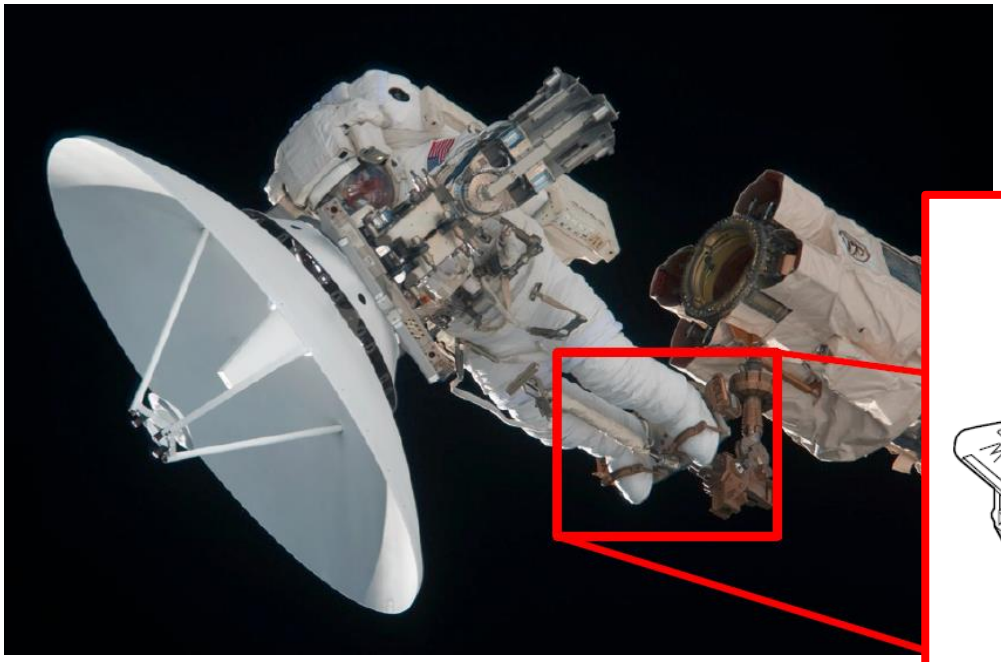
Figure 11-12. Mini-workstation

Carrying the tools around with you

and <u>ALWAYS</u> tethered (if not secured on your suit)

Foot restraints





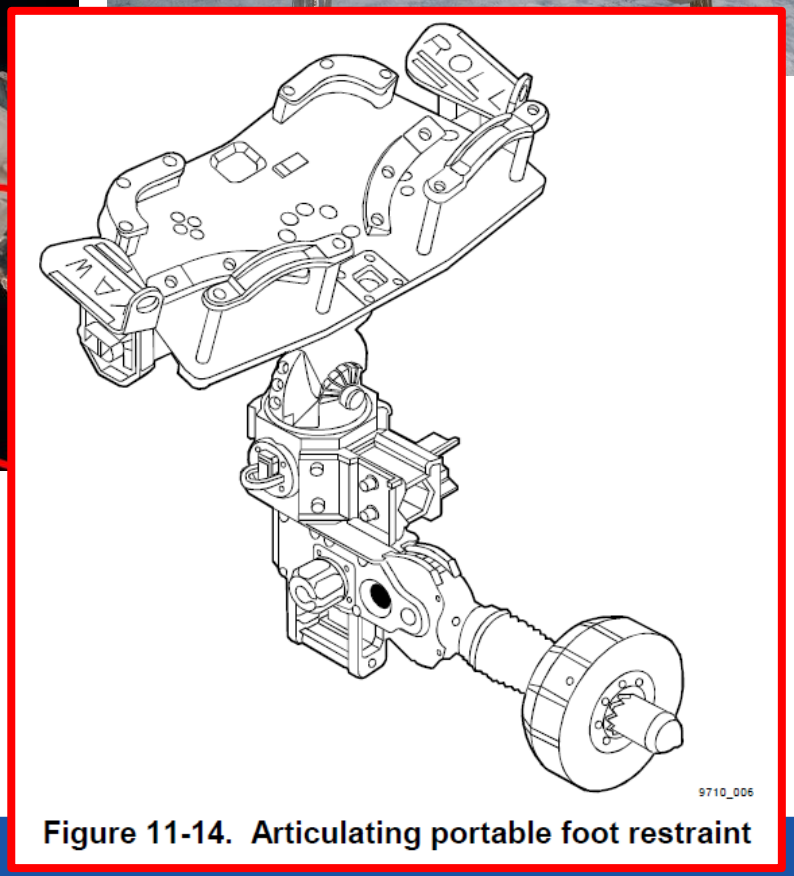
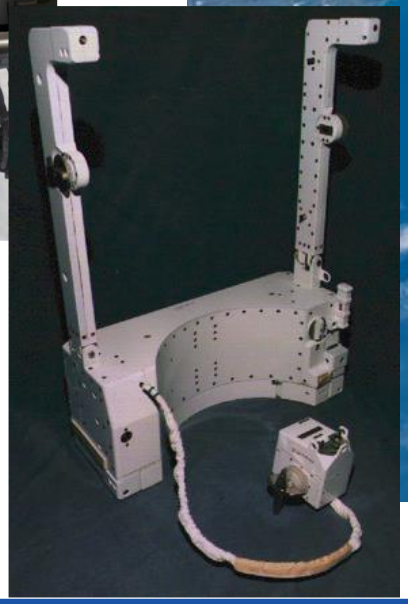


Figure 11-14. Articulating portable foot restraint

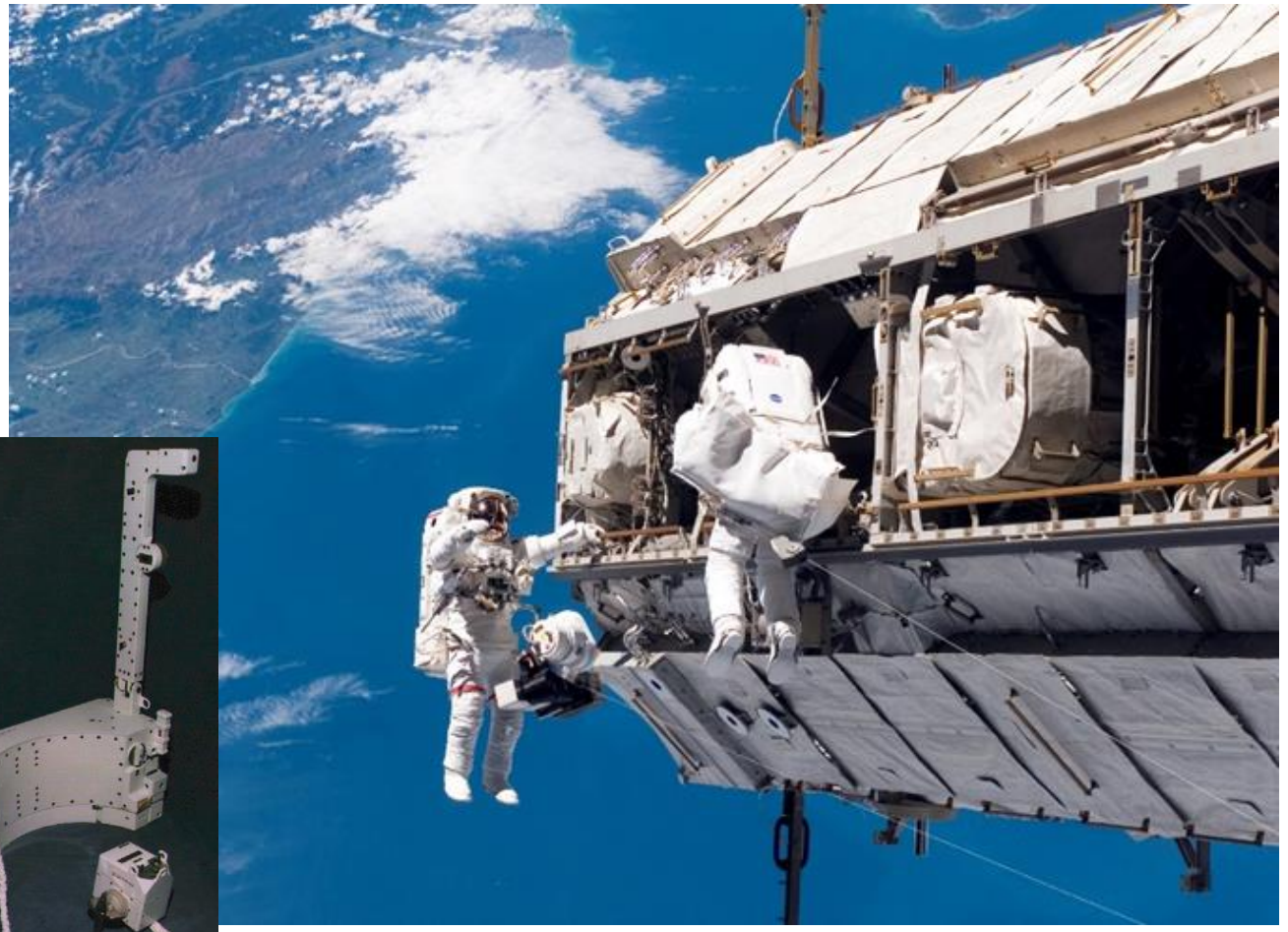
- When you need strong support, and/or two hands/arms, for getting transported on the robotic arm.
- Can be tricky to get into.
- Russian and US foot restraints work differently

Safety! Safety! Safety!

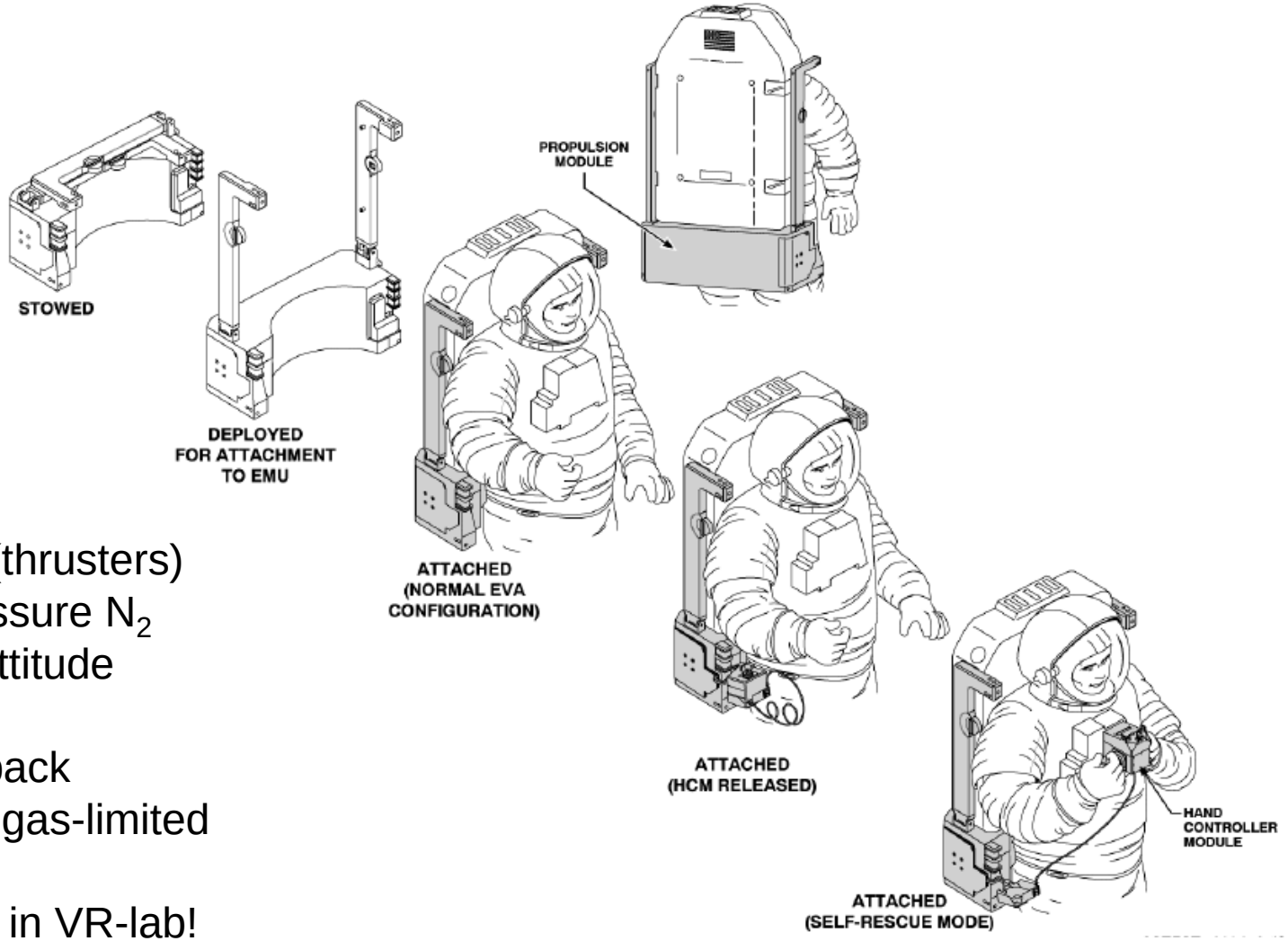
”Thether protocol”, back-up systems, always two people, SAFER



SAFER



SAFER - Simplified Aid For EVA Rescue



- 24 nozzles (thrusters) for high pressure N_2
- Automatic attitude stabilzation
- Manual fly-back
- Battery and gas-limited
- Mass: 38 kg
- Fun training in VR-lab!

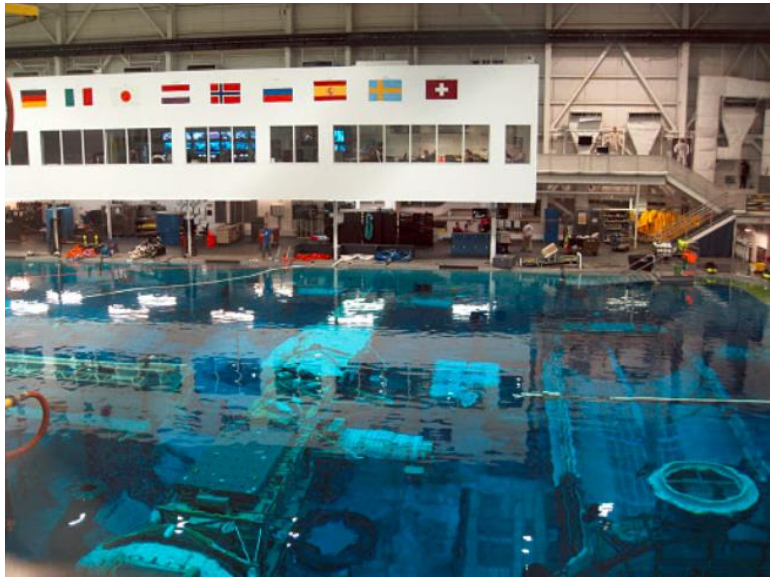
After 49 years and 367 EVAs – so far no fatality – but plenty of incidences

- Water leak – could have drowned Luca Parmitano
- Inflated suit – almost prevented Leonov getting back inside
- Lost grip – saved by safety tether (Gemini 10, shuttle)
- Some suit problems have necessitated terminated EVAs
  (ground is continously monitoring the suit status via telemetry – and the health of the astronaut (ECG)
- Blown ear drums (too fast repress in airlock)
- Damages on gloves – but never any leak.
- Many lost tools and equipments

A website chronicling many problems in human spaceflights: http://www.astronautix.com/articles/thespace.htm

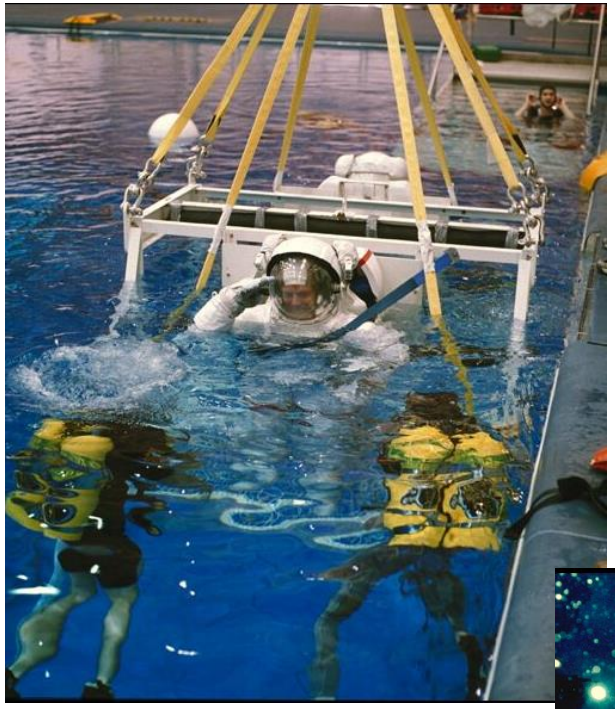
EVA Training – a lot of preparations

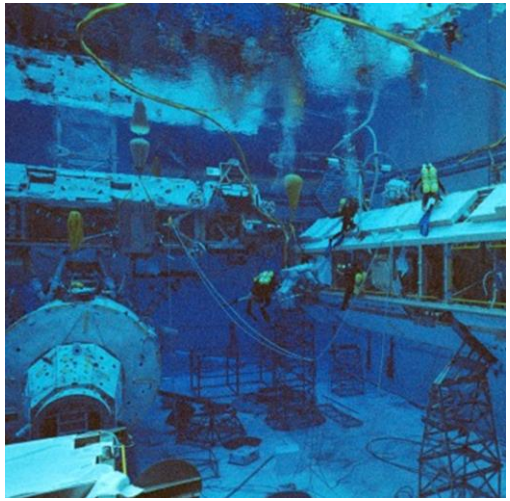
- The suit
  - Theory – how it works; what can go wrong
  - How to prepare the suit, how to fix it, how to re-size
  - Practice (don, doff, test in vaccum chamber)
- The tools
- The airlock
- The work to be done!
  - Help develope checklists
  - Do it in water – over and over again
  - Use VR-lab
  - Other special training facilities
  - Inspect the real hardware, when possible

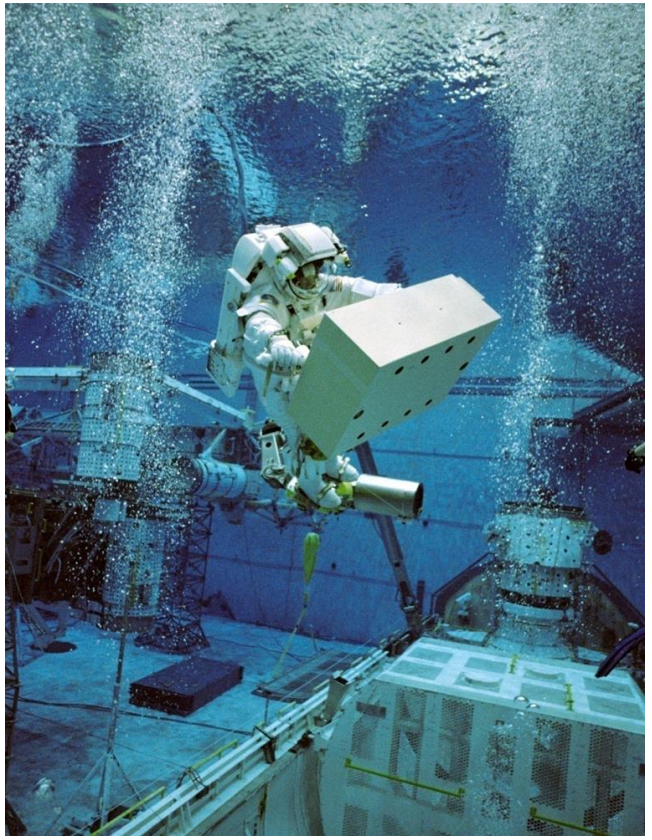


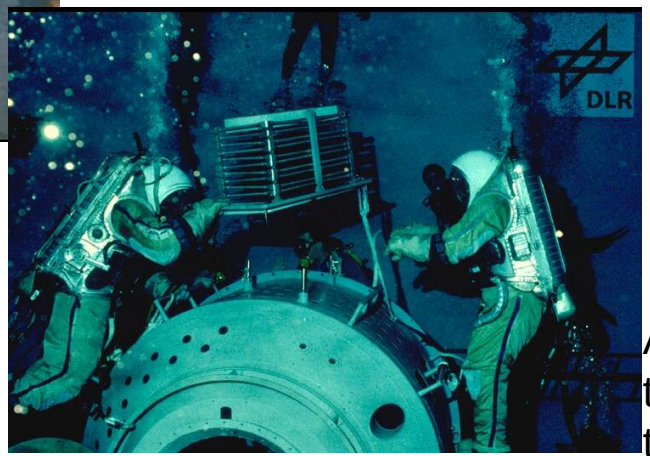
The Neutral Bouyance Lab at JSC

Under-water training for work in space!





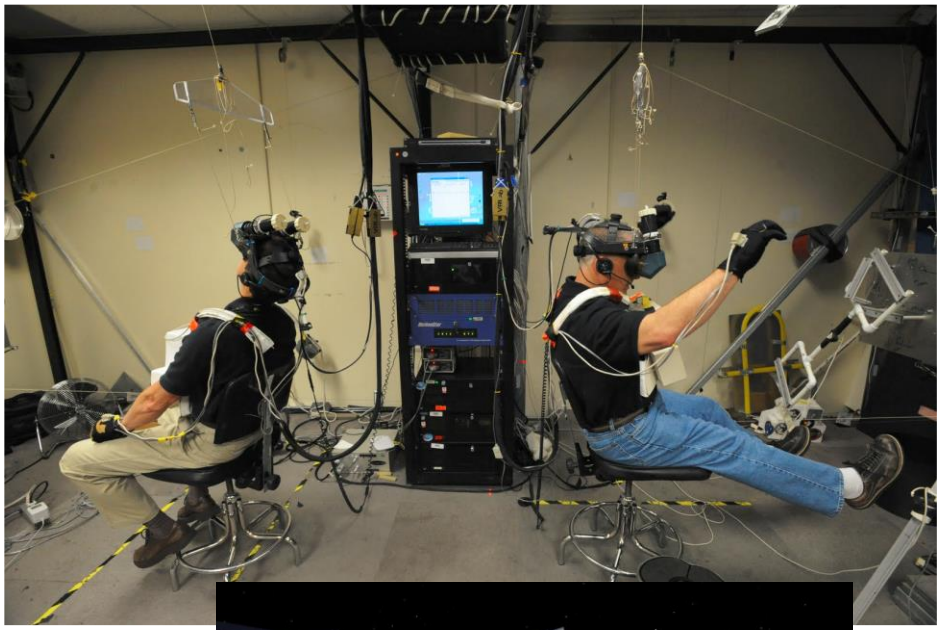




Also in EAC, Cologne, there is a pool for EVA training

Virtual Reality lab and computer models

You see the station, with the sensor gloves you can move around it
A special device simulates the forces (inertial) you would feel handling heavy items.



Future space suits (see Sec 6.5 in Course book)

New suits that can last longer, with less service and better mobility needed.

New suits for the Moonand for Mars

Futuristic thinas with skin-tight garments is the ultimate goal

Possible space suits to replace the present models are known as the Mark III and the I-Suit, both under construction by ILC Dover.

Posing on Mars in 2035?

Summary EVA

- EVA is a very delicate operation
- Must be carefully planned, trained and executed
- Working in an extreme environment:
- Special space suit = 1-person space craft with all life support system for 7-8 h.
- Special tools and eqiupment
- Back-up systems mandatory
- A lot of preparation on-board
- To be more efficient, the EVA is led from inside or ground