

Airlocks and Suitports

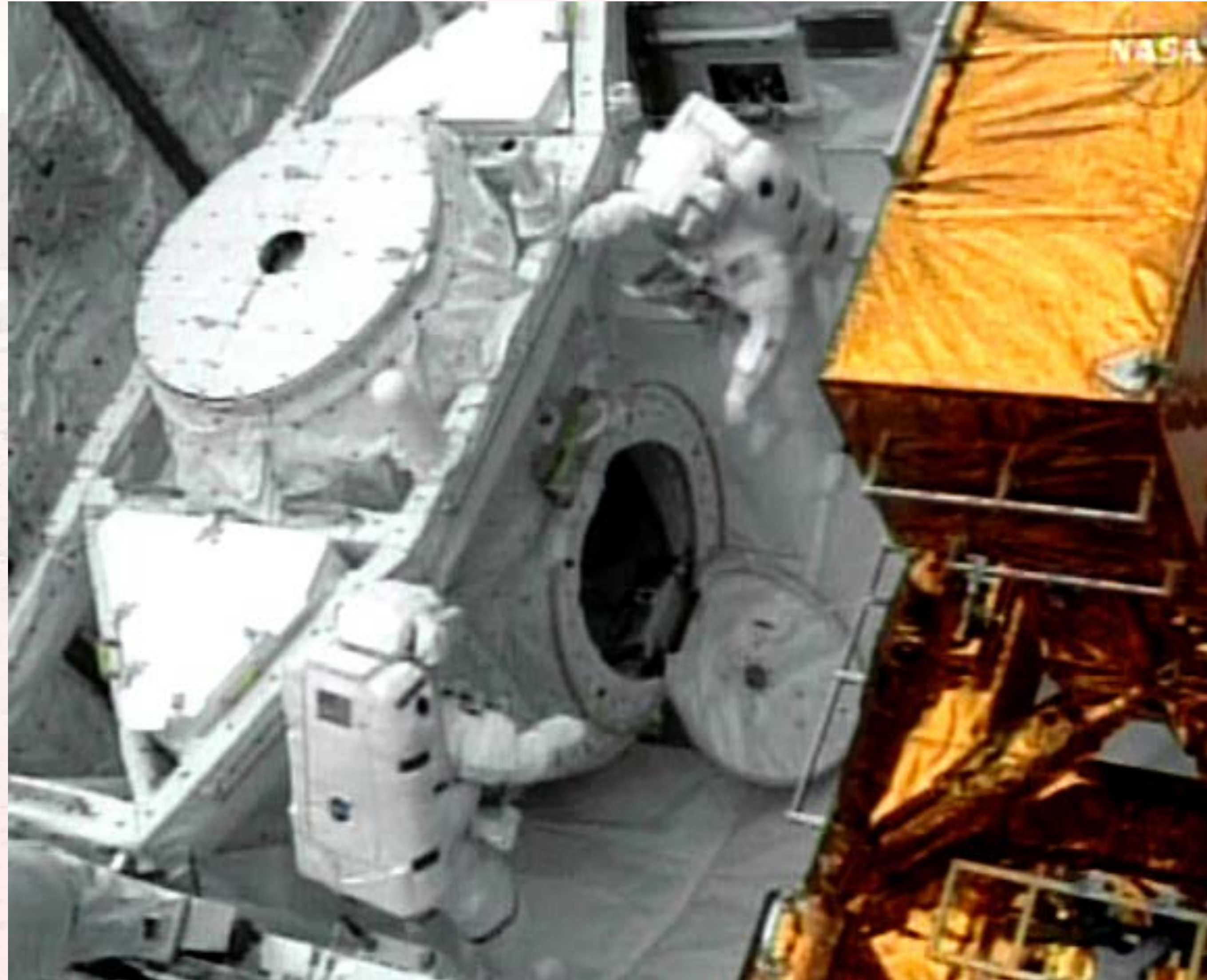
- Early history
- Airlock design and systems
- Suitport concept and instantiations
- Inflatable airlocks
- Reach and access limits in suits
- Logistics, revisited

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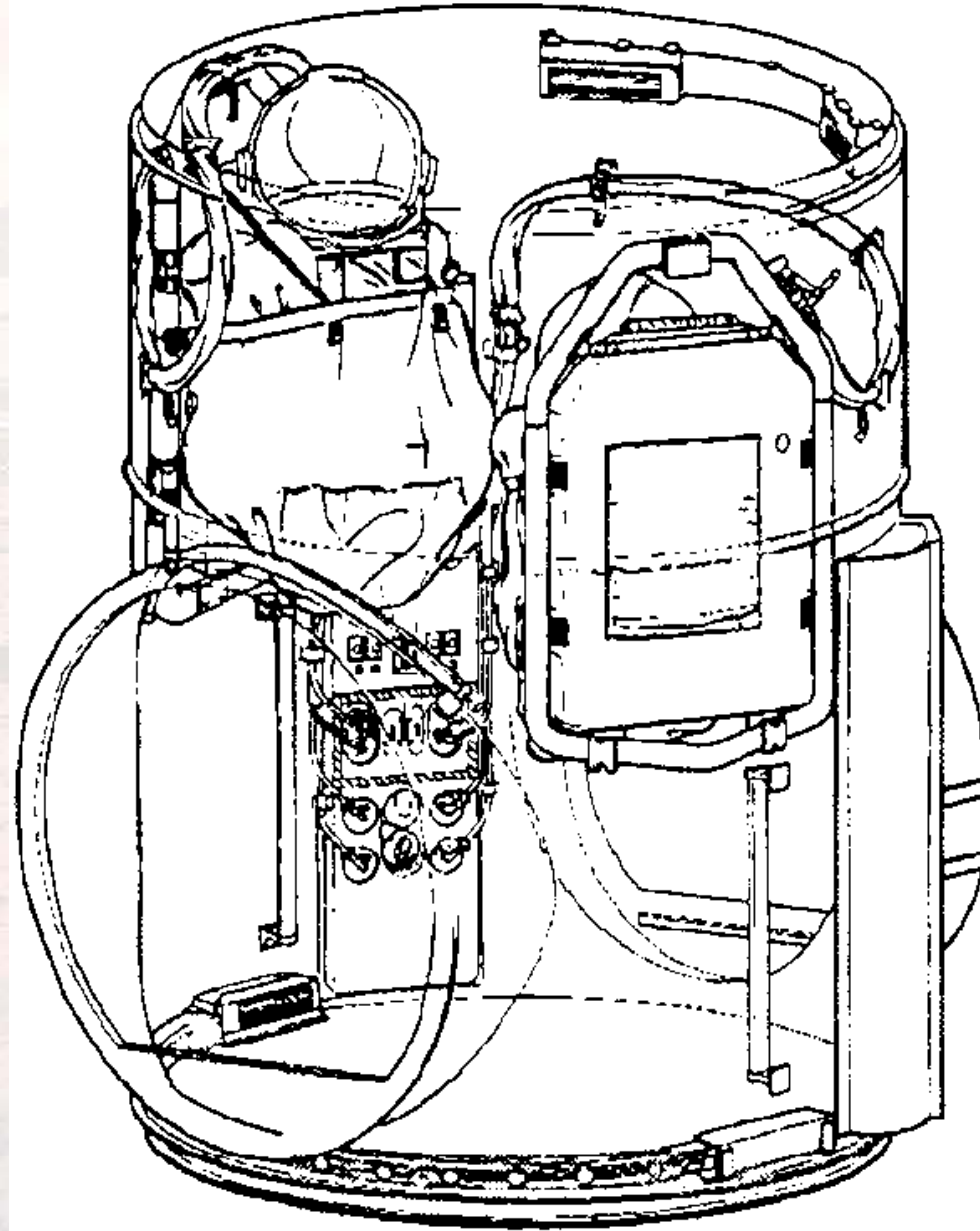
Voshkhod Airlock (Inflatable)



Space Shuttle Airlock (External)



Space Shuttle Airlock Interior



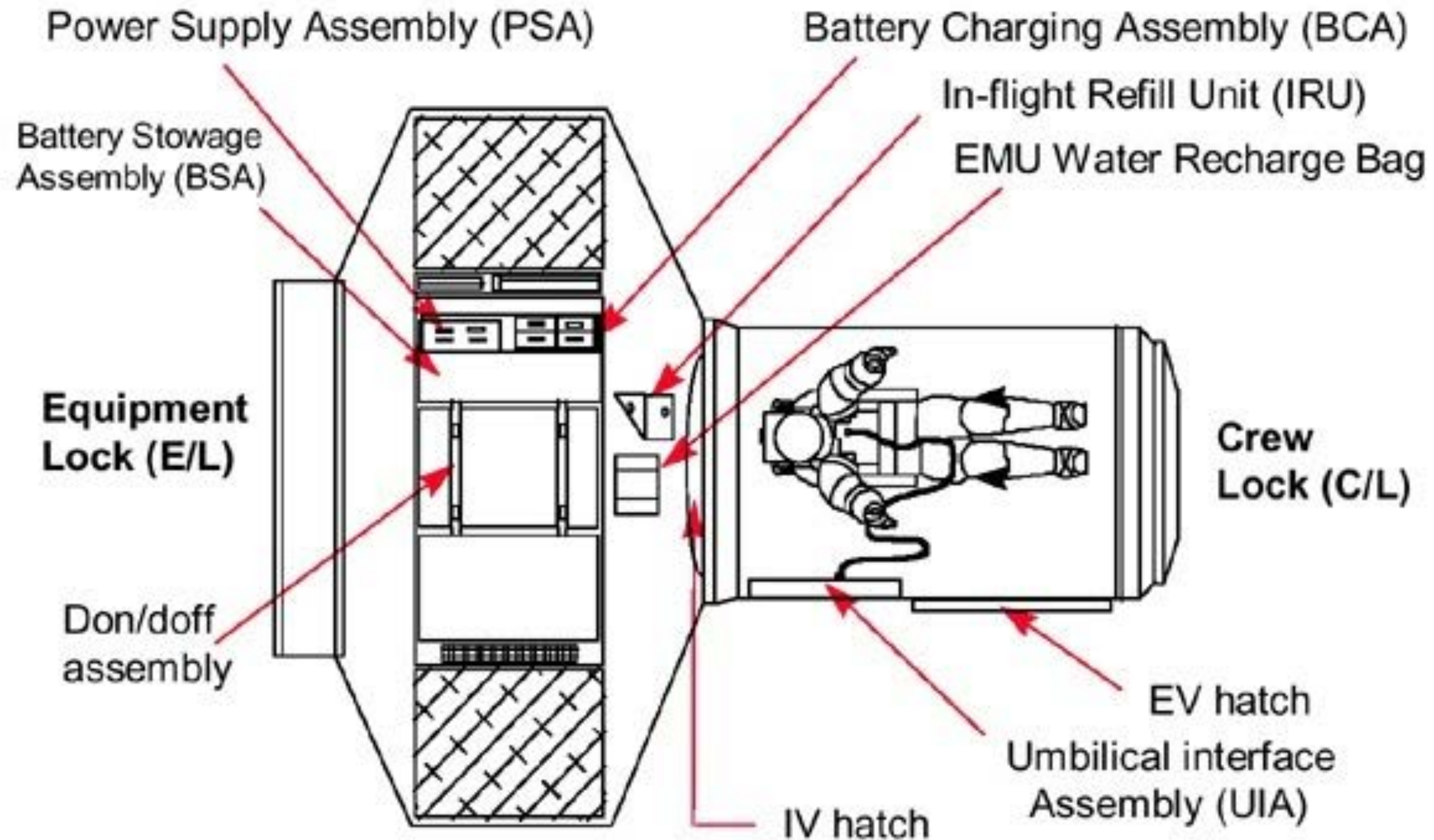
EMU in Shuttle Airlock



ISS Quest Airlock

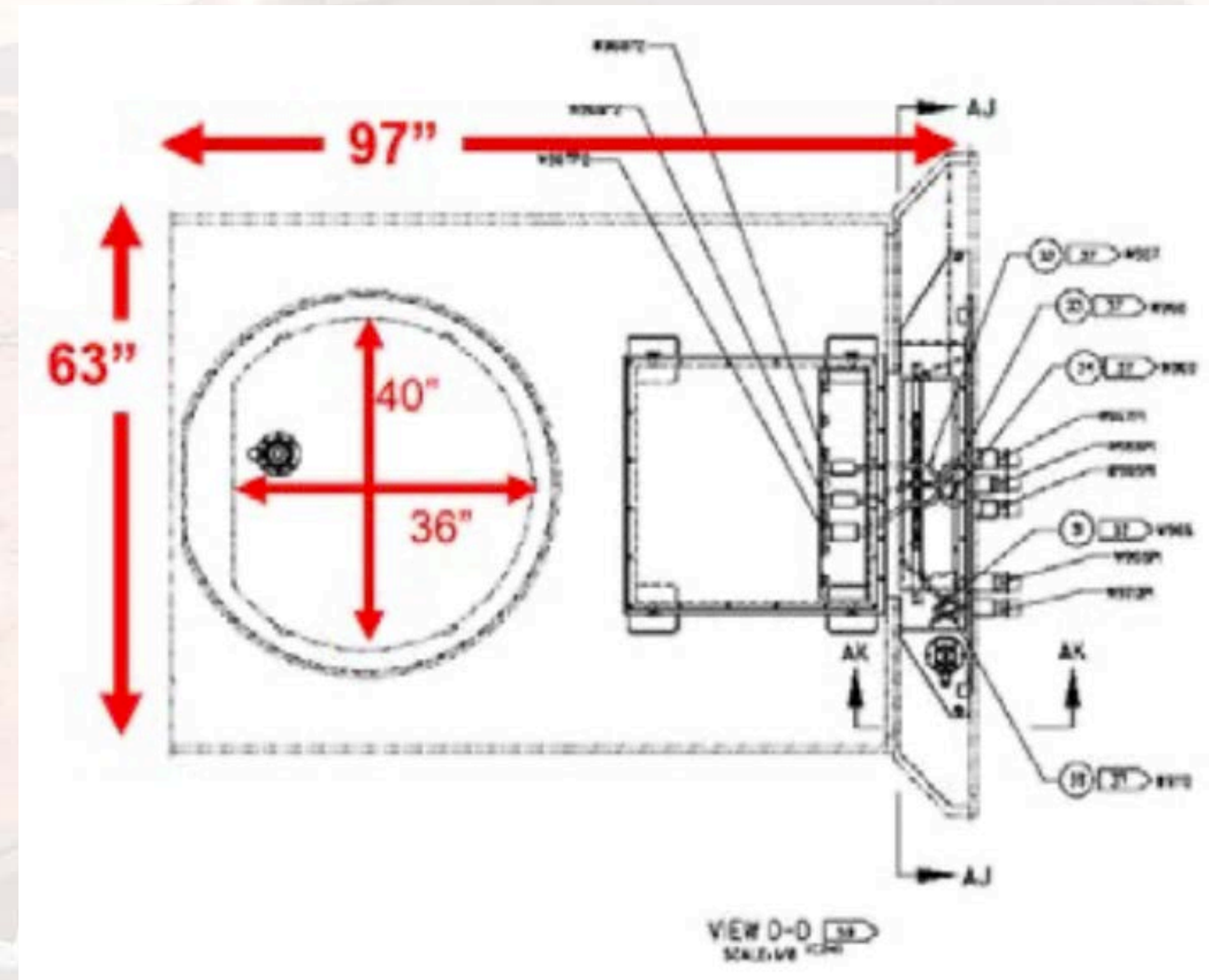


ISS Quest Airlock Interior



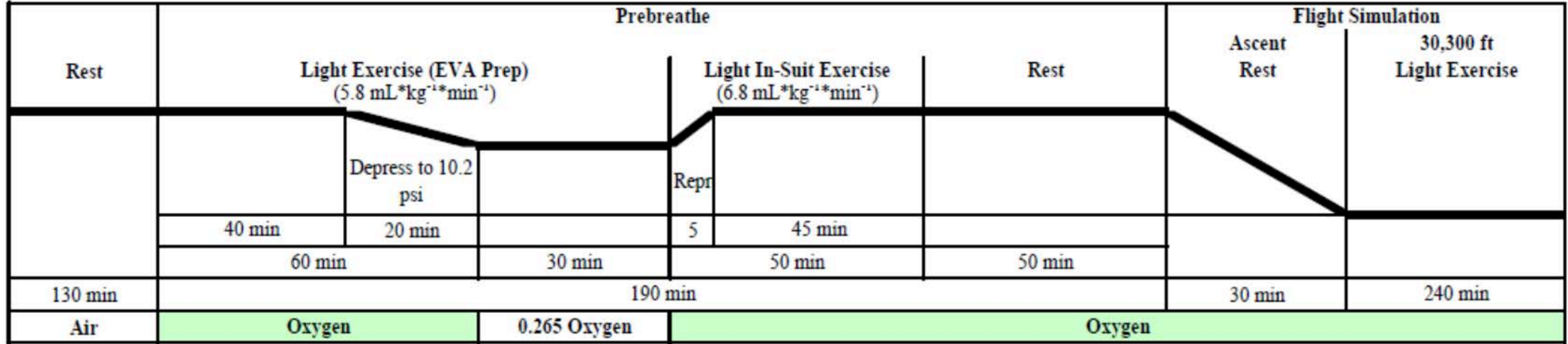
ISS U.S. Airlock Stats

- Crew lock is 5.6 m³
- Equipment lock is 25.7 m
- Air scavenged with 1.5 kW depress pump
- 1 lbm of atmosphere loss per airlock cycle
- Minimum EMU hatch size is 35in diameter
- Equipment lock at 10.2 psi @ 26% O₂ for campout prebreathe

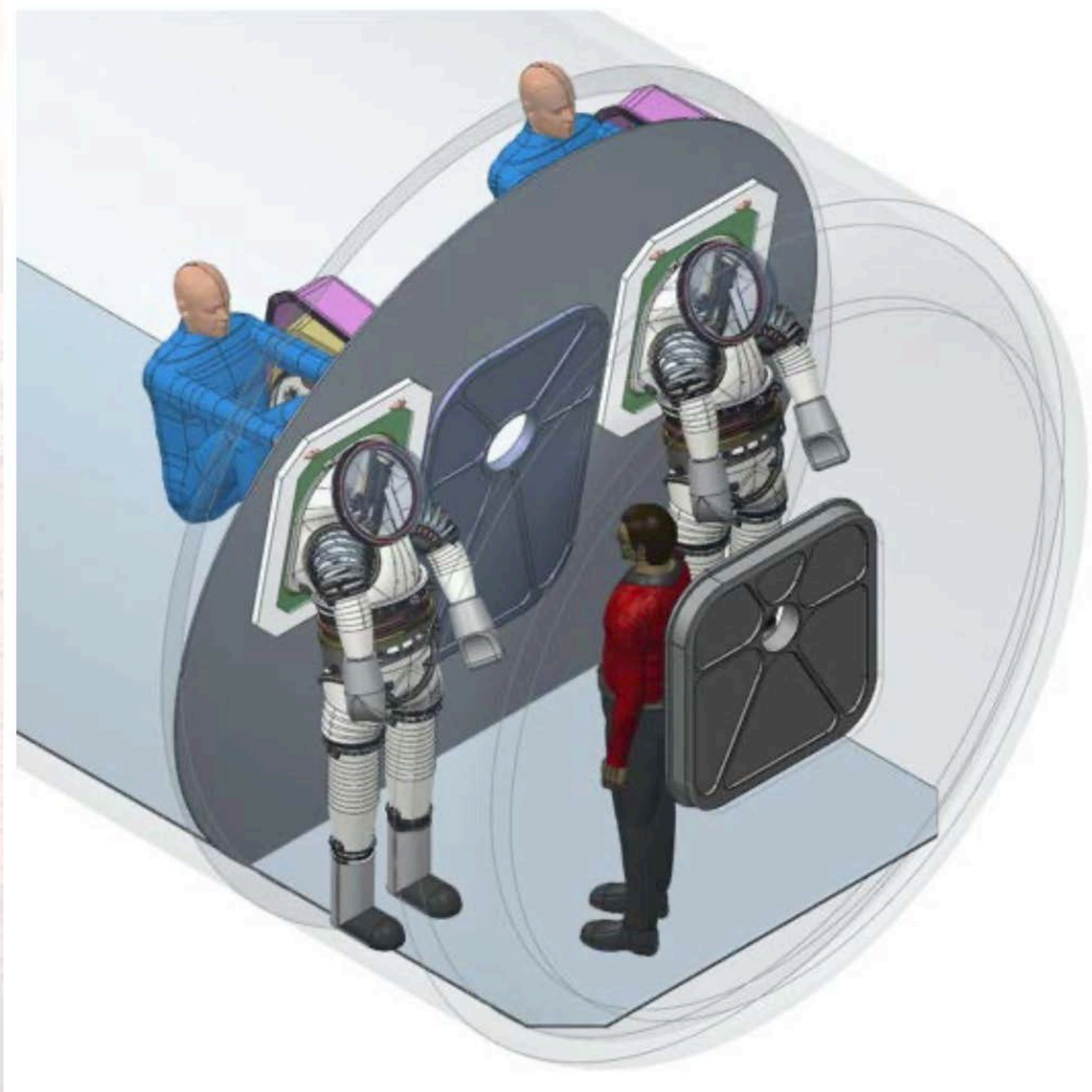


ISS Prebreathe Protocol

The Phase V-5 Protocol consists of 60 minutes of O₂ on mask while performing EVA preparations followed by a 10.2-psi depress (light exercise at 5.8 ml·kg⁻¹·min⁻¹) on enriched air (0.265% O₂). This is followed by a 30-minute suit donning at 10.2 psi, and then 50 minutes of in-suit light activity (6.8 ml·kg⁻¹·min⁻¹), which is equivalent to walking a mile in 70 minutes, breathing O₂. It must be noted that this degree of exercise can be achieved with minimal effort. There is a final 50-minute in-suit prebreathe at rest, breathing O₂.



Suitport Airlock Concept





EVAs per Scenario (alternative concepts highlighted in red)



EARTH RELIANT

PROVING GROUND

EARTH INDEPENDENT



ISS

- Microgravity
- 8 EVAs/year
- 7 hr EVA duration
- 14.7/10.2 psid module pressure with ISS Joint A/L equipment lock and crewlock
- EMU Upgrades
- **Exploration EVA demonstrations with 8.2/4.3 psid suit**
- **Limited alternative atmosphere testing**

Asteroid Redirect Mission

- Microgravity
- 2 EVAs
- 4 hr EVA duration
- Orion depress
- PLSS demonstration on MACES suit
- Sample handling and return
- EVA Tools
- Non-engineered surface

Proving Ground Scenarios

- Microgravity
- Contingency EVAs
- 8 hr EVA duration
- **8.2/4.3 psid suit**
- 14.7/10.2 psid module pressure w/ TBD A/L or common ingress/egress w/other DRMs
- EVA Tools
- Sample handling and return
- Deep space testing on radiation mitigation and possibly dust mitigation
- **Exploration EVA demonstrations with 8.2/4.3 psid suit**

Mars Transit Habitat

- Microgravity
- Contingency EVA only
- 8 hr EVA duration
- **8.2/4.3 psid suit**
- Spacecraft life testing in deep space
- Up to 1100 day Deep Space Habitat including long duration dormancy time periods
- **14.7/10.2 psid module pressure w/ TBD A/L or common ingress/egress w/other DRMs**
- **Suit Maintenance**

Mars Moons

- **Milligravity**
- **8.2/4.3 psid suit**
- **Pressurized Excursion Vehicles w/ suitports w/ 8.2 psid module pressure (8.2 psia/34% O2)**
- **Weekly EVAs**
- 3 to 8 hr EVA duration
- **Dust Mitigation**
- Up to 500 day Phobos Habitat w/ long duration dormancy time periods
- **14.7/10.2 psid module pressure w/ Suit Maintenance (rear-entry airlock or next gen airlock)**
- **Non-engineered surface**

Mars Surface

- **3/8 g Walking Suit**
- **8.2/4.3 psid suit**
- **Pressurized Rovers w/ suitports w/ 8.2 psid module pressure (8.2 psia/34% O2)**
- **Weekly EVAs**
- 3 to 8 hr EVA duration
- **Dust Mitigation & Planetary Protection**
- Up to 500 day Surface Habitat w/ long duration dormancy time periods
- **14.7/10.2 psid module pressure w/ Suit Maintenance (rear-entry airlock or next gen airlock)**
- **Comm. Delay**
- **CO2 Removal in CO2 atmosphere**
- **Convective Thermal Protection**

Lunar Surface

- International Partner led collaboration
- **1/6 g Walking Suit**
- X EVAs
- **8.2/4.3 psid suit**
- Up to 8 hr EVA duration
- **TBD Pressurized Rovers w/ suitports w/8.2 psid module pressure (8.2 psia/34% O2)**
- **Dust Mitigation**



ILC Inflatable Habitat and Airlock



Honeywell Inflatable Airlock (axial)



UMd Inflatable Airlock at JSC



UMd Airlock Internal Rigidizing Structure

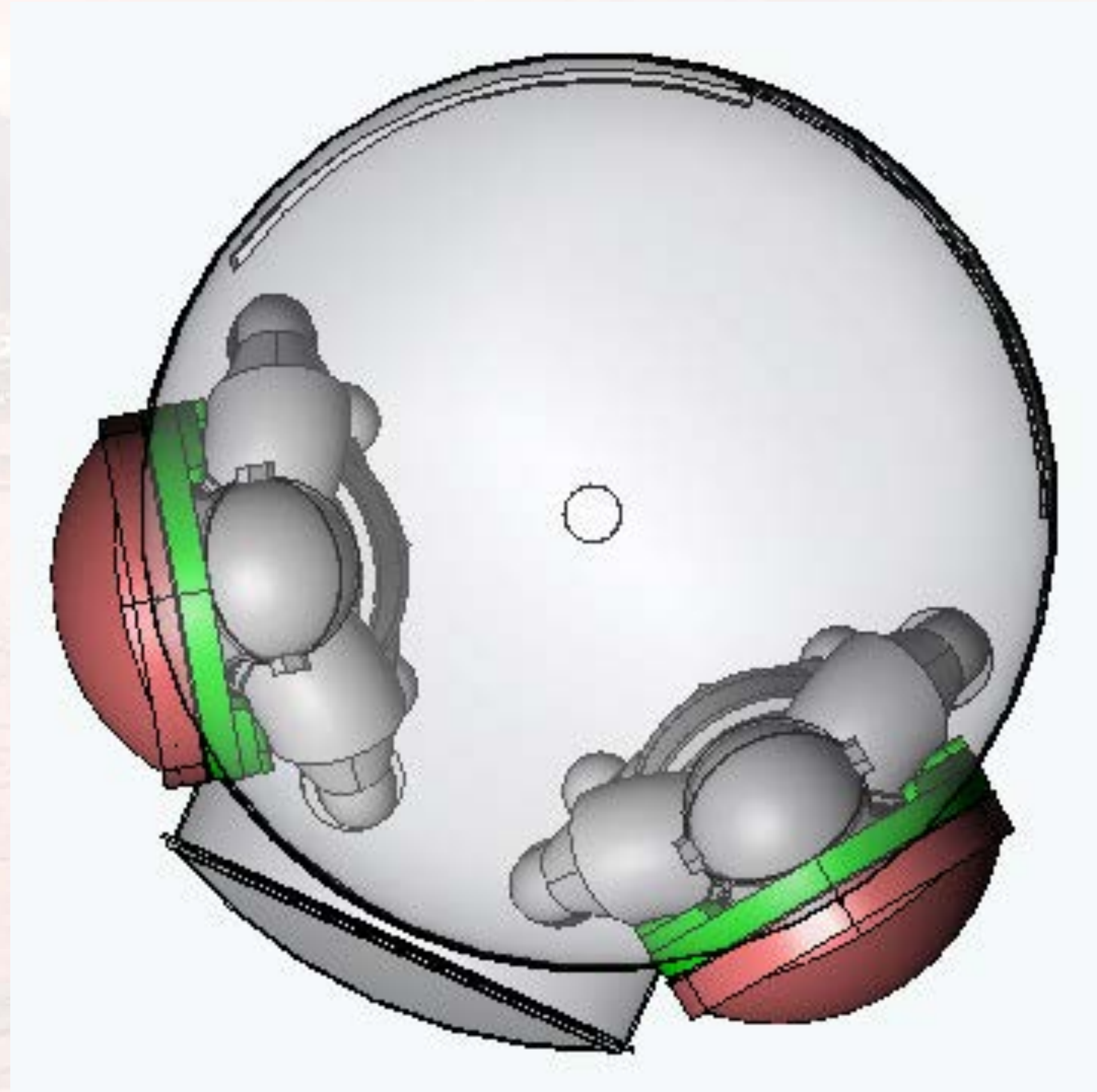
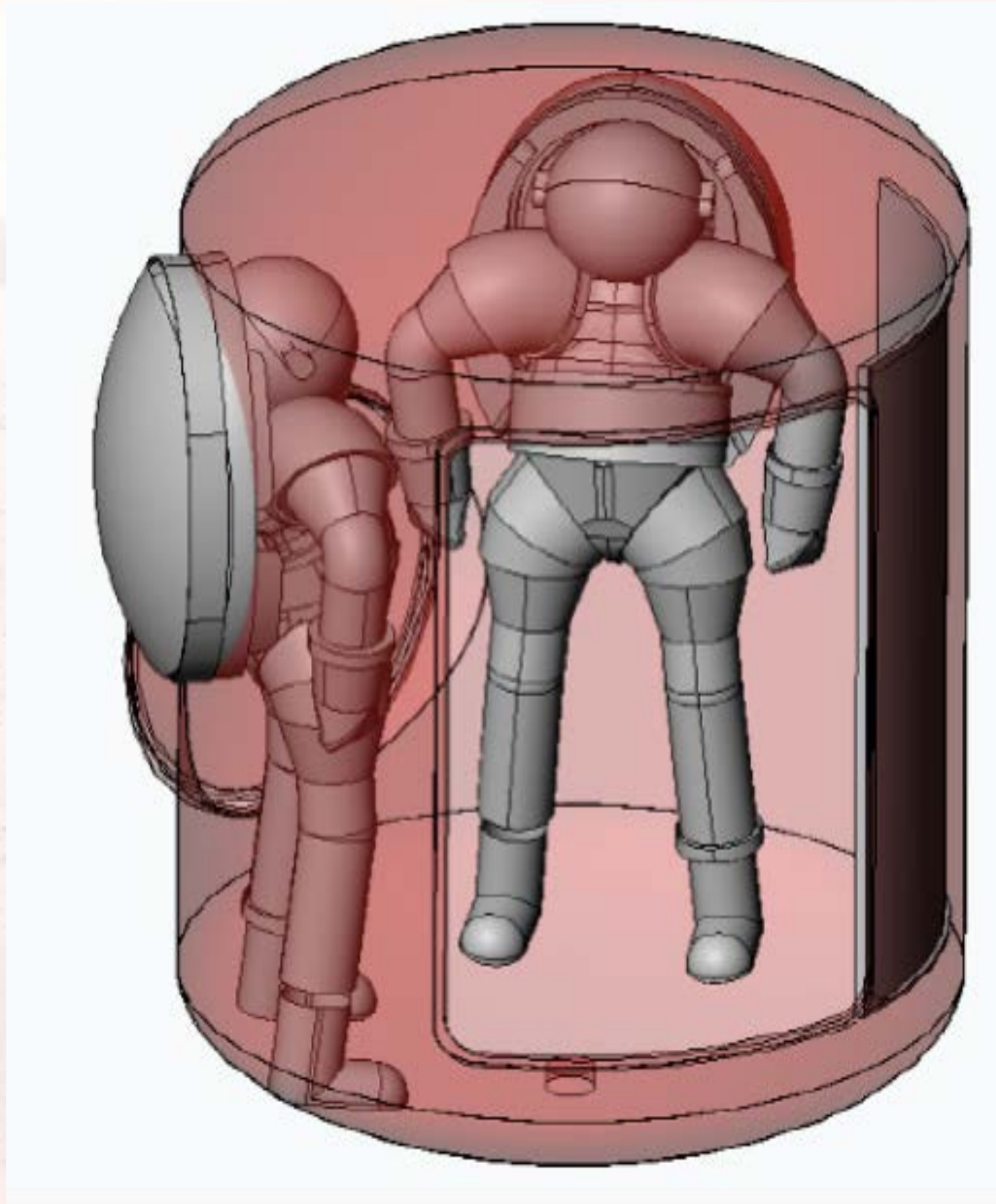


LSAT Airlock

- 5.5 m³
- Air density 0.6664 kg / m³ (8 psi with 32% O₂)
- Loses 0.128 kg of O₂, 0.272 kg of N₂ per depress
- Depress time 0.7 hrs



LSAT Suitlock

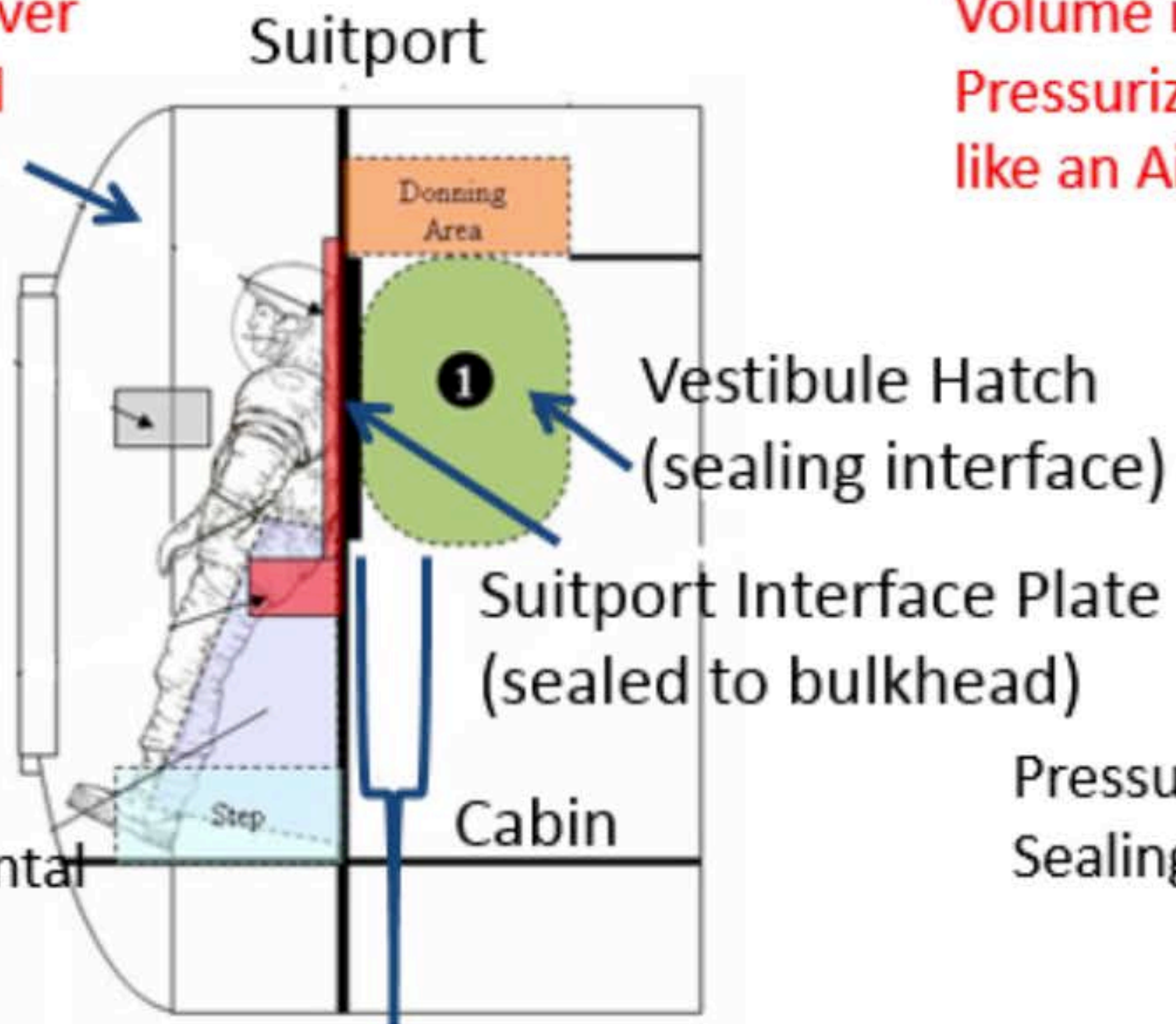


Z-1 Suit in Suitport Test



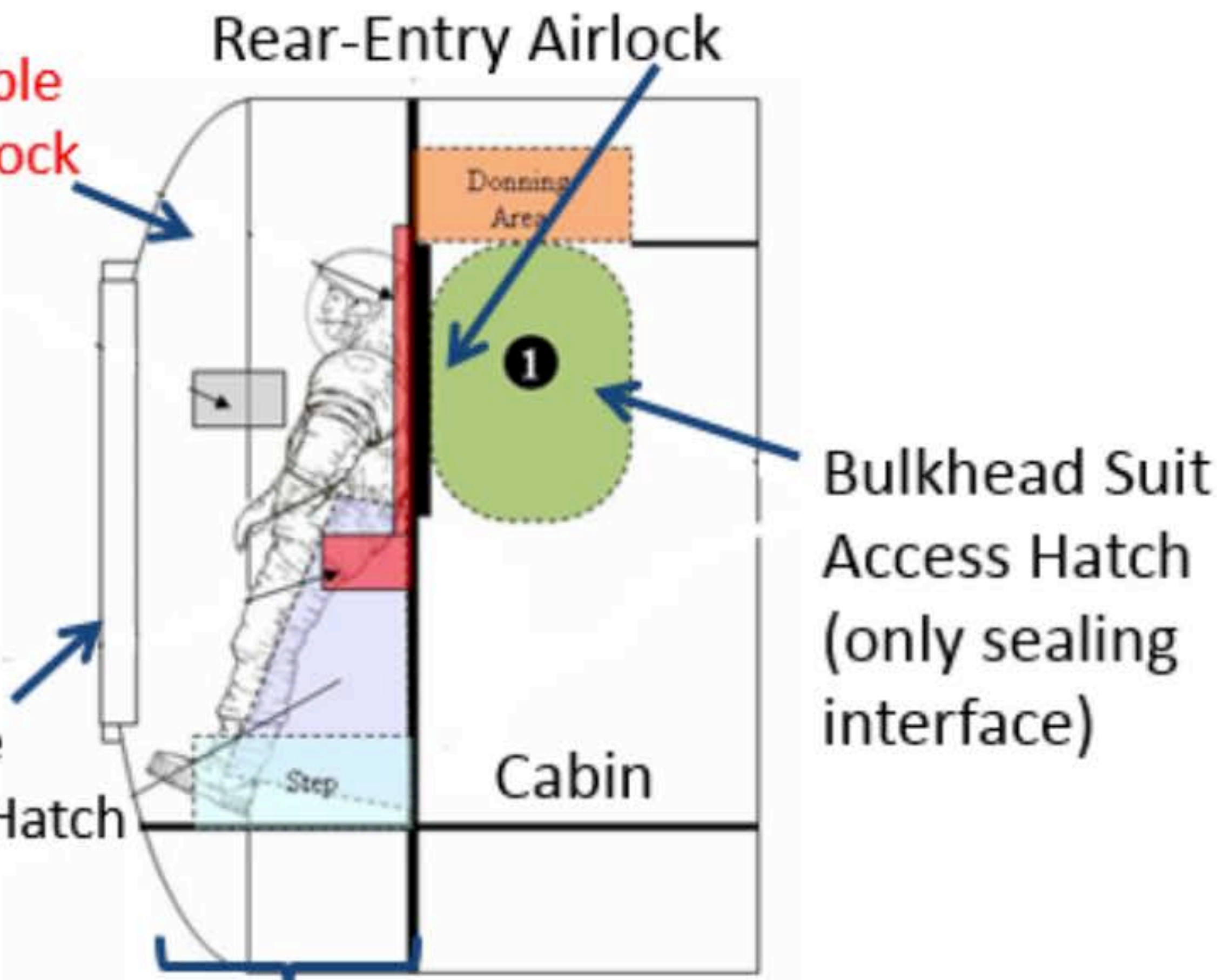
Suitport and Rear-Entry Airlock Differences

Volume Never Pressurized



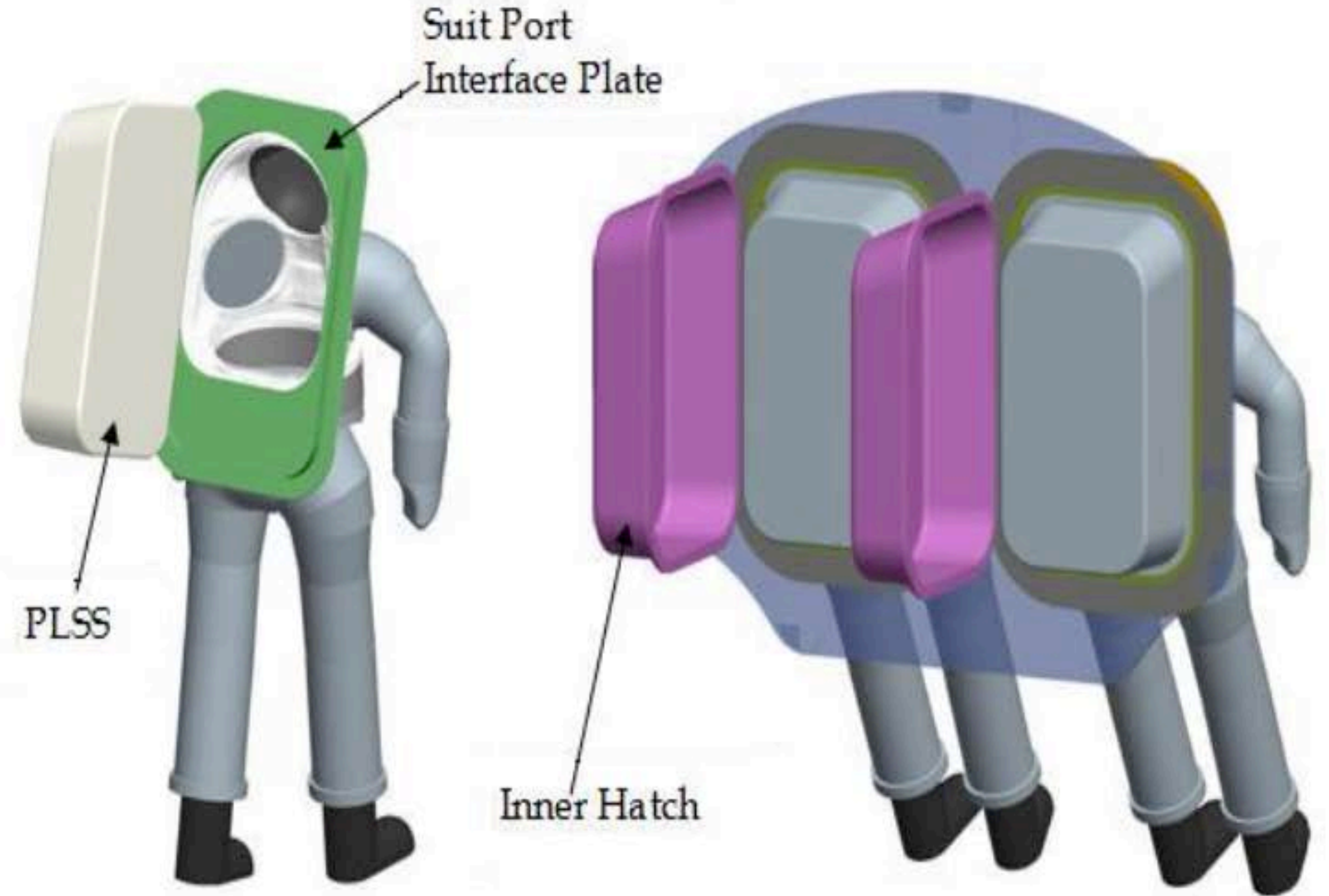
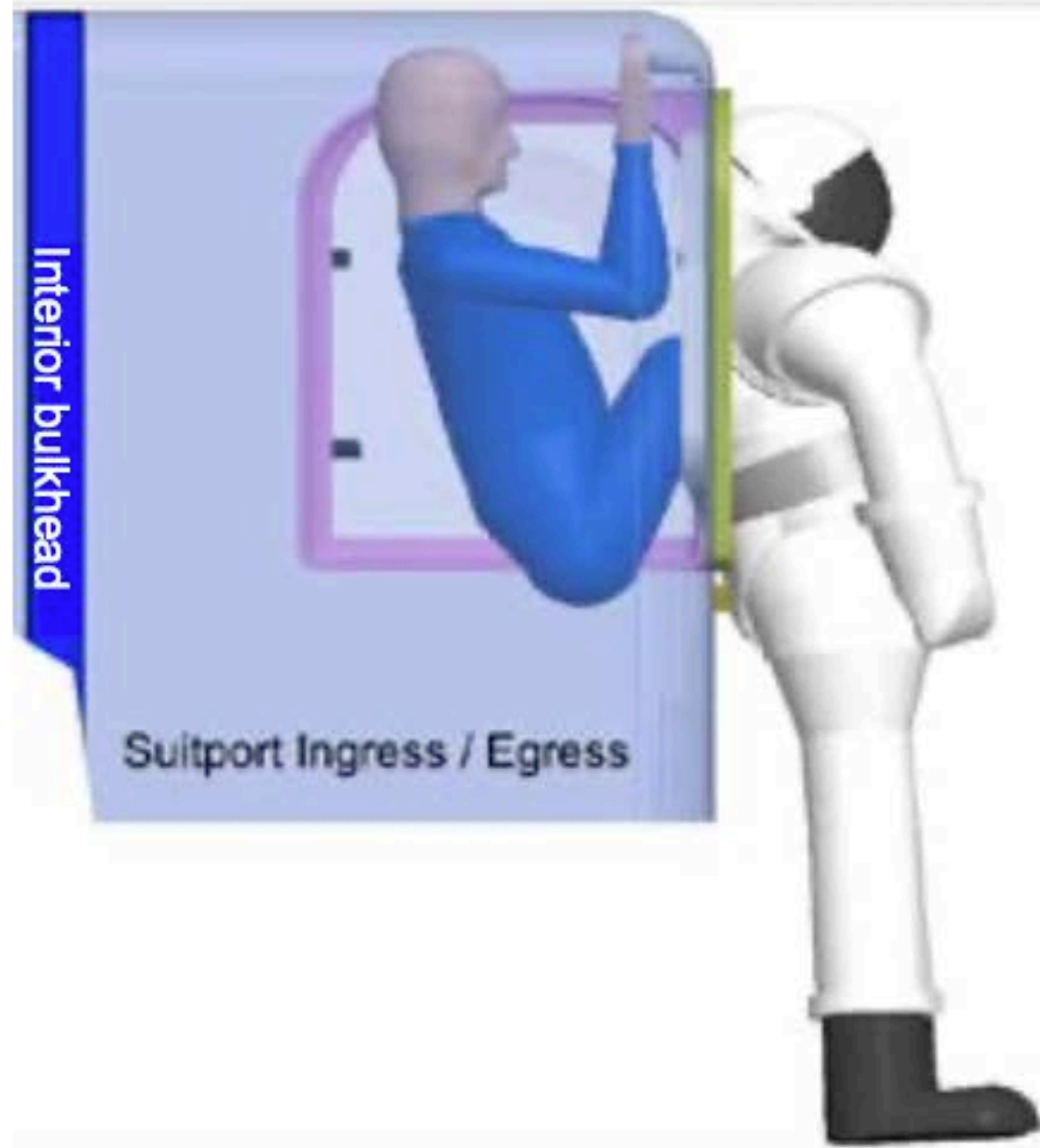
Vestibule Volume is at cabin pressure or depressed to vacuum

Volume is Pressurizable like an Airlock



Volume is at cabin pressure or depressed to vacuum

LSAT Suitports



Suitlock, Suitport Consumables

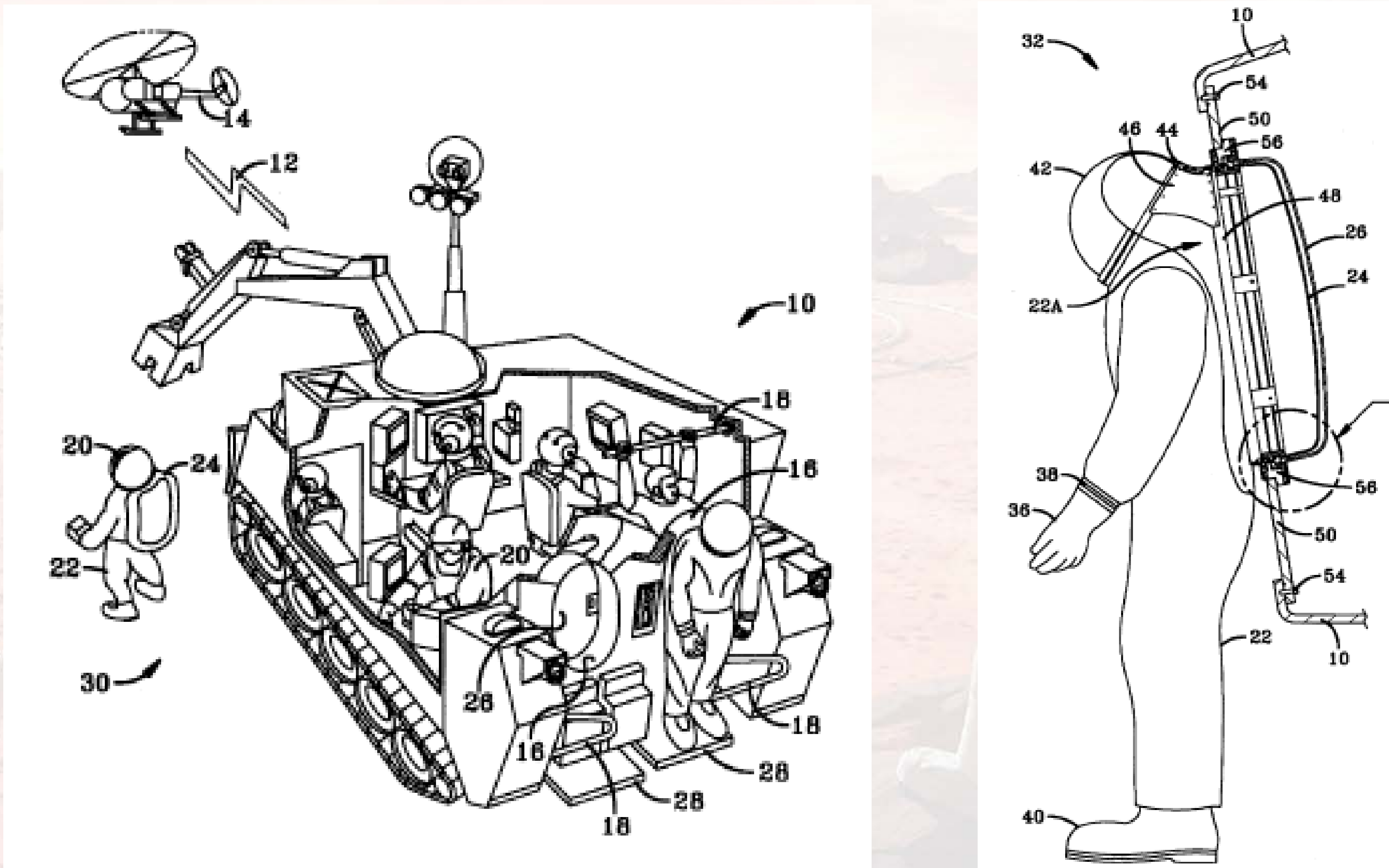
- Suitlock
 - 0.123 kg O₂
 - 0.229 kg N₂
 - 50 min depress time
- Suitport
 - 0.016 kg O₂
 - 0.030 kg N₂
 - 2 min depress time



Suitport in NASA SEV Rover

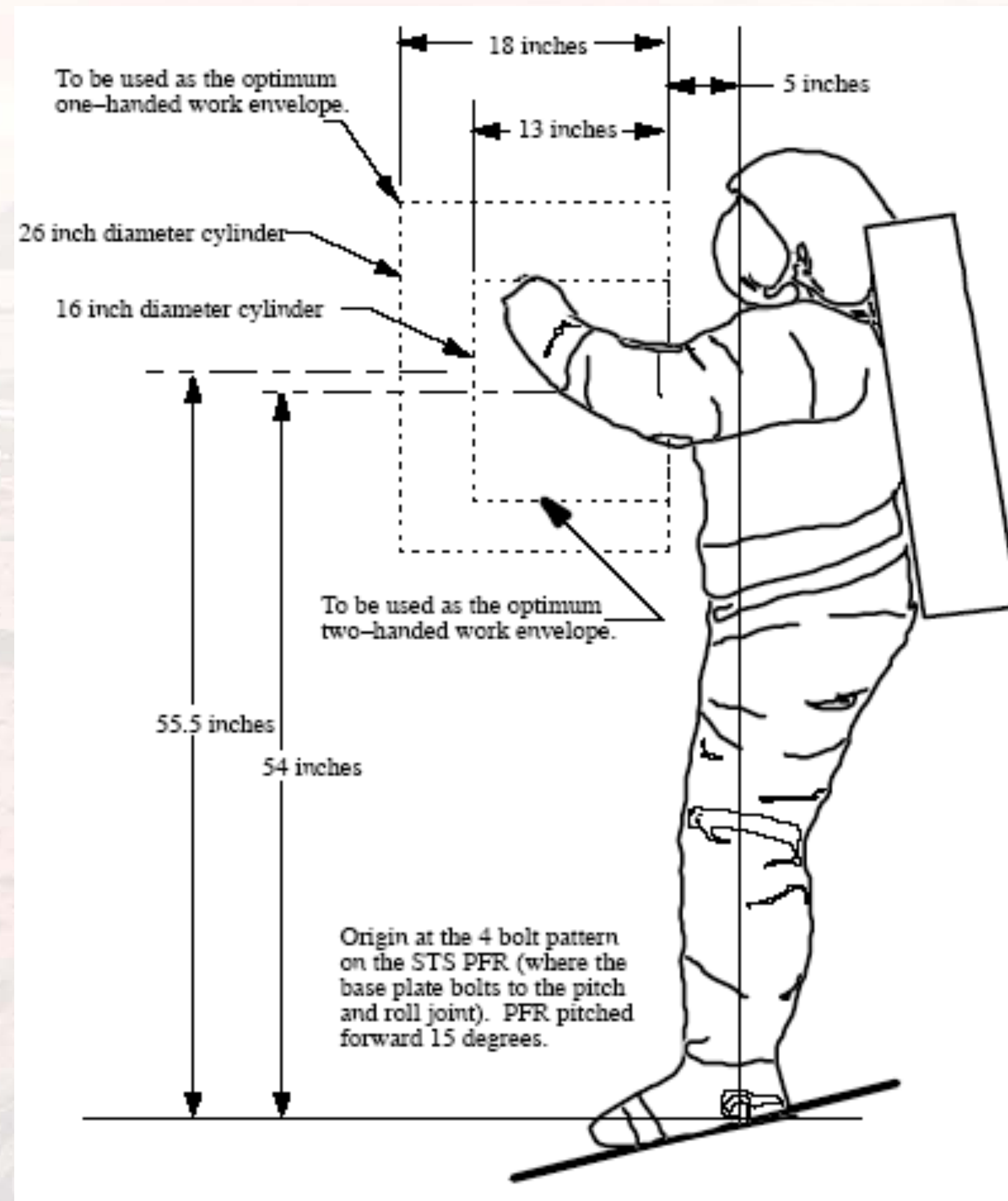


Suitlock Concept

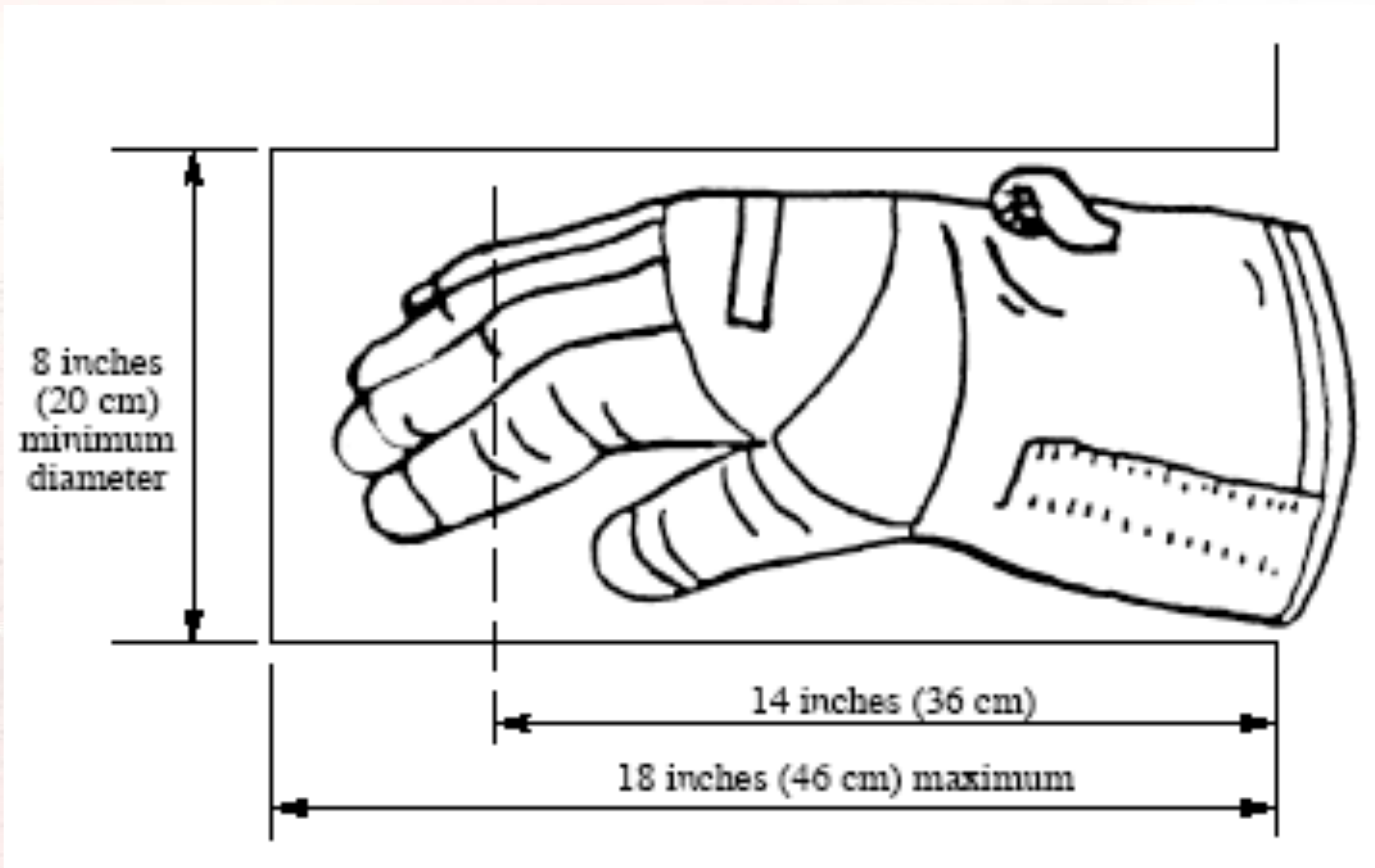


Patent 5,697,108 (NASA Ames) - Sketch taken from Hazmat application

EVA Optimum Work Envelope



EVA Gloved Hand Access Requirements



A Few Notes on Logistics

- Few of the interim reports discussed logistics (especially stowage)
- Can glean additional information from the previously presented details on current logistics elements (CTBs)
- Might be useful for your final projects

Details of ISS Cargo Vehicles

Spacecraft	Pressurized Volume (m ³)	Pressurized Payload (kg)	Payload Density (kg/m ³)
Progress MS	7.6	2230	293
Dragon 2	8.6	2507	292
Cygnus	12.9	3754	291
Dream Chaser	17.7	5000	282

Spacecraft	Avg. Pressurized Cargo (kg)	Avg. Days between flts	Cargo/crew-day (kg)
Progress MS	1432	129	1.59
Dragon 2	2128	138	2.20
Cygnus	3629	184	2.83
Totals		53	6.61

CTB Sizes and Utilization

Bag size	Volume (m ³)	Max Load (kg)	Avg Load (kg)	Avg Density (kg/m ³)	ISS Utilization
Half CTB	0.0247	13.6	5.13	207	15%
Single CTB	0.0529	27.2	10.26	194	75%
Double CTB	0.107	54.4	20.5	191	2%
Triple CTB	0.160	81.6	30.8	193	3%
M01	0.391	136	61.6	157	3%
M02	0.243	90.8	41.0	169	2%
M03	0.638	227	103	161	–

Lunar Pressurized Logistics Module Concept

- Resupply for four crew on 56 day cycle
- Assume same logistics requirements as ISS
- 1500 kg of cargo
 - 18 half-CTBs
 - 90 single-CTBs
 - 2 double-CTBs
 - 4 triple-CTBs
 - 4 M01 bags
 - 2 M02 bags
- LPLM would require 5.75 m^3 , empty mass 385 kg, total mass 1885 kg

BOE Analysis for Pressurized Rover

- Two crew for seven days @ 6.6 kg / crew-day \implies 92.5 kg of supplies
- Average fill of 10.3 kg / CTB \implies 9 single-CTBs of logistics \implies 0.5 m³