Testing the Exploration Conops (Excon) Mockup Suit in Lunar Analog Environments in 2022

International Conference on Environmental Systems

July 16-20, 2023
Calgary, Alberta Canada

DATE	CONTRIBUTORS	PREPARED BY
7/16/2023	Kris Davis, Christine Flaspohler	Zach Tejral

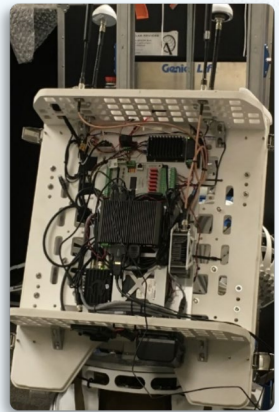
Suit Overview

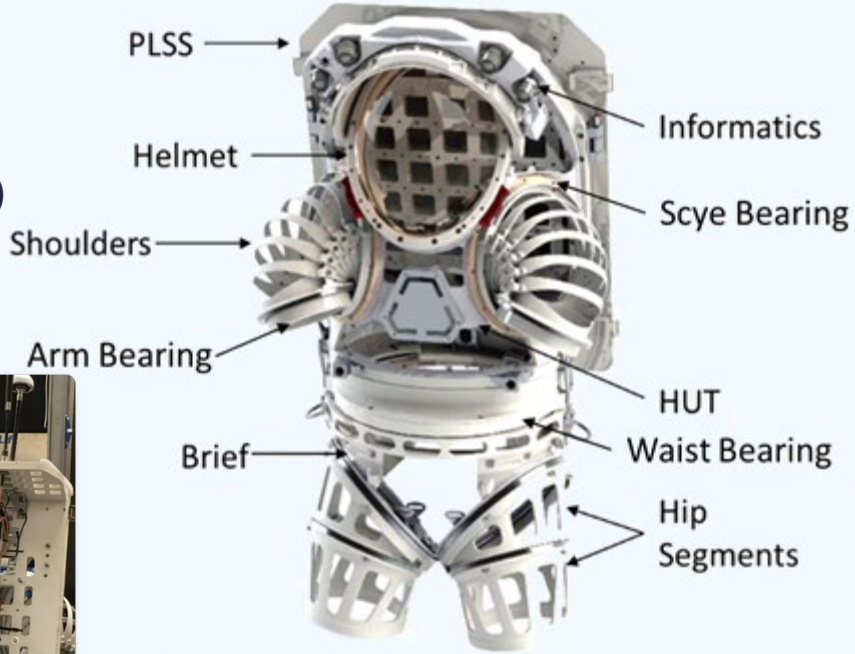
Mockup Suit Background

- Purpose: To represent some aspect(s) of a real spacesuit in a lower fidelity package.

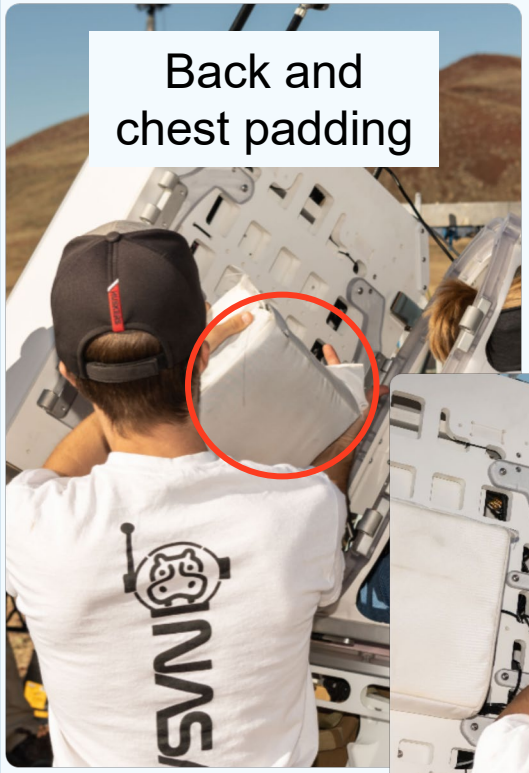
Exploration ConOps (Excon) Design

- Based on Exploration Extravehicular Mobility Unit (xEMU)
  - Informatics: Camera & Lights
  - Helmet
  - Small & Large Hard Upper Torso (HUT)
  - 6 pivot rolling convolute shoulders
  - Mobile Lower Torso Assembly (LTA)
    - Waist Flexion/Extension
    - Waist bearing
    - 2 bearing hips
  - Volumetric Portable Life Support System (PLSS)
  - Field Communications

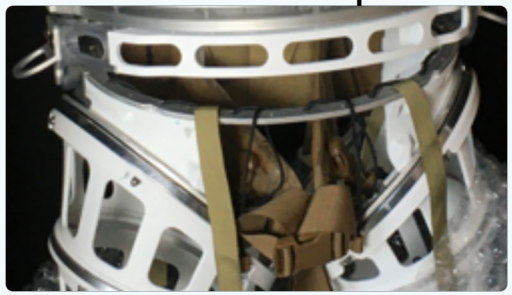


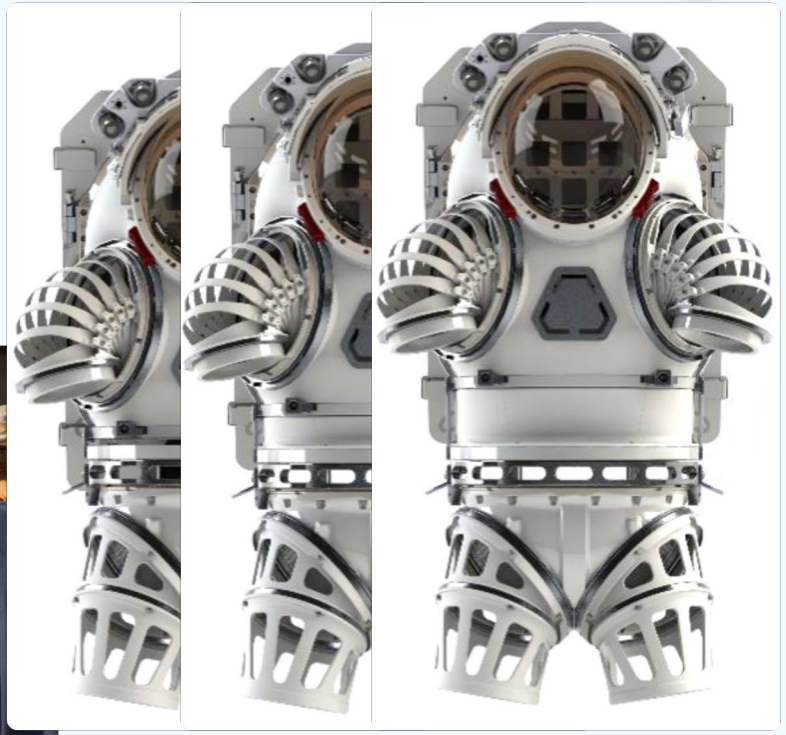


Sizing/Indexing



Waist Strap





Waist sizing

Donning/Doffing

- Height adjustable donning stand
  - Lower suit and subject steps in
  - Raise suit, tighten waist strap, shoulder straps
  - Install PLSS, egress donning stand, install helmet

Volumetric Performance

- Upper torso and PLSS are good volumetric representations of xEMU
- LTA is reasonably accurate after some modifications
- Arms, legs, hands, and feet are not well represented but not critical for majority of use cases

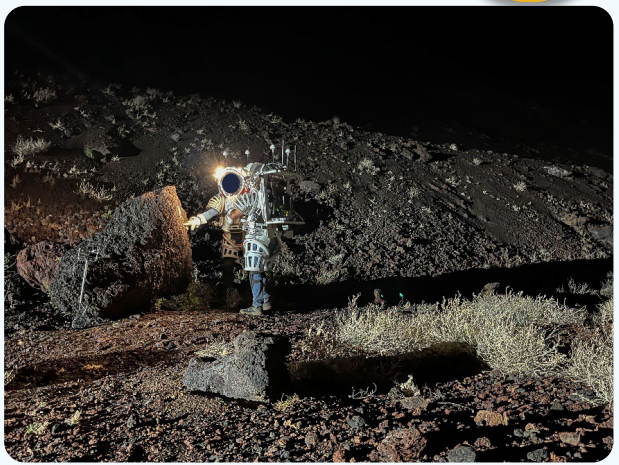
Mobility Performance

- Total range of motion
  - Some similarities to xEMU in isolated aspects
- Motion performance
  - Unpressurized
  - Different from xEMU in:
    - Necessary Mental Bandwidth
    - Joint “programming”
    - Required force

JETT Testing

JETT1

- Location: Kilbourne Hole by El Paso, Texas
- Test Goal: Initial Field Deployment of Excon Mockup Suits with a focus on at-station operations
- Test Time:
  - 7 subjects up to 2 hour test duration each



JETT1 Key Lessons Learned

- Lessons Learned
  - Excon is a useful tool for station ops in field
    - Improves simulation quality relative to shirtsleeve/backpack
    - Helps keep subject in suited mindset
  - 3 out of 7 subjects reported medium to heavy inner thigh contact
  - Subject familiarization
    - Critical to provide subjects with sufficient pre-deployment evaluation time (fitcheck, rockyard, etc.)
  - Subject feedback indicated suit system weighed too much
    - Not measured but expected to have been ~125lbs between suit, communications gear, and tools.

JETT2

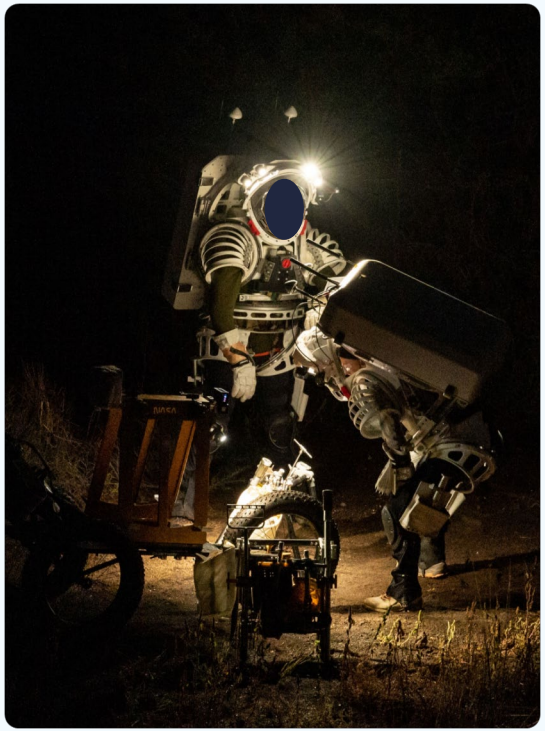
- Location: Icelandic Highlands
- Test Goal: Perform full-scale EVA in high lunar fidelity environment
- Test Time: 1 Subject - 4 hour EVA

JETT2 Key Lessons Learned

- 4 hour simulated EVA is possible but is physically challenging
- Updated hips improved inner thigh contact
- Suit weight is biggest issue
  - Suit system weight ~100lbs for majority of run (partial tool offloading)
  - Cumulative fatigue
- Waist belt comfort should be improved for long duration simulations

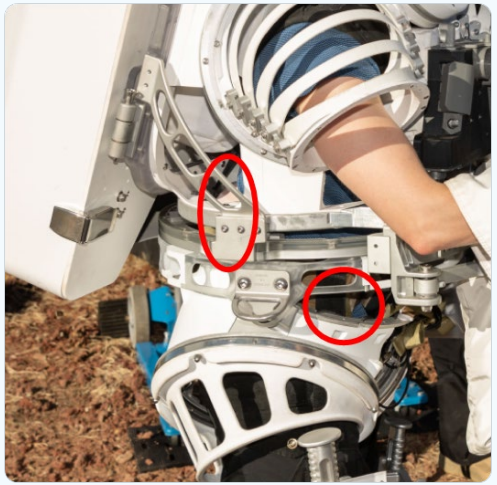
JETT3

- Location: SP Crater by Flagstaff, Arizona
- Test Goal: Artemis III EVA mission simulation in low light conditions
- Test Time: 2 subjects 3.5 hour EVAs on back-to-back days (EVAs 3 and 4 performed in field backpacks)



JETT3 Key Lessons Learned

- Back-to-back 3+ hour EVAs doable but very physically challenging
- Suit weight dominating source of crew fatigue
  - No opportunity for improvements between JETT2 and JETT3
- Waist belt comfort should be improved
  - Comfort padding was utilized but difficult to implement
  - Adjustments made during EVAs in an effort to improve subject comfort
- Front of thigh bruising due to hip design



Conclusions

- The Excon, and unpressurized mockup suits in general, are not useful for training subjects on how to operate a pressurized spacesuit
- In some cases, the Excon improves simulation quality for field testing by requiring subjects to think about suit impacts without the overhead of a pressurized suit
- Further weight savings are required to improve simulation quality and use cases


ADVANCED SUIT TEAM
NASA · JSC