

TBD

Artemis Crewed Surface Operations Training Dust Mitigation Test/Training Facility (DMTF)

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EXECUTIVE SUMMARY

Based on several Apollo mission(s) reports and lessons learned¹ on lunar dust impacts, it is imperative for successful Artemis missions, to develop dust mitigation methods & train crew in dust cleaning techniques for **efficient use of lunar surface time** and for **crew health**. **Longer durations and increased number of Extra Vehicular Activities (EVAs) for Artemis need better training**. Apollo missions lacked training in a dust facility.

Current facilities do not provide adequate fidelity to train crew in dust cleaning operations in suited, pressurized environments. Mimicking dust cleaning actions in existing facilities (eg- Neutral Buoyancy lab) does not provide in depth understanding of actions and time needed to clean suit or positions crew need to take to remove dust from suit. Available dust bins do not support suited/pressurized ops, personnel not trained in suited ops, more overhead/travel. **A local facility at Johnson Space Center (JSC) w/ adequate fidelity supporting suited/pressurized ops, personnel in suited ops is a crucial need for rapid development/testing and training.**

This facility will provide NASA capabilities to: 1. Provide a dust containment bin to perform **suited pressurized crewed training/testing activities for dust interaction/mitigation** leveraging existing JSC facility infrastructure and 2. Perform end-to-end simulated lunar dust testing of fluid, mechanical, and electrical systems to provide “test like you fly” confidence for industry developed solutions.

INNOVATION

The current Lunar Development and Dust Containment Room in B360 at JSC in the Energy Systems Test Area (ESTA) will be upgraded to support crewed Artemis EVA training and testing for dust mitigation operations. The training at this upgraded facility will provide a higher fidelity facility for dust training and understand suit capabilities for range of motion, cleaning techniques, solo/buddy cleaning, proper usage of EVA and dust tools, approximations of cleaning timeline etc, for Artemis EVA activities.

COLLABORATION

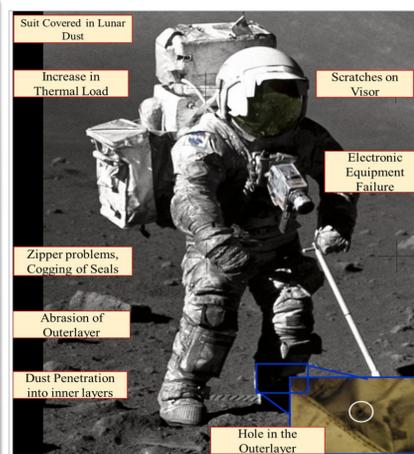
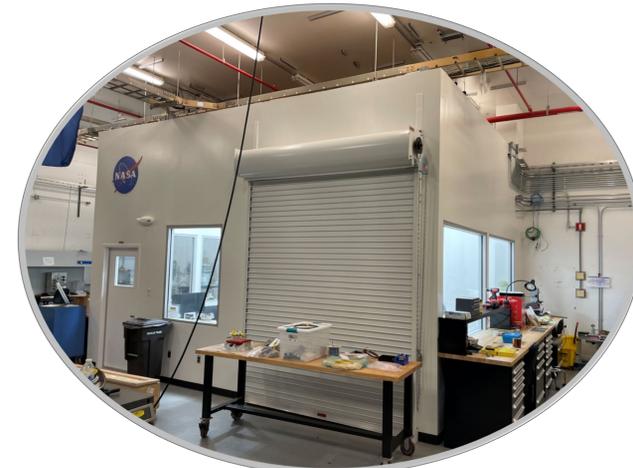
Member / Partner	Type	Role Descriptions
Anastasia Ford, EP6	PM / Co-PI	ESTA facility upgrade lead, Early Career Engineer
Kavya Manyapu, Ph.D. CX	Co-PI	Ph.D. Aerospace Sciences (Spacesuit dust mitigation research). FOD develops ConOps/ requirements/techniques for crew testing/training
Katy Hurlbert, EC	Dust testing SME	Dust mitigation requirements consultation
Amy Ross, EC	Space suit SME	EVA/IVA suit dust mitigation requirements consultation
Trevor Graff, XI	Science SME	EVA Hardware and Integrated Testing Lead of the Artemis Science Team
John Gruener, XI	Simulant SME	Lunar Regolith Simulant Lead
POC in work, NA	Safety SME	Institutional safety, Safety review panel, Safe inclusion of new technologies



Space suits in a Dusty Environment



Future Artemis Axiom space suit prototype

Lunar dust effects on spacesuits and operations during Apollo²

The Lunar Development Dust Containment Room (B360 JSC ESTA) to demo DMTF capability, NASA

OUTCOMES & INFUSION

This facility supports Artemis level risks and Gaps identified in the NASA Dust mitigation Roadmap³, provides capabilities to address JSC's responsibilities in crew health, EVA suits, crew habitation, lunar regolith testing and lunar surface crew operations. This facility enables analog capability to support and design Artemis elements capable of withstanding Lunar dust and other future surface missions to Mars or asteroids.

Dust is difficult!

Excerpts of few remarks on Lunar dust from Apollo astronauts during Apollo missions¹

- **Apollo 17-Cernan:** “Dust - I think probably one of the most aggravating, restricting facets of lunar surface exploration is the dust and its adherence to everything no matter what kind of material, whether it be skin, suit material, metal, no matter what it be and it's restrictive friction-like action to everything it gets on”.....“I think dust is probably one of our greatest inhibitors to a nominal operation on the Moon. I think we can overcome other physiological or physical or mechanical problems except dust.”
- **Apollo 16 -Young** “Dust is the number one concern in returning to the moon”

FUTURE WORK

Delivery:

Upgrade existing JSC facility in B360 to provide a dust containment system capable of supporting ambient dust technology demonstrations and suited pressurized operations capability.

Year 1:

Upgrade the lunar dust containment Room in B360 with dust simulants and test hardware.

Demo with a test subject wearing PPE to operate a test hardware in the dust containment bin to demonstrate electrical, fluid, mechanical connections (e.g. using existing Carbothermal ISRU reactor).

Design offloading and breathing cart HW to support year 2 evolution for human rated dust containment bin.

Year 2:

Develop dust containment to accommodate suited pressurized subject Demo with suited pressurized test subject conducting EVA/IVA dust cleaning tasks in the dust containment bin.

Other Potential Uses of Facility:

- Testing of science instruments and payloads, sample collection tools and containers, Vendor design verification/validation, Conops development and other operational scenarios that require suited pressurized interaction in an appropriate lunar-like regolith environment
- Applications to robotic missions (CLPS, Rover, etc.) for testing in an appropriate lunar-like regolith environment
- A resource for future proposal development and Vendor collaborations

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NTR#(s)

References

1. Gaier, J.R., NASA 2005, [The Effect of Lunar Dust on EVA systems during the Apollo missions](#)
2. Manyapu K.K. et.al, [Self-cleaning spacesuits for future planetary missions using carbon nanotube technology](#)
3. John, K. et al, [NASA, EHP Dust mitigation Roadmap](#)