# Aggie Team WERC: Dust Mitigation in Lunar Habitats

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## WERC 35*th* Environmental Contest

NM STATE — BE BOLD. Shape the Future. College of Engineering

35th WERC ENVIRONMENTAL DESIGN CONTEST

## Mission/SOW

WERC 2025 Design Challenge, NASA, and the New Mexico Space Grant Consortium are requesting a solution that effectively mitigates lunar dust. The solution must meet the following conditions:

- Remove lunar dust contamination
- Eliminate lunar dust from space suits or cargo transfer bags (CTB).
- Improve the Equivalent System Mass (ESM) by reducing the weight of the space, energy, and time spent by the crew.
- Endure the vacuum of the moon, extreme temperature, and abrasive dust, which ranges from -276°F to 232°F.
- Employ electrostatic repulsion, fluidic dust elimination, or a combination of mechanical techniques to control dust.

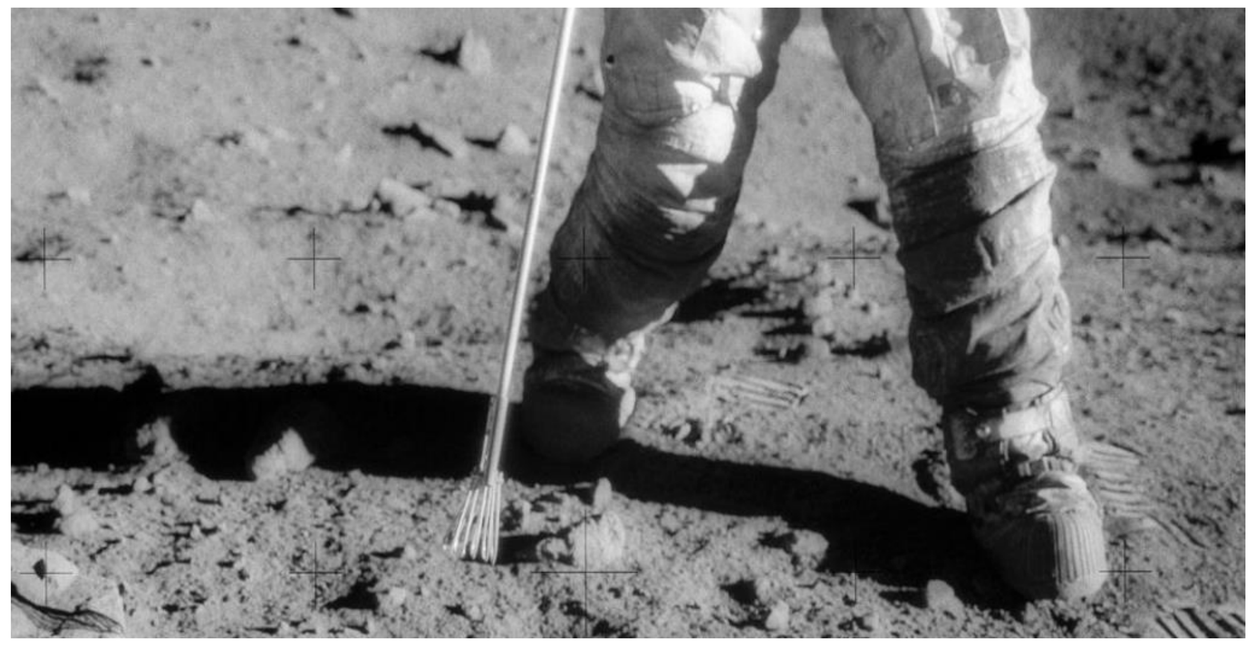
## Research

**<u>Problem</u>**

- Lunar dust is abrasive, electrostatically charged, and highly adhesive.
- Causes equipment degradation, health risks, and contamination inside habitats.
- Major concern for NASA's Artemis program and future lunar missions.

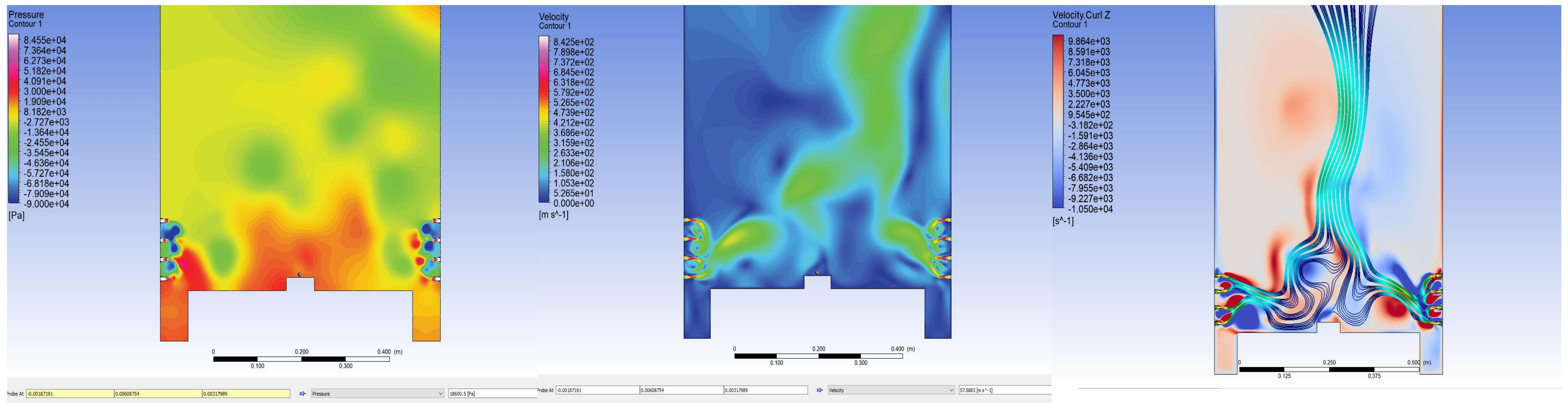
**<u>Competitor Analysis & Inspiration</u>**

- **Ionized Air in Electronics:** In cleanrooms and electronics manufacturing, ionized air blowers are commonly used to neutralize static charges and prevent electrostatic discharge (ESD) that can damage sensitive components such as microprocessors, circuit boards, and sensors.
- **NASA Lander to Test Vacuum Cleaner on Moon for Sample Collection:** NASA uses air pressure and vacuum-based systems, which are actively tested on lunar missions to collect dust samples.

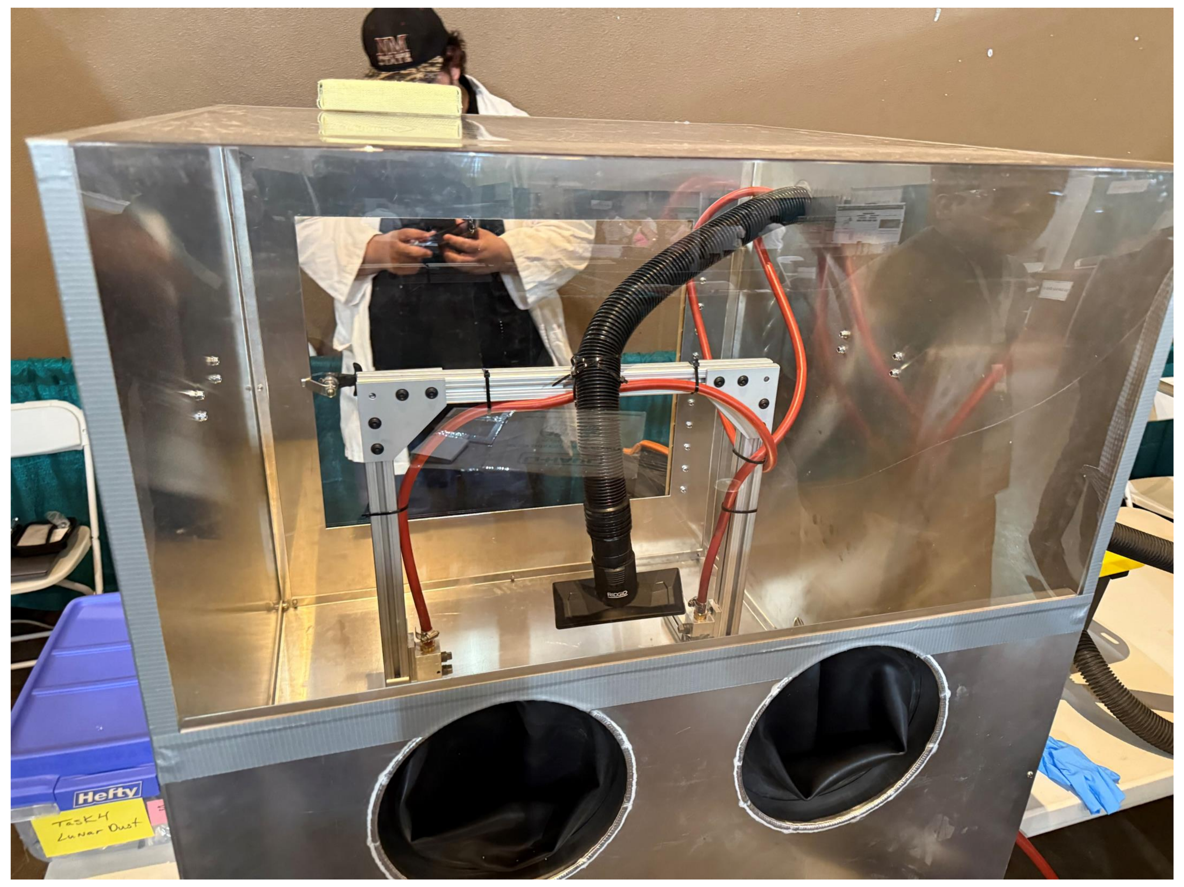


## Computational Fluid Dynamics

Multiple Computational Fluid Dynamics (CFD) simulations were performed using Ansys® Fluent™ to visualize and analyze the flow field and performance of the pressurized gas system. The figures below show results from one simulation in which the nozzle inlet pressure was 30 psi. These figures show a very turbulent flow with many vortices generated, which is desired for the vertical velocity component to bring the dust into the vacuum system. The bottom left figure is a plot of the pressure at a flow time of 30 seconds, the middle is colorized with flow velocity, and the bottom right shows a contour plot of the vorticity in the field and streamlines colorized by the velocity.



## Final Design



The final design includes a compact, modular decontamination chamber. It uses stationary air nozzles and a cyclone vacuum system. The key components are:

**<u>Stationary Air Nozzles</u>**: These nozzles are placed around the chamber. They deliver controlled bursts of air (40–60 psi) to dislodge dust from spacesuit sleeves and cargo transfer bags (CTBs). Their orientation maximizes coverage while minimizing power usage.

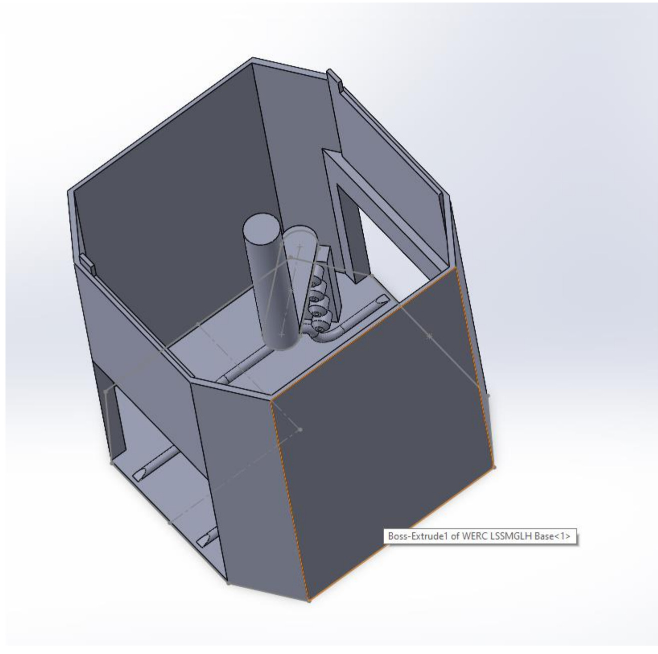
**<u>Cyclone Vacuum Filtration Unit</u>**: A commercial vacuum pump that creates the necessary airflow and directs dust-laden air into a cyclone chamber. Heavier particles are separated by centrifugal force and collected in a removable bin. A charcoal-based HEPA filter captures lighter particles.

**<u>Modular Aluminum Frame</u>**: Made from lightweight T-slotted aluminum, provides stability, and allows for tool-less adjustments and upgrades. The footprint meets lunar deployment constraints 25" x 25" x 28"

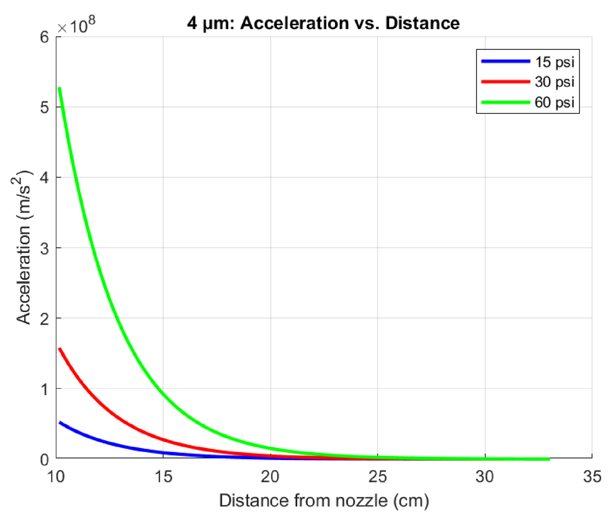
**<u>Optional Enhancements</u>**: Vibration modules and dust-repellent coatings can be added to loosen stubborn dust, increasing system efficiency without added complexity.

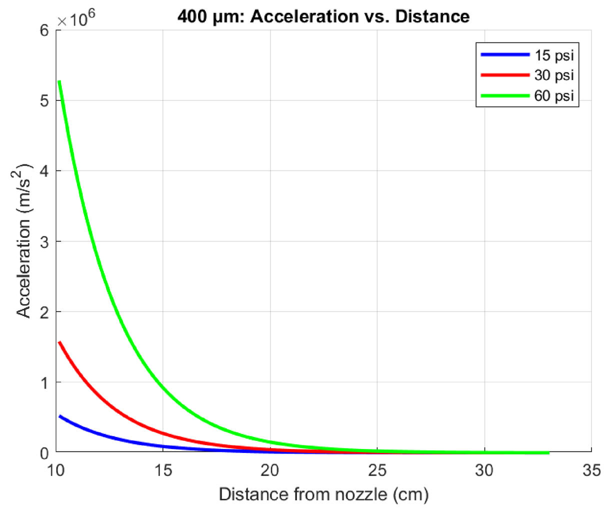
## Concept Development

- Early in development, multiple pneumatic dust removal concepts were considered.
- One early concept was a rotational arm pneumatic duster, which shares a standard shaft connected to the vacuum system that would hang above the object to be cleaned. An early CAD model of this concept can be seen below with a filtration system.



In combination with CFD simulations, a predictive model was created to analyze the acceleration of dust particles at opposite sides of the size spectrum for lunar highland dust at different pressures and nozzle distances as shown in the figures below.




## References

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