REACH NEW HEIGHTS

BENEFIT ALL HUMANKIND

Technology for Surface Exploration

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NASA Langley Research Center

3rd Annual John Glenn Symposium

Cleveland, OH (Virtual) July 14, 2021

REVEAL THE UNKNOWN

Radiation Protection – Shielding

Environments

- Galactic Cosmic Rays (GCRs)
  - Energetic charged ions spanning the periodic table and neutrons produced in the lunar regolith
  - Always present, but varies with the solar cycle
  - Small daily exposure, but increases astronaut health risks for long missions
  - Difficult to shield due to deeply penetrating particles
  - Hydrogen rich materials provide better protection
- Solar Particle Events (SPEs)
  - Low to medium energy protons
  - Large SPE are rare and short lived
  - Effectively shielded but optimization is needed to reduce parasitic mass
  - Unshielded exposure could result in acute radiation syndrome
  - Hydrogen rich materials provide better protection

Shielding Technology

- Development and integration of hydrogen rich structural materials
- Vehicle optimization to reduce thinly shielded regions
- Utilization of in situ regolith to create a really heavily shielded habitat
- Fixed location or reconfigurable SPE shelters
- Wearable SPE protection and blankets

Regolith Shielding Concepts

Wearable Protection Prototypes

POC: Martha Clowdsley

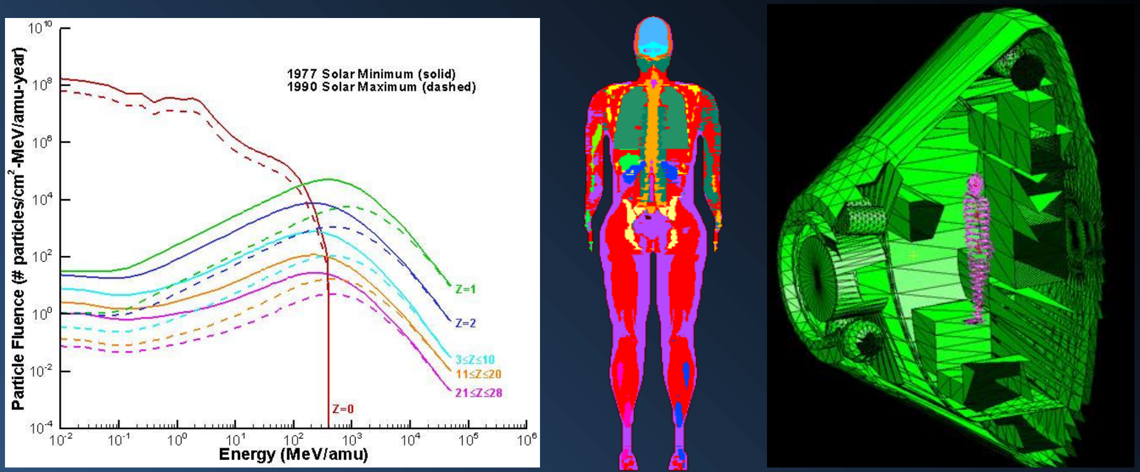
Radiation Protection – Exposure Assessment, Risk Modeling, and Countermeasures

Radiation Exposure Assessment Tools

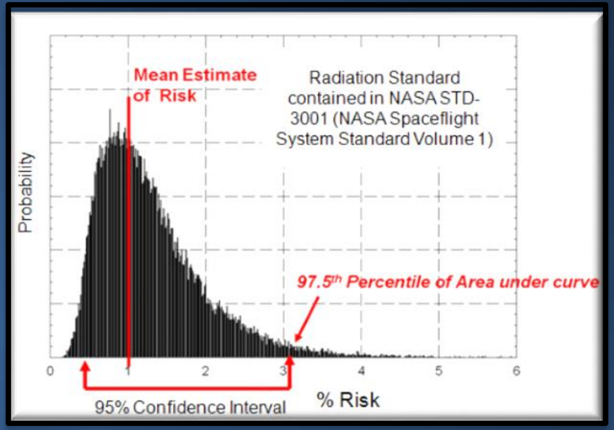
- Needed for vehicle design and operational planning
  - Vehicle optimization for GCR protection
  - Storm shelter and wearable protection assessment
  - Mission duration and EVA planning
  - Previous mission exposure assessments for crew selection
- Requires the integration of multiple tools and models
  - Space environment models
  - Vehicle CAD models which include all of the onboard mass
  - High fidelity human phantoms and human risk models
  - Space radiation transport codes
- Accessible through the On-Line Tool for the Assessment of Radiation In Space (OLTARIS)

Risk Modeling and Countermeasure Research

- Large uncertainties in crew risk estimation for space radiation environments limit allowable safe days in space – Current research may reduce that uncertainty
- Biological countermeasures to mitigate the near term effects of space radiation environments are being studied



Radiation Assessment Modeling Tools: Lunar Surface GCR Environment Model (left), FAX Human Phantom (middle), and Human Placement in CAD Model Example (right)



Human Risk Model with Large Uncertainty

Regolith Derived Materials for Lunar Surface Construction

- ❑ Materials fabricated at LaRC with polymer binders and Minnesota Lunar Simulant MLS 1-A using heat and pressure
- ❑ Polymers: Polyethylene, Polypropylene, and LaRC-SI
- ❑ Excellent consolidation up to at least 80% regolith simulant
- ❑ Largest sample is 6 inches by 6 inches

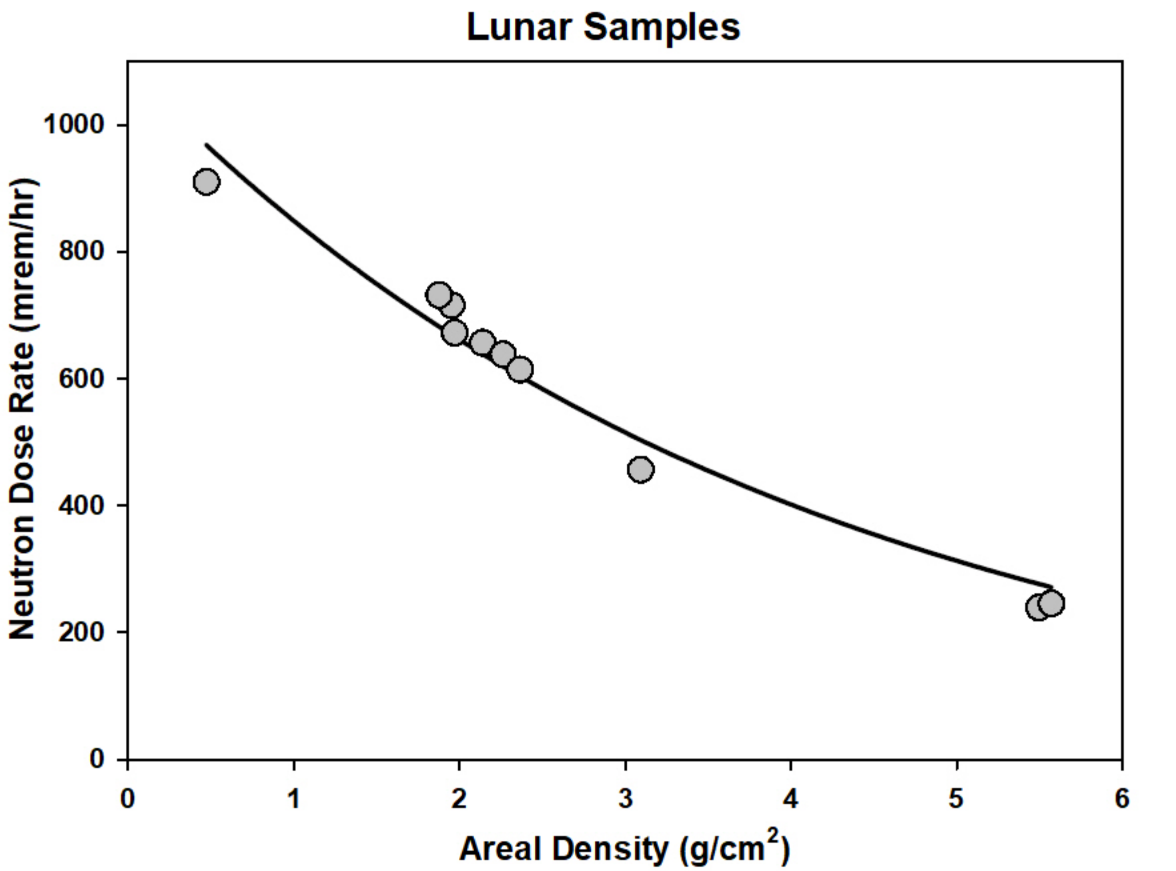
POC: Sheila Thibeault

Regolith Derived Materials for Lunar Surface Construction

Experimental Fragmentation Data

Z	Fluence/incident ion 100% Polyethylene (PE)	Fluence/incident ion 70% Regolith/30% PE	Fluence/incident ion 80% Regolith/20% PE
8	**0.672**	**0.740**	**0.740**
7	0.018	0.011	0.010
6	0.012	0.008	0.008
5	0.004	0.003	0.002
4	0.002	0.001	0.001
3	0.003	0.002	0.001
2	0.013	0.009	0.010
1	0.051	0.037	0.036

- Experimental data on regolith/polymer materials measured at the Brookhaven National Lab
- Incident oxygen ions (component of galactic cosmic radiation, GCR) with energy of 600 MeV
- Areal density is about 5.5 g/cm^2 for each sample
- Z is the atomic number of the fragment exiting the sample. If all oxygen ions were exiting, then the Fluence/incident ion for Z=8 would be 1
- Regolith/polymer materials fragment GCR ions



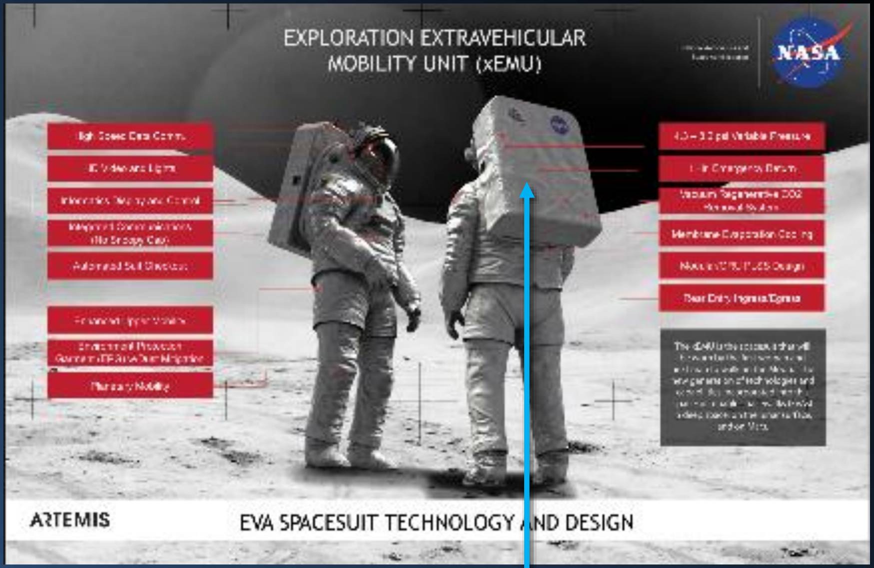
- Experimental data on regolith/polymer materials measured at LaRC using Americium/Beryllium source
- Incident neutrons with energy range 0 - 11 MeV
- Regolith/polymer materials shield against neutrons

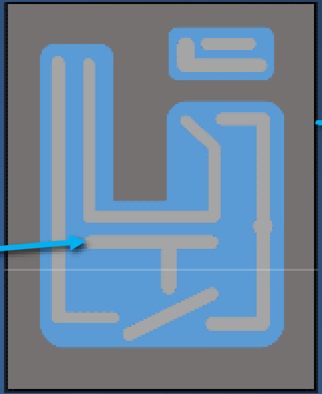
Regolith Derived Materials for Lunar Surface Construction - Summary -

- Regolith is an abundant material resource already on the lunar surface.
- Consolidating regolith by sintering
  - requires high heat
  - produces a brittle product.
- Consolidating regolith by binding it with polymers
  - requires less heat
  - produces a tougher product.
- Polymers repurposed on the lunar surface can be used for binders.
  - LaRC is also working on this.
- Consolidated regolith is superior for construction than loose regolith.
- The process for consolidating regolith can be automated.
- Experiments and calculations show that consolidated regolith provides some measure of radiation shielding from
  - neutrons
  - galactic cosmic radiation (by fragmentation)
  - solar particle events.

Exploration Extravehicular Mobility Unit (xEMU) Project

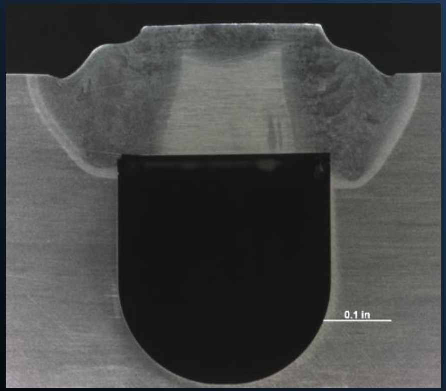
- Exploration Extravehicular Mobility Unit (xEMU)
  - First "clean sheet" design of astronaut space suit in >40 years
  - Supports future EVA operations on ISS and Moon
- Portable Life Support System (PLSS) backplate redesign
  - Design, drawings, final system integration and testing to be conducted by JSC
  - LaRC role is machining, welding, and inspection of embedded cooling channels in backplate





Notional PLSS "Embedded Channel" Backplate

Exploration Extravehicular Mobility Unit (xEMU)



Electron Beam (EB) Welds

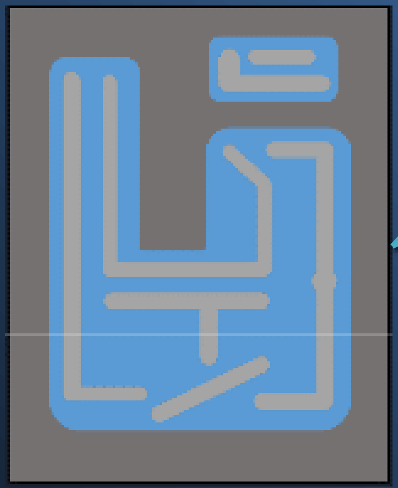
Example of Weld Development Coupon

POC: Karen Taminger

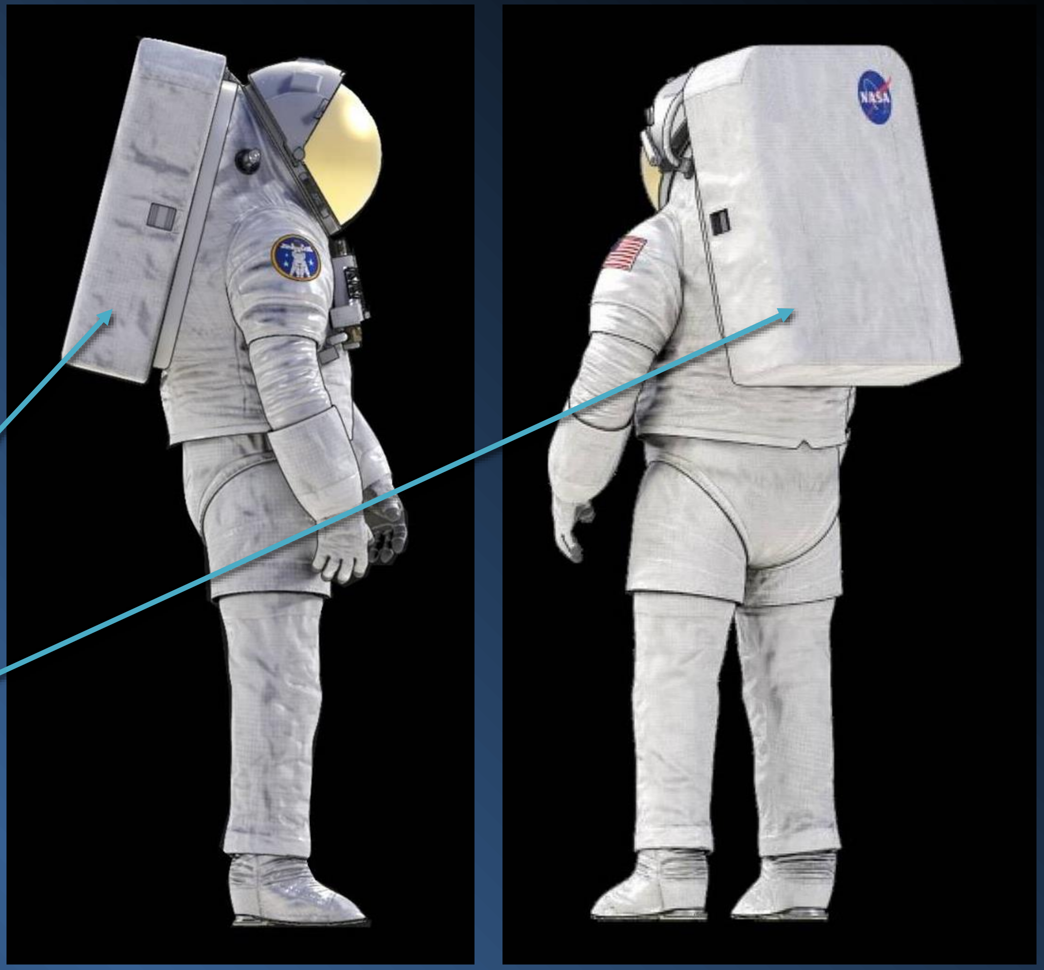
https://www.nasa.gov/feature/a-next-generation-spacesuit-for-the-artemis-generation-of-astronauts

Exploration Extravehicular Mobility Unit (xEMU) Project

- Exploration Extravehicular Mobility Unit (xEMU)
  - First “clean sheet” design of astronaut spacesuit in >40 years
  - Supports future EVA operations on ISS and Moon
  - Redesign reduces mass, volume, and improves astronaut mobility and ergonomics
  - Portable Life Support System (PLSS) provides redundant systems for life support, communications, thermal management all connected through the backplate



Notional PLSS “Embedded Channel” Backplate



CAD rendering of Exploration Extravehicular Mobility Unit (xEMU)

https://www.nasa.gov/feature/a-next-generation-spacesuit-for-the-artemis-generation-of-astronauts

Exploration Extravehicular Mobility Unit (xEMU) Project

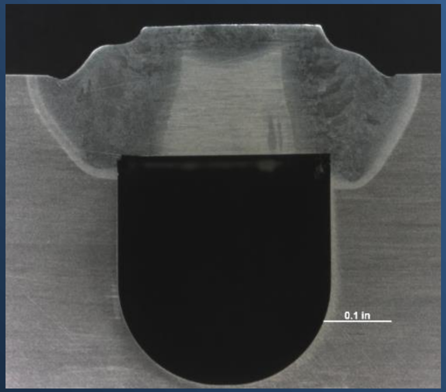
- Portable Life Support System (PLSS) backplate redesign (material: Ti-6-4)
  - Design, drawings, final system integration and testing to be conducted by JSC
  - LaRC role is machining, welding, and inspection of embedded cooling channels in backplate
  - Current activities involve developing high precision techniques and documenting procedures
  - Space flight units will be delivered to JSC in FY22

Machining

Notional PLSS "Embedded Channel" Backplate

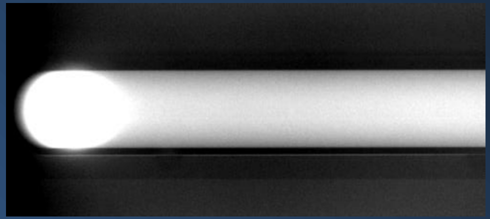
Electron Beam Welding

Example of Weld Development Coupon

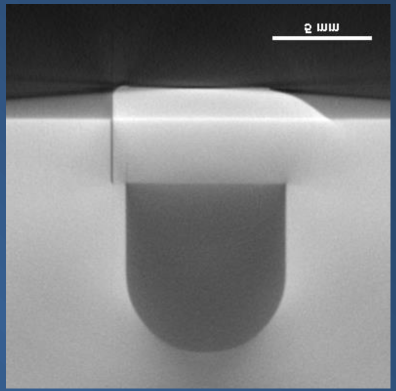


Electron Beam (EB) Weld Cross-Section

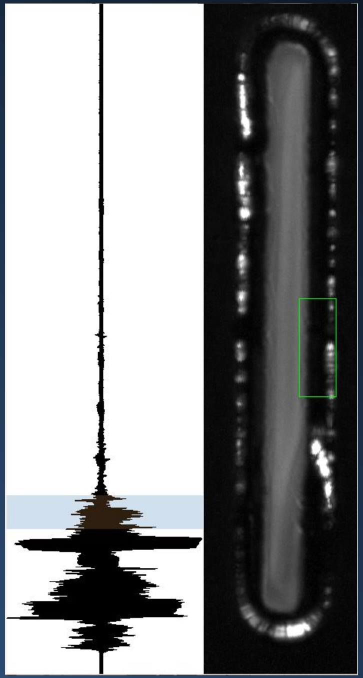
Non-Destructive Inspections



Direct Radiography (DR) of Welded Sample



Computer Tomography (CT) scan of Welded Sample



Ultrasonic Inspection (UT) scan of Welded Sample

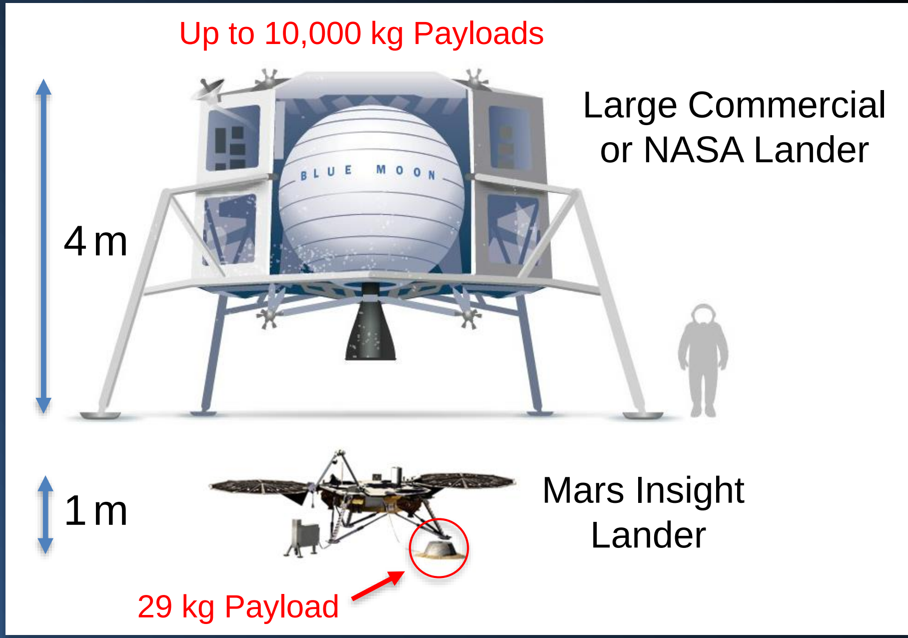
Lightweight Surface Manipulation System (LSMS) - Overview

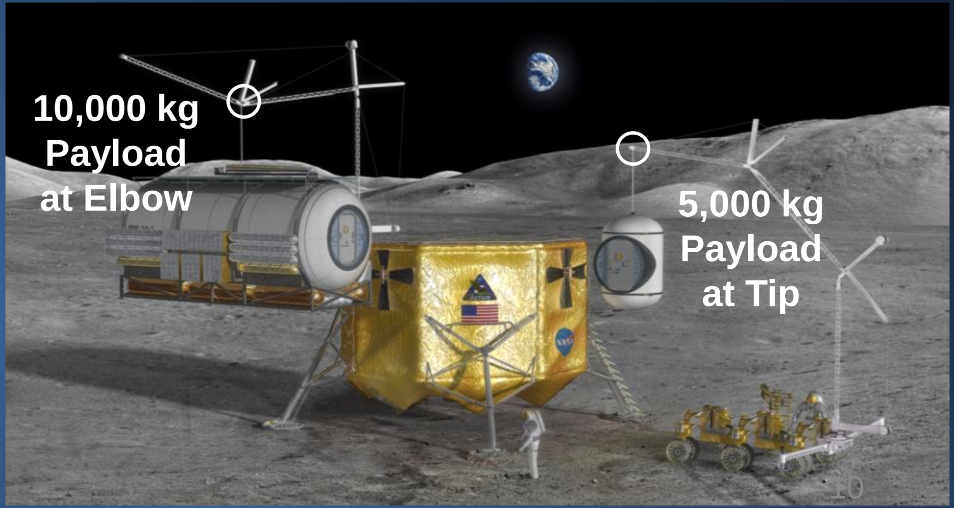
The Problem: NASA and commercial landers require a robust approach to offloading and maneuvering payloads in a wide range of masses, sizes, and shapes.

State of the Art: Planetary-surface serial manipulators do not scale to heavy payloads.

- Payload mass and size, reach required, and height and size of lander, are all significantly greater for large commercial and NASA landers.

The Solution: A lightweight, scalable and versatile, long-reach manipulator that combines the structural efficiency and robustness of commercial cranes, with the enhanced dexterity and multi-functionality of a deployable robotic arm.





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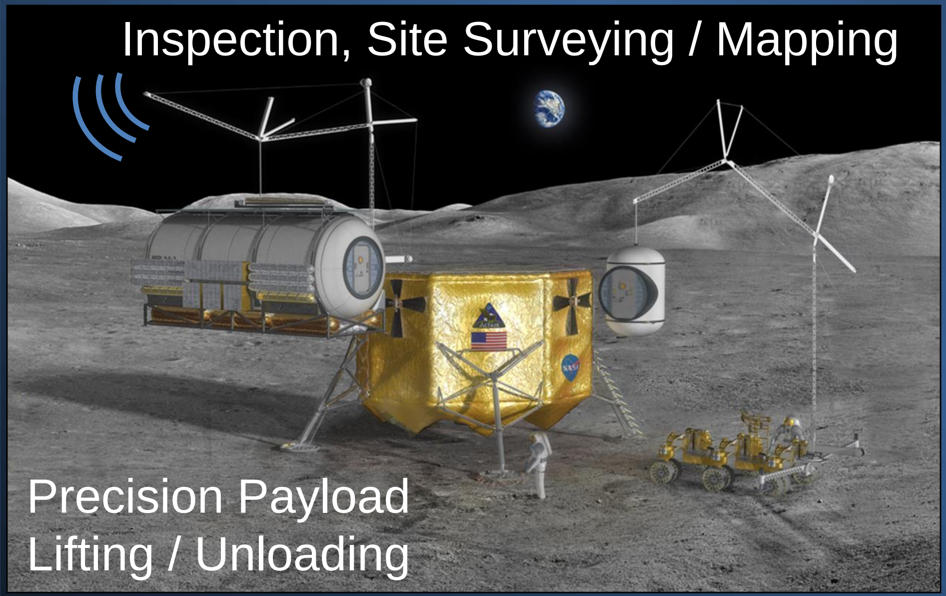
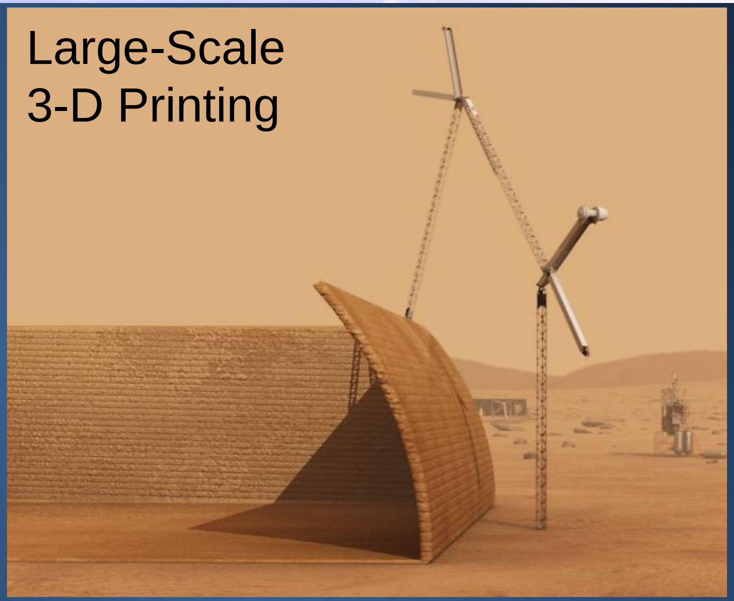
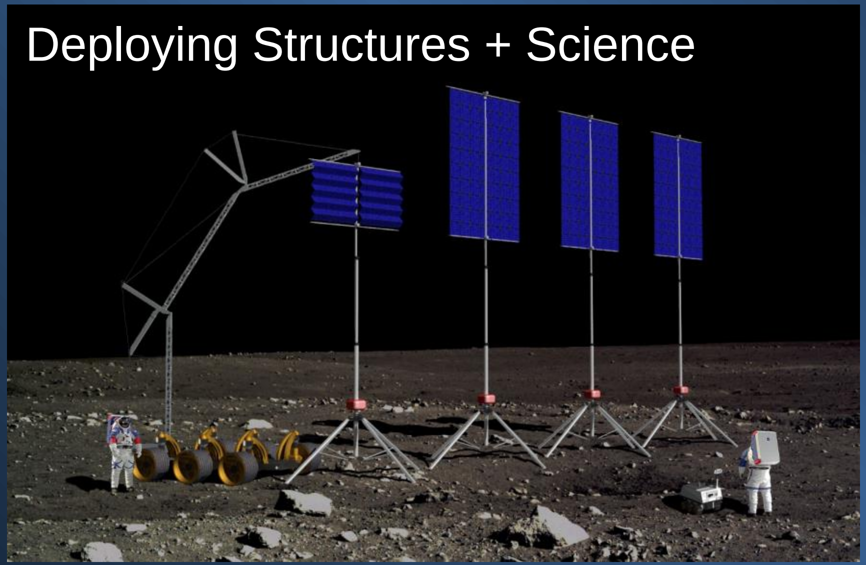
POC: Thomas C. Jones

LSMS: Versatile and Multi-Functional








CELEBRATING
100
YEARS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