

National Aeronautics and Space Administration



In-Situ Resource Utilization for Deep Space Exploration

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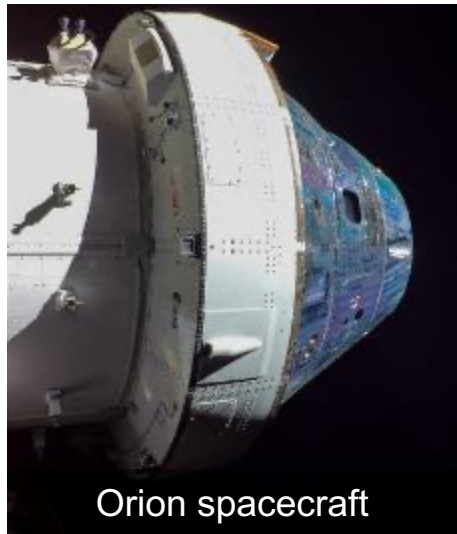
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Artemis: A Foundation for Deep Space Exploration



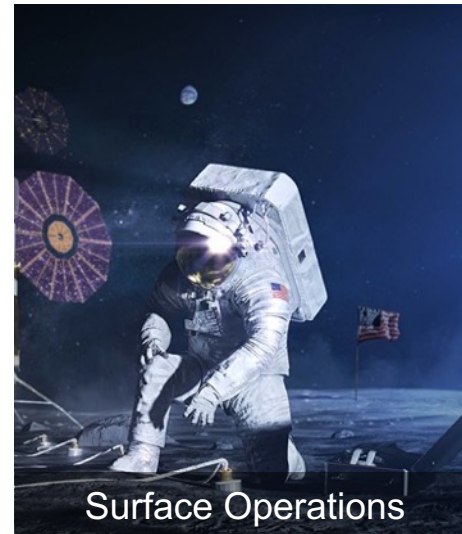
Space Launch System



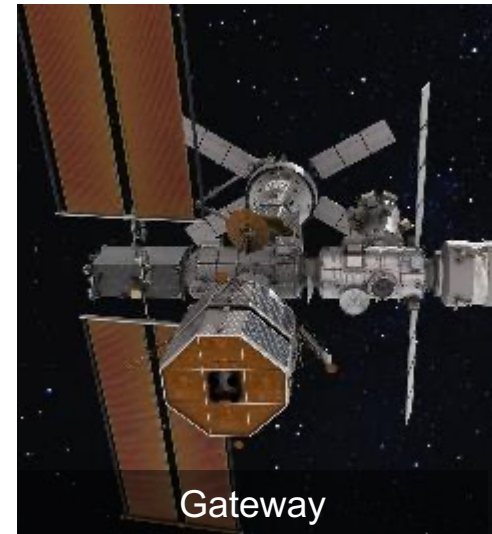
Orion spacecraft



Human Landing System



Surface Operations



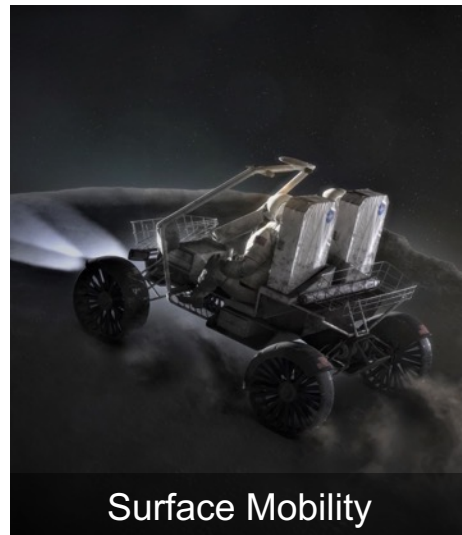
Gateway



Exploration Ground Systems



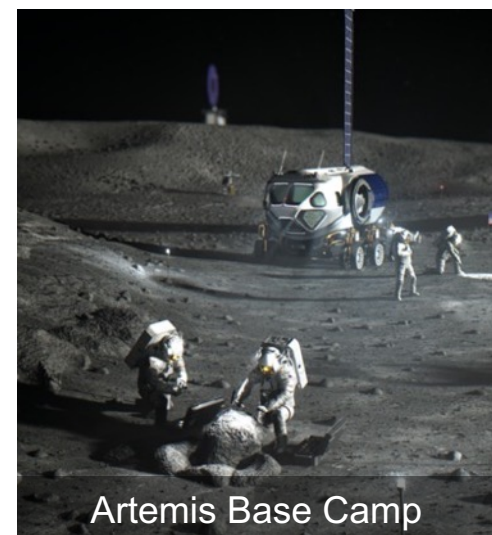
Space Communications & Navigation



Surface Mobility



Spacesuits



Artemis Base Camp

In-Situ Resource Utilization (ISRU)

Using space-based resources for deep space exploration

Traditional examples of ISRU:

- Extracting volatiles from soil for consumption, hygiene, propulsion
- Using soil/regolith for construction materials

Intangible assets and characteristics of space:

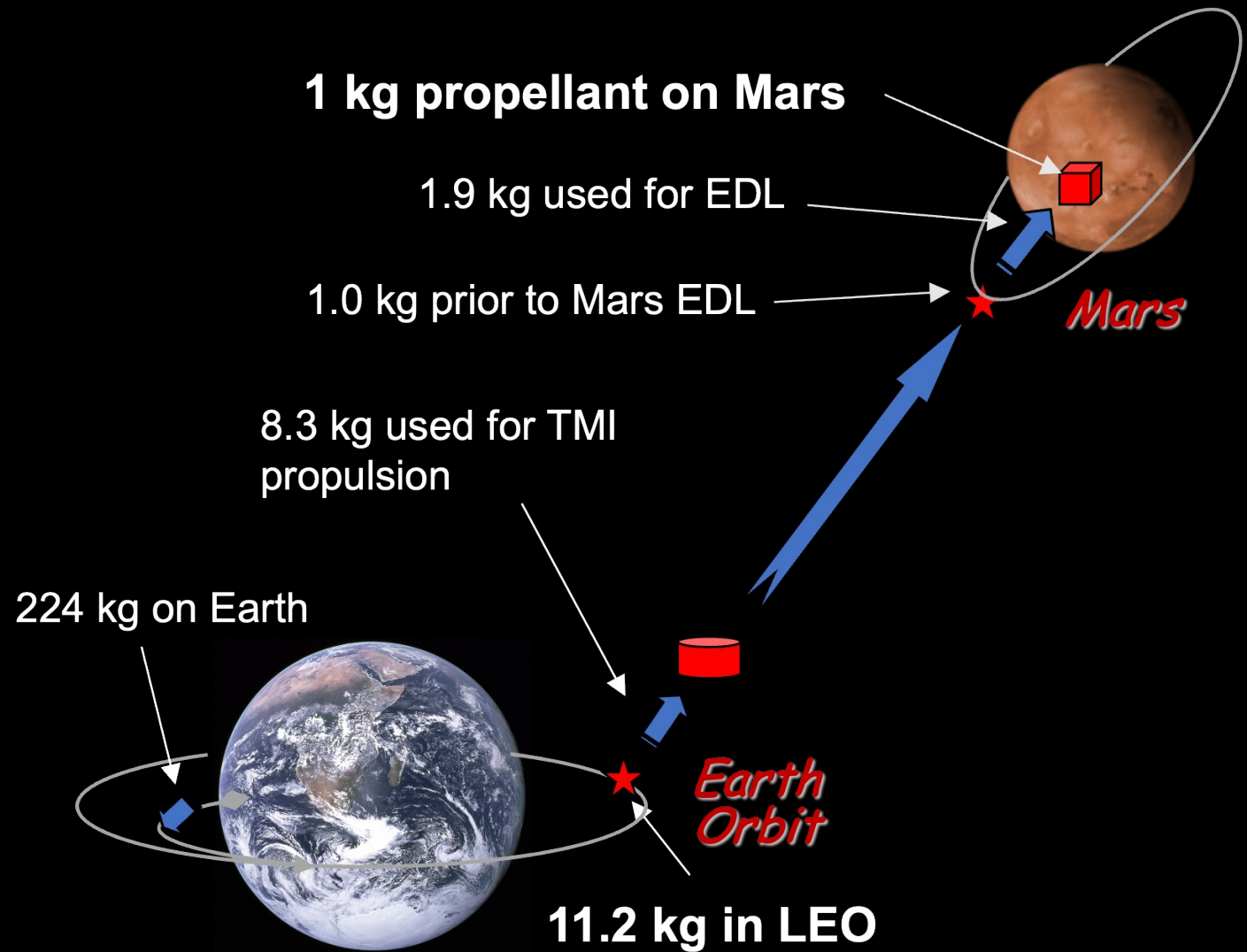
- Atmosphere
- Solar power
- Gravity assist



Making Propellants on Planetary Surfaces to Save on Launches and Cost

The Gear Ratio Effect

One example of how ISRU could benefit long-term human exploration in deep space



Estimates based on Aerocapture at Mars

Analogy: Camping vs. Living off the Land

Both respect the land – one is temporary and one is long-term independence



CAMPING: Bring all supplies with you - pack in, pack out.



Photo Credit: Outdoor Life

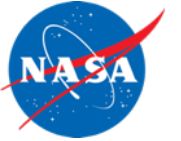
Living off the Land: Requires more infrastructure but establishes more independence



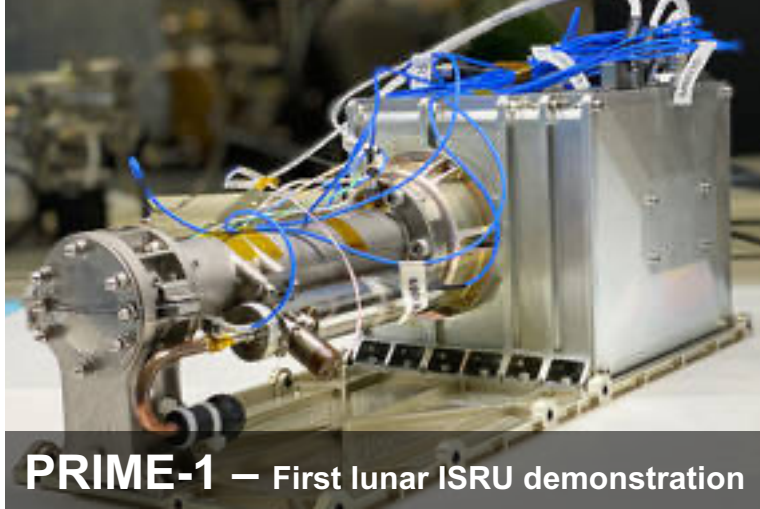
Photo Credit: BTL

Sustenance:	Packaged food and water	Seeds, well or rainwater
Shelter:	Tents	Tools for construction
Energy:	Batteries, fuel/kerosene	Water, wind, charcoal

In-Situ Resource Utilization Instruments and Vehicles



MOXIE — Oxygen from Mars Atmosphere



PRIME-1 — First lunar ISRU demonstration



VIPER — Origin and distribution of lunar resources



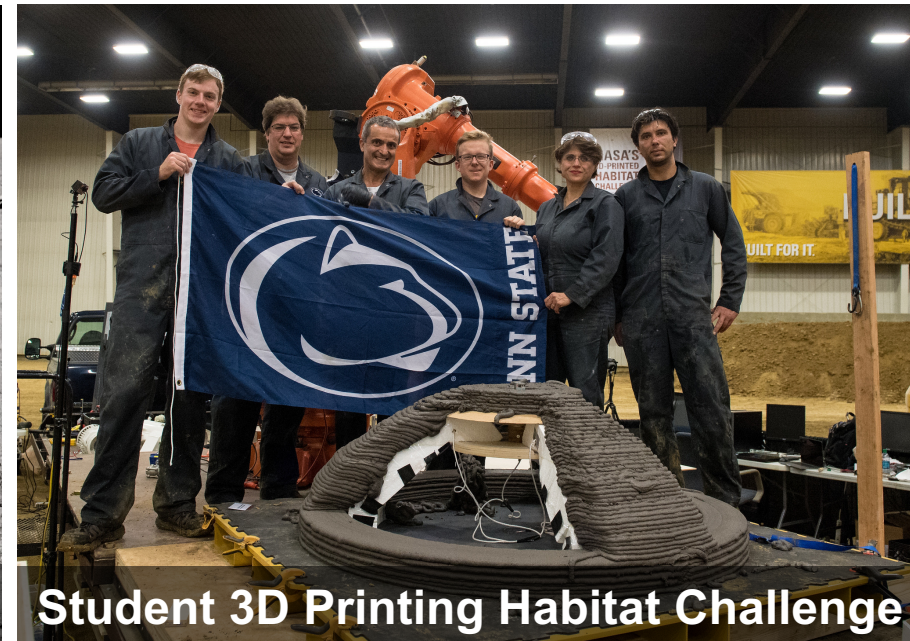
ISRU Pilot Excavator — Digging up to 10 mT of lunar regolith



Gateway Power and Propulsion Element



Artemis ISRU Demo Plant



Student 3D Printing Habitat Challenge

The Space Perspective: a Long-range View

- ISRU can reduce mission and architecture mass and costs
 - Allows us to use fewer launches to get supplies to our destination – propellant, consumables, construction materials, etc.
- ISRU can increase safety for crew and enhance mission capabilities, allowing us to explore farther from Earth with more independence.
- Learning to use space resources can help us on Earth
- Planetary preservation is important in responsibly using space resources.

