Providing Affordable Access to the Lunar and Martian Gravity Environments for Conducting Scientific Research and Enabling Technology Development

Daniel F Brown; David L Urban
NASA Glenn Research Center, Cleveland, OH 44135

Abstract

NASA's Artemis campaign aims to explore the Moon for scientific discovery, technology advancement, and to learn how to live and work on another world as we prepare for human missions to Mars. Like the Moon, Mars is a rich destination for scientific discovery and a driver of technologies that will enable humans to travel and explore far from Earth.

Conducting space research and validating gravity-dependent technologies in low-Earth orbit or on the surface of the Moon or Mars is expensive and typically requires long project life cycles. To achieve NASA's Moon to Mars objectives, it will be necessary to have affordable, ground-based test platforms for carrying out this research and technology development in the relevant gravity environment.

A proposed upgrade to NASA Glenn Research Center's Zero Gravity Research Facility is presented that will provide more than 10 seconds of any prescribed gravity level between microgravity and Earth gravity, allowing users to rapidly conduct dozens of tests per day in a microgravity, Lunar, and Martian gravity environment. The design concept is described along with expected performance characteristics, and technologies and research areas that will benefit.

The proposed ground-based variable gravity test capability will enable scientific breakthroughs and Moon to Mars technology and subsystem development while also providing a tool for educating and inspiring future scientists and engineers..

Facility Description

The **Variable Gravity Test Facility** is a proposed upgrade to the existing Zero Gravity Research Facility (ZGF) – NASA Glenn's 5.2-sec drop tower. It will provide an affordable ground-based test platform for conducting scientific research and advancing technologies necessary for meeting NASA's Moon to Mars objectives and more!

Benefits

Capability Gap Closure
The facility will revolutionize NASA's reduced-gravity, multidiscipline research capability, especially in the advent of the International Space Station retirement.

Science and Technology Advancement
The ground-based test capability will enable scientific breakthroughs and NASA's lunar/Mars technology and subsystem development activities.

Cost Savings
Thousands of ground-based tests can be conducted at a fraction of the cost of a single flight experiment.
90% Reduction in cost per test
20% Reduction in annual facility costs

Risk Reduction
Performing research and advancing technologies in a relevant environment prior to flight will maximize return on investment and minimize failures.

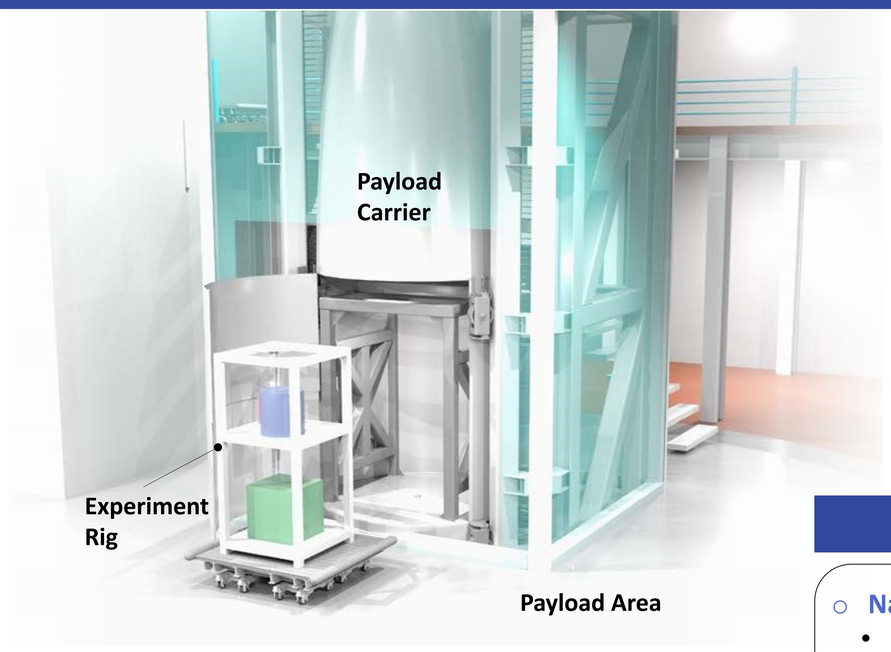


Figure 1. Conceptual rendering of Variable Gravity Test Facility showing ground floor loading of experiment rig into Payload Carrier

Applications

- Fundamental Physics
- Biological and Physical Science
- Space Exploration Systems and Technology Development
- Fire Safety
- Materials Synthesis
- Education and Outreach

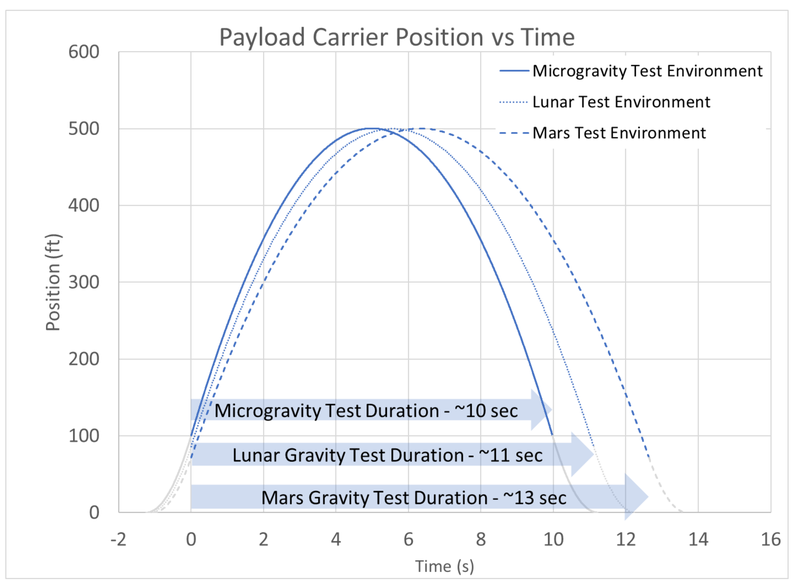
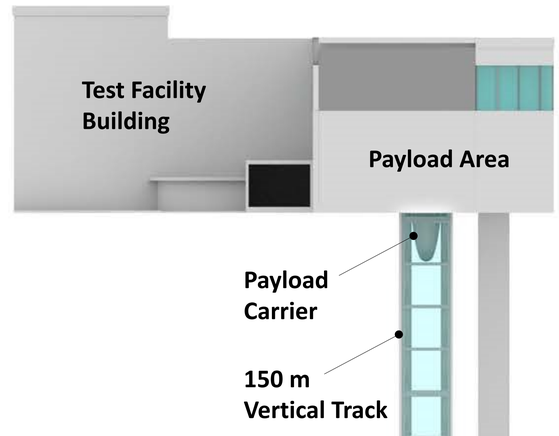


Figure 2. Plot of Payload Carrier Position vs. Time showing approximate test duration for three reduced-gravity levels



Sampling of Use Cases

- **Nanoparticle Dispersion**
  - development of superalloys
- **CFD Slosh Model Validation**
  - effects on HLS vehicle dynamics
- **Liquid Mass Gauging**
- **Oscillating Heat Pipes**
  - thermal management of space power electronics
- **Lunar Dust Removal and Mitigation**
- **Cryogenic Fluid Storage and Transfer**
- **Inflatable Soft Goods Deployment**
- **In-Space Manufacturing Technologies**
  - laser welding and spot welds
- **Regolith Fluid Dynamics**
  - granular flow of Lunar regolith
- **Fire Safety**
- **Human Risk Model Development**
  - Improve models of bone fracture risk due to falls in space

Improvements to Zero-G Facility

	Old	New
Gravity Level	Microgravity Only	Variable
Test Duration	5.2 Seconds	> 10 Seconds
Throughput	2 Drops/Day	> 20 Drops/Day
Experiment Loads	40 g	6 g max
Infrastructure	Aging Equipment	Modernized

Additional Questions? Contact Us:

Daniel Brown
NASA Glenn Research Center
Phone: 216-433-8456
Email: daniel.f.brown@nasa.gov

David Urban
NASA Glenn Research Center
Phone: 216-433-2835
Email: david.l.urban@nasa.gov

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