2027 Micro-g NExT Challenge Descriptions

Microgravity Neutral Buoyancy Experiment Design Teams (Micro-g NExT) challenges undergraduate students to design, build, and test a tool or device that addresses an authentic, current space exploration challenge. Micro-g NExT is offered as one of several student challenges and competitions provided by NASA's Office of STEM Engagement (OSTEM). All OSTEM student challenges and competitions are designed to prepare tomorrow's aerospace workforce through agency and industry skill development, hands-on engineering design protocol, test operations, industry and community outreach, and unique workforce development opportunities. Participants will develop technical and career skills during their Micro-g NExT experience.

Micro-g NExT test operations are conducted in the simulated, reduced gravity environment of the Neutral Buoyancy Laboratory (NBL) at NASA's Johnson Space Center in Houston. Teams will propose a design and prototype a tool identified by NASA engineers as necessary for space exploration missions. Professional NBL divers will test the tools and students will direct the divers from the Test Conductor Room of the NBL facility. Micro-g NExT provides a unique opportunity to contribute to NASA's missions and prepare tomorrow's aerospace workforce.

Figure 1: Artist concept for Moon Base. (Credit: NASA)

Challenge 1 - Cable Management Device

Background

The Moon Base is humanity's first lunar outpost, a place where astronauts will live, work, and explore near the Moon's South Pole. Through a series of crewed and uncrewed missions, NASA and its partners will build the infrastructure needed to support an enduring human presence on the lunar surface while advancing science, technology, and exploration for the benefit of all. Moon Base architecture consists of a wide variety of surface-based assets. In early missions, the power transfer between assets may be handled by EVA (extravehicular activity) crew. This power transfer could be between a power station and mobile vehicle, or a habitat, or other nearby payloads. To facilitate these efforts, EVA crew will need a tool to manage the cable and assist crew with deployment and stowage of the cable.

Objective

Design a lunar Cable Management Device (CMD) that allows 1st – 99th percentile astronauts to easily deploy the power transfer cable as they traverse the lunar surface. The device should allow astronauts to deploy across a surface with low rock and obstacle dispersion. All actuations must be glove-compatible to allow safe and reliable EVA actuation. The device should have simple, dust tolerant mechanisms allowing crew to set it in regolith when not in use. Astronauts will use the device with limited mobility in a spacesuit, so carefully consider the ergonomics of the device's operations. The device will be tested in the Neutral Buoyancy Laboratory (NBL) for overall tool function and concept of operations. The device may also be tested in additional analog settings such as the Simulant Development Lab, Planetary Test Analog Site (The Rock Yard), etc.

Assumptions

- Test will not involve any power transfer, just the cable routing
- 25-30-ft cable of 6/2-gauge wire - The average outer diameter for a heavy duty 6/2-gauge portable power cable typically ranges from 0.72-inches to 0.81- inches
- The termination of the cable will be in eyelets to simplify testing
- The starting point of the cable run will be a fixed point
- Single crewmember handling

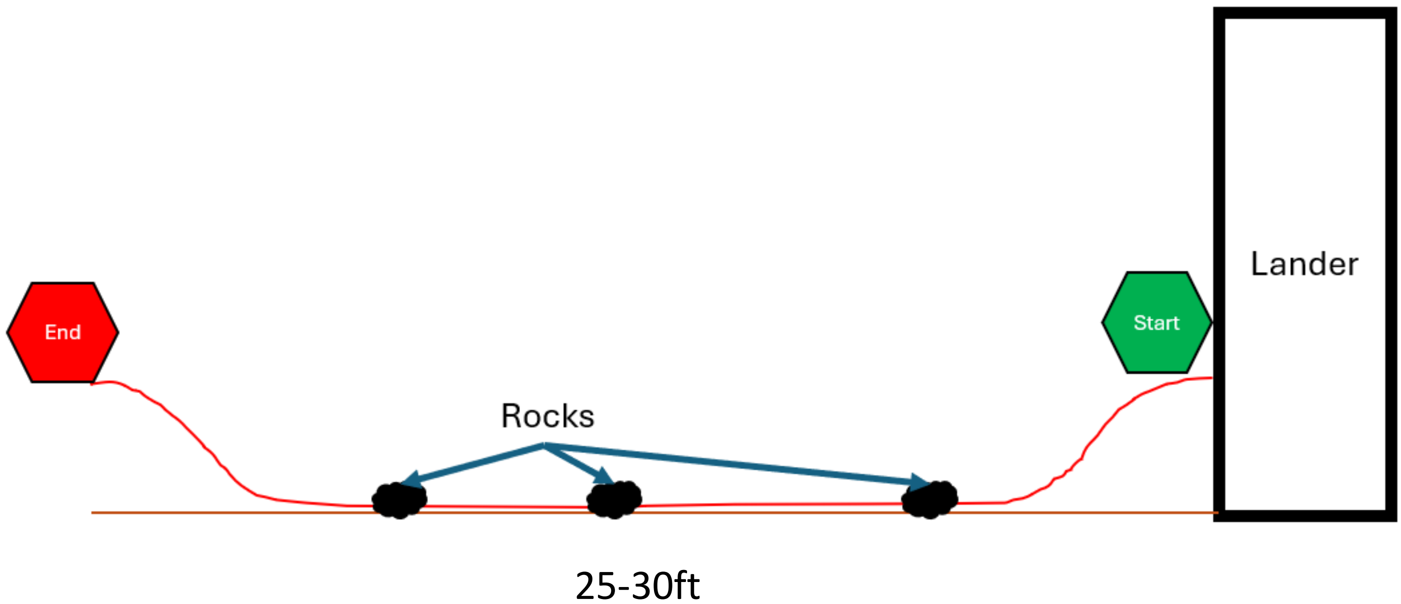

Figure 2: Reference drawing for cable management tool test set up in NBL.

- In the NBL, the test subject will be weighed out to near-lunar gravity (1/6 of Earth's gravity), and they will walk along the bottom of the NBL pool. Selected teams will be responsible for their own test plans. The NBL will be responsible for facility-related hazards (e.g., drowning, barotrauma).
    - To simulate being in a spacesuit, the subject will be diving with a surface supplied diving helmet and EVA gloves. The helmet reduces peripheral visibility, and the gloves reduce dexterity
    - The NBL pool is ~86 °F and 40 ft. deep
    - We will test the device in coarse sand approximately 3-inches deep on the floor of the NBL
    - The device should be designed to be regolith tolerant

Hardware to Provide

- One lunar Cable Management Device (CMD), configured for NBL testing.
    - We will evaluate the device concept of operations in the NBL, where a test subject will provide feedback on overall usage of the tool.
    - Bring the fully assembled tool configured as it would be used during a lunar EVA with the exception of the cable.
- A second device of the same design may be needed for other analog testing. If a second device is needed, teams will be notified by the preliminary design review date.
- ***NOTE:*** *You may choose to use the same hardware for the NBL and simulant testing, if activated. However, there will be approximately 24 hours between your test in the pool and in the Simulant Development Lab. Teams must provide fully dry devices for simulant testing. This means you may need to disassemble and dry or replace certain components which will not fully dry in time.*

Requirements

Functional Requirements

Requirement Number	Minimum Acceptable	Desired
1	You should provide a device that allows astronauts within the full anthropometric range to maneuver with the device.	Prefer the device enables easier, more efficient maneuverability across the lunar surface.
2	Mass of the device shall not exceed 15-lbs if handheld (without cable) and wheeled devices shall not exceed 25-lbs (without cable)	Prefer handheld devices be under 10-lbs (without cable)
3	The device shall fit within a volume of 24-in. x 24-in. x 30-in. (W x L x H) Wheeled devices may exceed height requirement.	
4	Wheeled devices may exceed mass and volume requirements	We prefer a wheeled device to not exceed 20-lbs
5	For a linear-actuating mechanism, the force required to actuate shall not exceed 20-lb (89-N). For a rotating mechanism, the torque required to actuate shall not exceed 30-in-lb (3.4-Nm).	
6	Device shall maintain a minimum 6-in. bend radii of the wire while stored	
7	Device shall allow both termination ends of the cable to be accessible at various lengths of deployment.	
8	Device shall be able to go from unloaded status to fully loaded with cable within 5-8 minutes.	While the tested cable length is 25-30ft, scalable designs are preferred.
9	The device shall require only manual power.	
10	The device shall be able to deploy the length of cable in 6-min	Preferred Deploy Time: 5-min
11	The device shall be able to stow the length of cable in 6-min	Preferred Stowage Time: 5-min
12	Wheeled devices might be able to navigate rocks of at least 18-cm diameter	
13	The device shall pass stress analysis, meeting or exceeding a factor of safety of 2.0 for ultimate stress. Submit a preliminary hand-calculated stress analysis of your proposed design as part of your proposal. It is expected for your stress analysis to include free body diagrams, tracked assumptions, and	We prefer the following stress analysis: • The device passes stress analysis for a 99th percentile astronaut applying their full weight to the end of the handle in lunar gravity (1/6 of Earth's gravity). • The device passes stress analysis for being dropped in any orientation from 4

	equations. Finite Element Analysis (FEA) may be included but is optional. Conduct your stress analysis assuming nominal operation. The objective of the analysis is to identify the most critical component of your device(s) (i.e., the first part to fail, the part with the lowest factor of safety). Report factors of safety based on your design, materials selected, and input loads required for nominal operation. Remember to consider sub-components of mechanisms. *Note: If your proposal is selected, you will be expected to provide additional stress analysis in the spring semester.*	feet above the ground in lunar gravity (1/6 of Earth's gravity). *Note: While it is not a requirement, please consider the implications of dropping the device in Earth gravity when writing your Hazard Analysis.*
14	The device must sink in water.	

Material Requirements

Requirement Number	Minimum Acceptable	Desired
1	You should make the device from materials on the NBL Approved Materials List (contained in the Proposal Guidelines document). This includes metals, plastics, lubricants, coatings, foam, and adhesives. We may grant a waiver on a case-by-case basis if the team provides rationale for material not included on the NBL Approved Materials List and receives approval. The proposed design shall specify all materials used in the provided hardware. **<u>No regular PLA allowed</u>.** Tough PLA is acceptable.	
2	All 3D printed components must be at least 75% infill. This is to help ensure 3D printed parts are strong enough for the application and dense enough to sink in water.	Some parts of your prototype are subject to significant loads during use. We prefer that all cantilevered, mechanism, and handle components are machined out of an NBL-compatible metal.

Safety Requirements

Requirement Number	Minimum Acceptable	Desired
1	There shall be no sharp edges on the device except functional sharp edges needed to meet the required challenge functionality. All functional sharp edges must be protected/inaccessible to the subject when not being used. All functional sharp edges must remain outside a "keep out zone" of at least 3-in. away from the user's hands.	We prefer that the device can meet the challenge functionality with no sharp-edged components.
2	You should present hazards inherent to the device in the proposal and, if selected, in subsequent deliverables to Micro-g NExT. See the Proposal Guidelines document for guidance on conducting a hazard analysis.	
3	There shall be no pinch points on the device. Any pinch points that cannot be eliminated shall be labeled per NBL Labeling Guidelines.	
4	Uncovered holes or gaps, other than tether points, shall be less than 0.5-in. (1.27-cm) or greater than 1.4-in. (3.56-cm) to avoid finger entrapment. Any holes or gaps which cannot be eliminated shall be labeled per NBL Labeling Guidelines.	
5	Hazards that cannot be eliminated (e.g., a functional sharp edge) shall be labeled as "Do Not Touch" zones per NBL Labeling Guidelines.	
6	Areas on the device that are intended for the user to hold shall be labeled per NBL Labeling Guidelines.	

Additional Considerations

- Consider what the astronaut(s) will grab onto to stabilize the device during operation. Handles should be suitable for use with a pressurized suit glove. *Note: smooth, round, rod-like handles tend to cause hand fatigue in a spacesuit glove.*
- Consider the ergonomics of wearing a pressurized spacesuit. Any operations requiring fine motor control in the hands or requiring the astronaut to get into an unnatural position will be much harder to conduct in a spacesuit.
- Refer to the following NBL Labeling Guidelines below to color code your device as outlined below to ensure safe test subject handling and usage of your tool.

NBL Labeling Guidelines

Intended Touch Zones	Do Not Touch Zones	Pinch Points
Solid Yellow	Solid Red	Striped Red and White
A handle, switch, or trigger that is intended for the test subject to use.	A keep out zone around a functional sharp point.	An area to avoid placing hands when actuating a moving part.

- Labeling may be done with marker, vinyl tape, paint, 3D-printed colored filament, waterproof label, etc. as long as it is colorfast and remains intact when exposed to chlorinated water
- Ensure your labeling does not interfere with your device functionality
- All labeling must be fully dried/cured before testing in the NBL

Challenge 2 – Lunar Adjustable Multipurpose Stand

Background

Starting with Artemis IV, NASA astronauts at the Moon's South Pole will face challenging visibility due to harsh lighting and long shadows. To address this, strategically positioned lighting systems are needed to illuminate work areas and paths, especially in permanently shadowed regions. Innovative lighting stands that can be deployed up to 20-feet in height will help direct light into shadows and high-contrast zones, improving crew visibility and safety. The stand must collapse for stowage and fit into a payload slot. Additionally, it should support cameras or communication arrays by providing multiple interfaces for expanded functionality.

Objective

Design and build a Lunar Adjustable Multipurpose Stand that extends above crew height to minimize shadows, supports crew operations, and meets mass and stowage constraints. The stand can also hold cameras, communication arrays, and other EVA or Moon Base equipment. The stand should allow astronauts to deploy across a rocky or smooth surface as well as on a slope not to exceed 25 degrees. All actuations must be glove-compatible to allow reliable, safe EVA actuation. The stand should have simple, dust-tolerant mechanisms allowing crew to set it in regolith when not in use. Astronauts will use the device with limited mobility in a spacesuit, so carefully consider the ergonomics of the device's operations. The tool will be tested in the Neutral Buoyancy Laboratory (NBL) for concept of operations and overall operations including the unstow, deployment, repositioning, and stowage on lunar surface terrain. Additional consideration may be given to a light enclosure mount as well as pan and tilt functions. The device may also be tested in additional analog settings such as the Simulant Development Lab, Planetary Test Analog Site (The Rock Yard), etc.

Assumptions

- The Sun angle varies between 2 and 7 degrees, so shadows extend to large distances depending on the height of the object.
- The height of the stand needs to be above the height of the 99th percentile crew to allow for the position of the light source to point downward at an angle to reduce additional shadowing effects from objects in the work area.

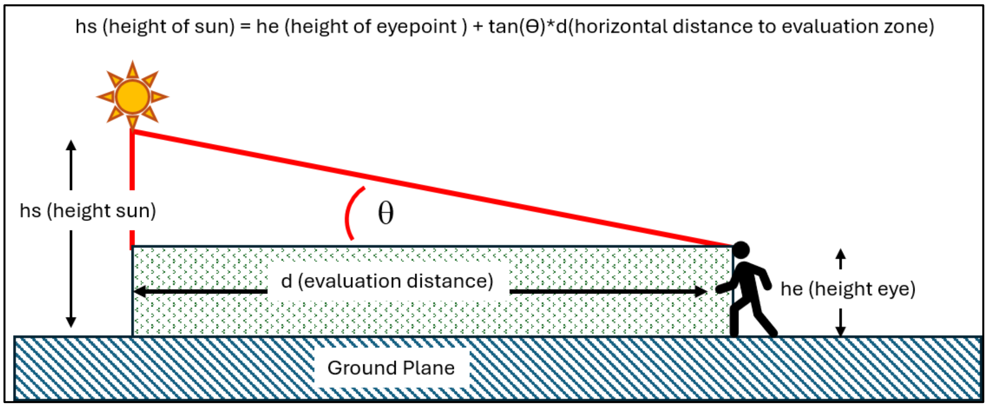

Figure 3: Reference image to calculate the solar height relative to an astronaut's eye height.

- In the NBL, the test subject will be weighed out to near-lunar gravity (1/6 of Earth's gravity), and they will walk along the bottom of the NBL pool. Selected teams will be responsible for their own test plans. The NBL will be responsible for facility-related hazards (e.g., drowning, barotrauma).
    - To simulate being in a spacesuit, the subject will be diving with a surface supplied diving helmet and EVA gloves. The helmet reduces peripheral visibility, and the gloves reduce dexterity.
    - The NBL pool is ~86°F and 40-ft. deep.
    - We will test the device in coarse sand approximately 3-inches in depth on the floor of the NBL.

Hardware to Provide

- One Lunar Adjustable Multipurpose Stand, configured for NBL testing.
    - We will evaluate the device concept of operations in the NBL, where a test subject will provide feedback on overall usage of the tool.
    - Bring the fully assembled system configured as it would be used during a lunar EVA.
- A second device of the same design may be needed for other analog testing. If a second device is needed, teams will be notified by the preliminary design review date.
- ***NOTE:*** *You may choose to use the same hardware for the NBL and simulant testing, if activated. However, there will be approximately 24 hours between your test in the pool and in the Simulant Development Lab. Teams must provide fully dry devices for simulant testing. This means you may need to disassemble and dry or replace certain components which will not fully dry in time.*

Requirements

Functional Requirements

Requirement Number	Minimum Acceptable	Desired
1	You should provide a device that allows astronauts within the full anthropometric range to transport and deploy the light stand.	We prefer that the device enables efficient carrying and repositioning of the light stand along the lunar surface.
2	The device shall allow repositioning of the light stand despite dust intrusion or jamming.	We prefer that the device is dust-tolerant and allows actuation of adjustment despite exposure to the dusty lunar surface environment.
3	Mass of the device shall not exceed 9-kg (19.8-lb).	We prefer that the tool or suite of tools does not exceed 5-kg (11-lb)
4	The device shall stow to fit within a volume of 0.4-m (1.3-ft) x 0.4-m (1.3-ft) x 0.61-m (2-ft). The device shall be deployed to a maximum height of 6.1-m (20-ft) and a base of 3-m (9.8-ft). The device shall allow an interface for an extension to support communication devices.	We prefer the width of the base to be as small as possible to manage both a tripping and tipping hazard.
5	For a linear-actuating mechanism, the force required to actuate shall not exceed 20-lb (89-N). For a rotating mechanism, the torque required to actuate shall not exceed 30-in-lb (3.4-Nm).	
6	The tool shall require only manual power.	
7	The device shall pass stress analysis, meeting or exceeding a factor of safety of 2.0 for ultimate stress. Submit a preliminary hand-calculated stress analysis of your proposed design as part of your proposal. It is expected for your stress analysis to include free body diagrams, tracked assumptions, and equations. Finite Element Analysis (FEA) may be included but is optional. Conduct your stress analysis assuming nominal operation. The objective of the analysis is to identify the most critical	We prefer the following stress analysis: • The device passes stress analysis for a 99th percentile astronaut applying their full weight to the end of the handle in lunar gravity (1/6 of Earth's gravity). • The device passes stress analysis for being dropped in any orientation from 4-feet above the ground in lunar gravity (1/6 of Earth's gravity). *Note: While it is not a requirement, please consider the implications of dropping the*

	component of your device(s) (i.e., the first part to fail, the part with the lowest factor of safety). Report factors of safety based on your design, materials selected, and input loads required for nominal operation. Remember to consider sub-components of mechanisms. *Note: If your proposal is selected, you will be expected to provide additional stress analysis in the spring semester.*	*device in Earth gravity when writing your Hazard Analysis*.
8	The device must sink in water.	

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