MICRO-G NEXT 2022 DESIGN CHALLENGES

NASA's Micro-g 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. The overall experience includes hands-on full-scale engineering design, test operations, and public outreach. Throughout Micro-g NExT, students submit a proposed design before completing a preliminary design review, test equipment data package, and test readiness review to review boards of NASA employees. Test operations are conducted in the lunar analog testing environment of the Neutral Buoyancy Laboratory (NBL). 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 as the design challenges are identified by NASA engineers as necessary in space exploration missions. The 2022 Micro-g NExT challenges focus on the lunar extravehicular activity (EVA) aspects of the upcoming Artemis missions.

NASA Micro-g NExT

Lunar Surface EVA Operations

EVA Sample Size Location Calibration Marker

NASA Mission Connection

NASA is sending the first woman and first person of color to the Moon through the Artemis program. Artemis III astronauts will collect geological lunar samples during extravehicular activities (EVAs). Deployment of sample markers by astronauts next to potential lunar samples is one of the first steps of sample documentation. Photographs taken of the samples and sample markers before collection will help identify and provide information about the sample and its original location when analyzed back on Earth. The sample markers will include a reflectivity chart with color references and a grayscale along with a measurement bar to calibrate the photo documentation and provide sample size and color reference.

Objective

Design a sample marker for astronauts to deploy on the lunar surface. The design should focus on ease of use with limited hand dexterity and body positioning in a spacesuit. The purpose of the sample marker is to provide real-time data about a sample or rock to the scientists back on Earth. Using the marker, scientists can identify information such as location, size, and color of the sample, which helps identify the type of rock. While the scientists decide if the sample should be collected, the astronauts can place markers at other sampling locations. The sample markers may be collected and reused in other sampling locations. This concept of operations is referred to as flexecution and is intended to maximize the astronauts' EVA time while allowing scientific experts on Earth to aid in sampling decisions.

Focus Areas

Mechanical Engineering, Geology, Visual Arts, Graphic Design

Assumptions

- Testing occurs on the bottom of the Neutral Buoyancy Laboratory pool floor.
- The test subject is weighed out to lunar gravity (one-sixth of Earth's) and can walk on the bottom of the NBL pool floor.
- The testing takes place on a variety of surfaces.
- NASA provides rocks, boulders, and lunar regolith simulant during testing.

Requirements

1	The sample marker set includes five sample markers.
2	Each sample marker is placed on the lunar surface and a boulder up to a 20° incline and remain independently stable.
3	Each sample marker is deployed **and** retrieved without the crew member kneeling all the way down to their knee.
4	Each sample marker includes a 2" x 2" label with unique alphanumeric identification information (ex. A1, 01-A, 1A).
5	Each sample marker includes a label with a color reference scale consisting of red, blue, green, black, grey, and white blocks at least 1 cm x 1 cm each. **Note:** no specific RGB color codes are required.
6	a) The proposed sample marker **design** uses flight-like materials and adhere to all requirements. *****
	b) The sample markers **built for NBL testing** is made for an underwater testing environment and

	made from NBL approved materials. A waiver may be granted on a case-by-case basis. *****
7	Each sample marker fits within a volume of 2” x 4” x 15” in its stowed configuration.
8	The total weight of each sample marker is less than 1 lb.
9	Each sample marker is operable with EVA gloved hands (like heavy ski gloves).
10	Each sample marker uses only manual power.
11	No holes or openings allowing/causing entrapment of fingers on the sample markers.
12	No sharp edges on the sample markers.
13	Minimize and label pinch points.

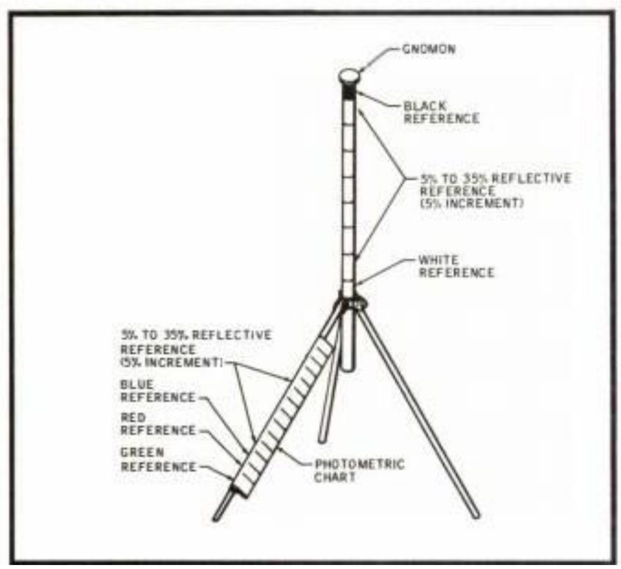
***Materials clarification:** You are expected to propose a flight-like **design** meeting all the requirements. Flight materials need to withstand temperature extremes, temperature fluctuations, solar wind, radiation, etc. However, the sample markers you **build** will be tested underwater in the approximately 86°F pool at the NBL; the materials you build your sample markers out of for NBL testing can be non-flight-like and must follow the NBL approved materials list. You are expected to detail your selected materials for **both** scenarios in your proposal.

Additional Considerations

- Vehicle decent and accent operations limit available mass requiring design and development of lightweight tools.

Past solution: Apollo-era Gnomon

Apollo missions used an item similar to sample markers. Astronauts placed a tripod near the samples and photographed capturing the same type of information. The tripod folded up for easier transport and stowage and included color references (red, green, blue, and grayscale), reflectivity references, and a gimbal mechanism allowed the top rod to sit upright no matter the terrain or slope of the surface. The shadow from the top rod also indicated the location of the sample based on the sun angle. This last feature is no longer necessary based on technological advancements of cameras and location tracking.



NASA Micro-g NExT

Lunar Surface EVA Operations

EVA Sample Bag & Dispenser

NASA Mission Connection

NASA is sending the first woman and first person of color to the Moon through the Artemis program. Artemis III astronauts will collect geological lunar samples during extravehicular activities (EVAs) and will store each sample in an individual sample bag. NASA needs a dispenser which can hold multiple sample bags and dispense one bag at a time during EVAs. Astronauts will carry the sample bag dispenser by hand or mounted to their spacesuits or tool carriers to allow solo sampling operations. The one-time use sample bags need to be durable enough to hold and retain samples of various sizes and types. Find a simple and reliable design for sample bags and their dispenser to aid in sampling operations on the lunar surface.

Objective

Design a sample bag and dispenser system for use during lunar surface sampling operations. The design focuses on ease of use with limited hand dexterity in the spacesuit while following the specified requirements.

Focus Areas

Mechanical engineering, geology, materials science.

Assumptions

- Device testing occurs underwater at the Neutral Buoyancy Laboratory (NBL).
- The test subject is weighed out to near-lunar gravity (one-sixth of Earth's) and can walk on the bottom of the NBL pool floor.
- The sample bags hold rocks, loose regolith, or a combination.
- The mounting mechanism is designed separately and is not in the scope of this challenge. NASA provides the mounting hardware. An interface requirement is detailed in this document.

Requirements

1	The sample bag set includes 10-25 sample bags.
2	Each sample bag is made of **2-5 mil (1/1000 of an inch, NOT mm)** thick,transparent, and flexible plastic material.
3	Each sample bag's interior dimensions is 9" x 9" to ensure the desired size range of samples fit inside the bag and retained.
4	Each sample bag withstands the force of a roughly 5" diameter rock dropping inside the bag from 1" above the opening. See the Additional Considerations section for examples.
5	Each sample bag operable without needing to touch the inside of the bag with the crew member's gloves.
6	The sample bag includes a method to close the bag and retain its contents (*assume it needs to retain rocks and small sand particles*).
7	Each sample bag stays open on its own.
8	The dispenser holds a minimum of 10 and a maximum of 25 sample bags.
9	The dispenser allows crew member to use one hand to open a single sample bag while attached to the dispenser.
10	The dispenser allows crew member to use one hand to dispense a single sample bag at a time.
11	The dispenser restrains the sample bags enough to prevent bag damage, deformation, or accidental opening when not in use. **Note:** an enclosed housing is not prohibited, but also not necessary to meet this requirement.
12	The dispenser is capable of holding an open bag filled with a sample (up to 2 lbs) **prior** to dispensing the filled bag.
13	a) The proposed sample bags and dispenser system **design** should use flight-like materials and adhere to all requirements. *
	b) The sample bags and dispenser system **built for NBL testing** is made for an underwater testing environment and made from NBL approved

	materials. A waiver may be granted on a case-by-case basis. *
14	The sample bags and dispenser system fit within a volume of 15” x 12” x 8” when in use.
15	The sample bags and dispenser system needs a 4-hole bolt pattern to interface with a NASA-provided tool belt. See the Interface Details section for details.
16	The total weight of the dispenser when loaded with bags is less than 3 lbs.
17	The sample bags and dispenser system is operable with EVA gloved hands (like heavy ski gloves).
18	The sample bags and dispenser system uses only manual power.
19	No holes or openings allowing/causing entrapment of fingers on the sample markers.
20	No sharp edges on the sample bags and dispenser system.
21	Minimize and label pinch points.

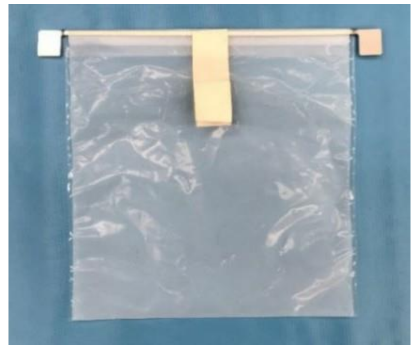
***Materials clarification:** You are expected to propose a flight-like **design** meeting all the requirements. Flight materials need to withstand temperature extremes, temperature fluctuations, solar wind, radiation, etc. The sample bags and dispenser you **build** will be tested underwater in the approximately 86°F pool at the NBL; the materials you build your sample bags and dispenser out of for NBL testing can be non-flight-like and must follow the NBL approved materials list. You are expected to detail your selected materials for **both** scenarios in your proposal.

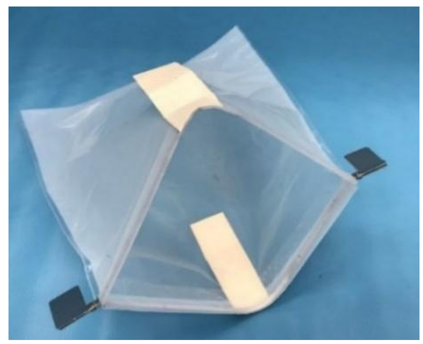
Additional Considerations

- The crew **never** puts their gloves inside the sample bag eliminating sample contamination.
- Vehicle decent and accent operations limit available mass requiring design and development of lightweight tools.
- Three configurations of the sample bag are anticipated:
    - prior to dispensing,
    - open filling, and
    - closed to retain the sample.
- A Ziploc bag or similar is not be strong enough. Some recommended plastics to consider for bag material are:
    - LDPE,
    - Fluoroplastics,
    - vinyl, and
    - polypropylene.

Past Solution: Apollo Sample Bags

Your proposed sample bags **can** be similar in design to the Apollo Documented Sample Bags. Below are images of an Apollo sample bag mockup. More details and imagery available online.





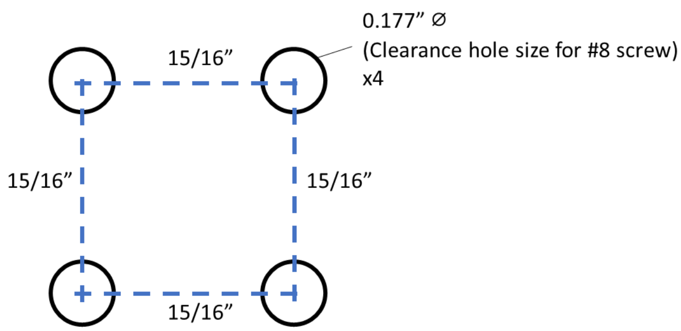
Sample Bag Rock Drop-Test

A drop-test is recommended to meet Requirement #4. Conglomerate rocks are examples of rocks used for a similar purpose for bag development and testing. Conglomerate rocks (formed in a river environment and made up of many rocks stuck together) and represent the larger end of potential rock samples. The rocks were held one inch above the opening of the bag, measured from the bottom of the rock, and dropped into an open sample bag to test the heat seals and bag integrity. The test was repeated with varying rock sizes and shapes. This is sufficient test to meet Requirement #4.

Rock types to consider using include conglomerate, vesicular basalt, anorthosite, and sandstone.

Interface Details

Use the following 4-hole bolt pattern for your bag dispenser. #8-32 screws secure your dispenser to the NASA-provided Tool Belt interface for NBL testing. Your team can determine the bolt head type and screw length that works best for your design.



NASA Micro-g NExT

Lunar Surface EVA Operations

Lunar Reusable Surface Anchoring Device

NASA Mission Connection

NASA is sending the first woman and first person of color to the Moon through the Artemis program. Artemis missions will initially send robots, followed by astronauts, to obtain samples of the lunar surface, including the icy lunar south pole. Additionally, NASA is developing systems to explore underneath the ice-covered surface of celestial bodies such as Europa and Enceladus. These systems operate underwater and sample both the surrounding water and any ice-structures. Buoyancy acts similarly to the reduced gravity of the Moon in an underwater environment.

Astronauts or robots may require a quick temporary anchor to be established when working in these environments. Anchors designed to quickly deploy without power and provide significant holding strength to a variety of surfaces is important. The anchoring mechanism may be used to secure astronauts while they retrieve rock samples, hold up a structure on rocky terrain, or secure an underwater vehicle in the face of strong currents.

Objective

Design and manufacture an anchoring mechanism, able to provide holding force on a variety of objects with different types of faces. Anchoring mechanisms have multiple uses in spaceflight. In 2014, Philae, a robotic lander from the European Space Agency had difficulty landing on a comet when the anchoring mechanism did not work properly. A reusable anchoring mechanism allows for a variety of work to be performed in carrying out a successful mission.

Focus Areas

Mechanical Engineering, Geology

Assumptions

- The test subject is weighed out to lunar gravity (one-sixth of Earth's) and can walk on the bottom of the NBL pool.
- Device is deployed by hand and requires no power nor chemical adhesion.
- Device testing occurs on the bottom of the Neutral Buoyancy Laboratory pool.
- The device is reusable
- The device is used with either hand.

Requirements

1	The device anchors on a variety of rock textures, from smooth to rough, where each rock presents at least a 12" diameter face
2	The device does not penetrate the surface of the rock face.
3	The device is started with one or two gloved hands.
4	The device is not externally powered or pressurized.
5	The device does not chemically adhere to the object.
6	The device (all parts, when stowed) fit within an 18" long cylinder with 6" diameter.
7	The device (all parts) operates underwater.
8	The device (all parts) has a dry weight less than 5 lbs.
9	The device is compatible with a chlorine water and a salt-water environment.
10	The device operates within an environment from 23°F to 86°F (-5°C to 30°C).
11	The device provides at least 10 lbs of holding strength at any angle 90° off the face of the rock.