MICRO-G NEXT 2021 DESIGN CHALLENGES

09.28.2020 Design challenge descriptions contained in this document are intended for participants in Micro-g NExT.

NASA Micro-g NExT

Orion Crew Safety -

Surface Autonomous Vehicle for Emergency Rescue (SAVER)

NASA Mission Connection

NASA has been challenged to go forward to the Moon by 2024 with our Artemis Program, using Orion as the spacecraft. In the event of an unplanned egress (launch abort, contingency landing, etc.), Orion crewmembers will be exiting the crew vehicle and using a life raft. Each astronaut will be equipped with a 406 MHz emergency distress beacon to ensure they can be located should they individually be separated from the life raft and Orion capsule. The SAVER vehicle will assist with long-range Search and Rescue efforts by acting as a force-multiplier, assisting current efforts to tend to survivors on the scene immediately. The current ability to drop a lifeboat from rescue assets allows on-scene rescuers to immediately tend to survivors in the main life raft while SAVER autonomously searches for any isolated victims.

Objective

Design a surface vehicle capable of assisting astronauts in distress in a maritime environment, through the location and delivery of crew survival aids.

Assumptions

- For testing purposes, the vehicle will be powered by an umbilical in the NBL.
- To address requirement #4, the team may use commercially available 121.5 MHz homing equipment, or develop a unique solution for use with the NASA-provided beacon.

Requirements

1	The vehicle shall be capable of being dropped from a 10-15 foot height into the maritime environment.
2	The vehicle shall be capable of being carried on a Group 1 (small) or Group 2 (medium), Close-range UAV.
3	The vehicle shall be capable of transporting (carrying or towing), at a minimum, the following items to the victim: a. Water (1 liter minimum - 2.5 Liters max per Human Systems Integration Standard) b. Medical kit (Orion 0.6 lb kit) c. Spare Life Preserver Unit (LPU)* d. Contingency/Spare 406 MHz Second-Generation Beacon (ANGEL) e. Survival Radio Optionally, the following may also be included: f. Inflatable life raft (taking into account size/mass considerations) *Note: A pair of Orion LPU lobes with an existing, integrated ANGEL beacon may be used in lieu of other options for requirement c.
4	The vehicle shall be capable of using existing equipment to detect the ANGEL beacon 121.5 MHz homing signal in order to guide the vehicle toward the beacon.
5	The vehicle shall be capable of traveling to the person in distress via the most direct route in an autonomous manner, including:

	a. Unmanned operation (no local or remote human intervention) b. Programmed with mission profiles to address specifics of rescue scenario
6	The vehicle shall include protections in software/hardware to ensure no harm to the crew upon arrival in their vicinity.

NASA Micro-g NExT

Lunar Surface EVA Operations

Space Suit Attachment Quick Release System

Background

NASA has been challenged to go to the Moon by 2024 with our Artemis Program. On the lunar surface, astronauts will perform spacewalks, also called Extravehicular Activities (EVAs). The EVA Tools Team is pursuing a concept for carrying tools on the Exploration Extravehicular Mobility Unit (xEMU) called the Utility Belt. Carrying tools on the spacesuit can increase efficiency of a spacewalk and enable a single astronaut to perform end-to-end sampling operations on the Moon and eventually Mars. The tools that are being considered for attaching to the Utility Belt are likely to be accessed repeatedly during lunar EVAs and need to be easy to remove and replace. Lunar dust is guaranteed to get into this mechanism throughout an EVA, so it will need to be designed to function even in the presence of dust.

Objective

Design an attachment method for EVA Tools to the xEMU Utility Belt. The design should focus on tool stability and security when attached to the Utility Belt and ease of actuation by a suited astronaut. It also must be dust tolerant.

You are to design 2 items: The interface piece that will be on the EVA Tool itself and the corresponding interface piece that will be on the Utility Belt.

Assumptions

- The subject will be weighed out to lunar gravity (1/6th of Earth's) and can walk on the bottom of the NBL.
- NASA will provide EVA Tools and a Utility Belt for testing at the NBL that will use the bolt pattern defined below.

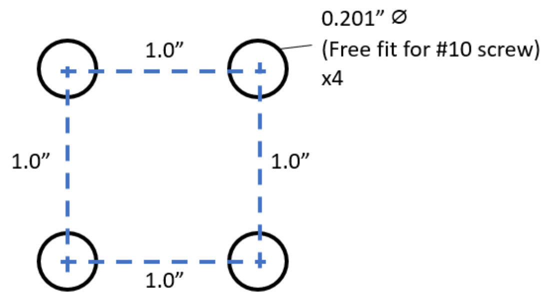
Requirements

1	The attachment shall be able to support at least 15 lbs of weight in Earth's gravity.
2	The attachment mechanism shall be operable outside of the astronaut's line of sight. In other words, the astronaut shall be able to operate the mechanism without being able to see it.
3	The attachment mechanism shall be operable with one hand (the other hand can be used to place the tool into the mechanism).
4	The device shall be able to function as intended after being fully submerged in lunar dust simulant. The device will be fully submerged in lunar dust simulant, removed, and then cycled 10 times.
5	The two pieces should install and separate from each other with minimal force for ease of use but has enough force to stay in place while walking/bending.
6	The device shall use only manual power.
7	The device shall fit within a volume of 4" by 4" by 3", the smaller the better.
8	The device shall have a 4-hole bolt pattern to interface with the Utility Belt. See ***Interface Details*** below.
9	The device must be operable with EVA gloved hands (like heavy ski gloves).
10	The total weight of all parts you provide should be less than 2 lbs, the lighter the better.
11	The parts must not have holes or openings which would allow/cause entrapment of fingers.
12	The parts should be made from only Aluminum 6061, Aluminum 7075, Stainless Steel (any series), or Teflon. Any other materials must get prior approval from the EVA Tools POC*.
13	There shall be no sharp edges on the tool.
14	Pinch points should be minimized and labeled.

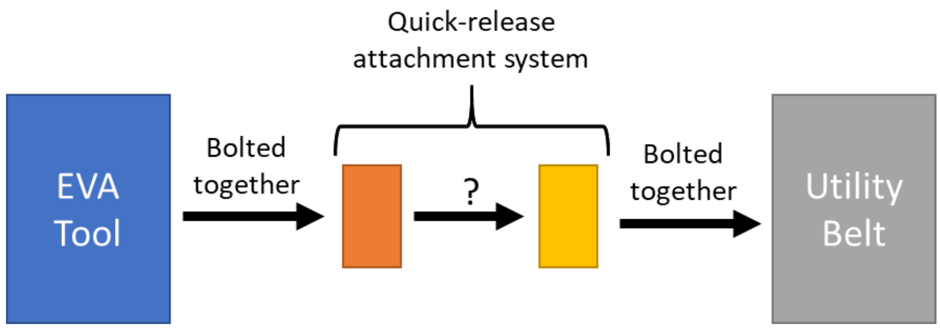
*NOTE: If 3D-printing and/or any other materials are necessary to use due to financial reasons or other extenuating circumstances, please contact the EVA Tools POC via email with rationale. An additional load test or drop test could be required for devices with 3D-printed parts.

Interface Details

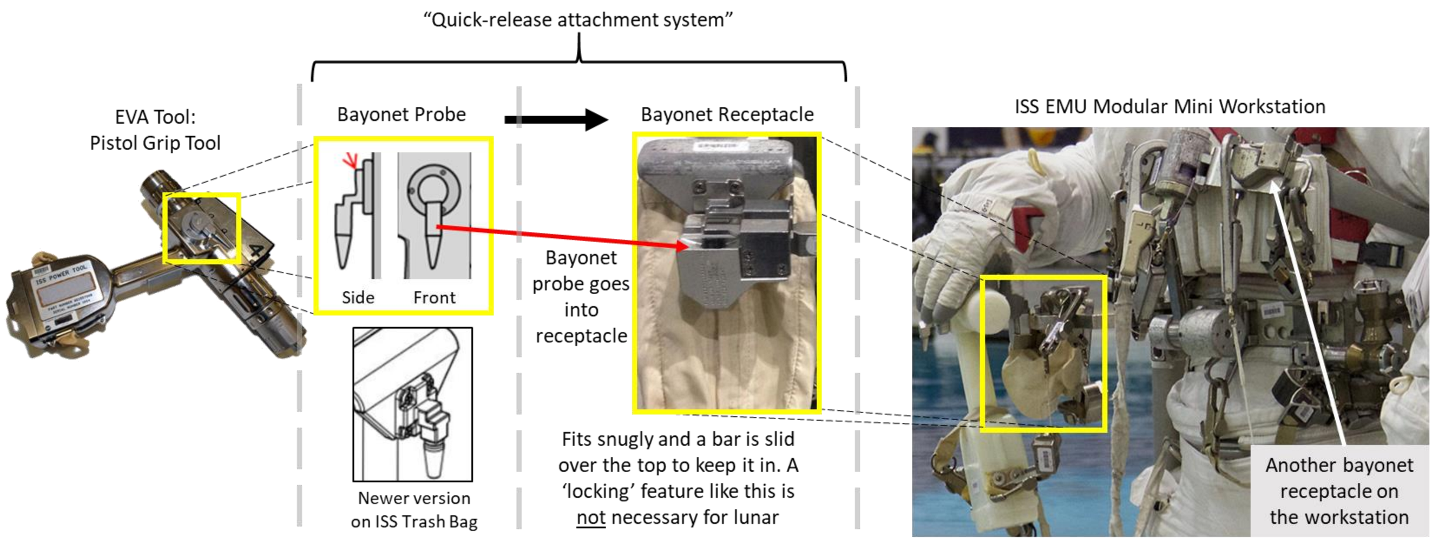
Use the following 4-hole bolt pattern for both parts you design to allow them to attach with the NASA-provided EVA Tool and Utility Belt.



The graphic below shows the stack up from an EVA Tool to the Utility Belt. Your task is to design the quick-release attachment system (orange and yellow parts), specifically the interface between them.



Example from current ISS EMU. Remember, this is the non-dust-tolerant design that we do not want to use for lunar surface operations on the xEMU Utility Belt.



NASA Micro-g NExT

Lunar Surface EVA Operations

Sample Container Dispensing Device

Background
NASA has been challenged to go to the Moon by 2024 with our Artemis Program. On the lunar surface, astronauts will collect geological samples during spacewalks, or Extravehicular Activities (EVAs), and will store each sample in an individual sample bag. There is a need for a sample bag dispenser which can hold multiple sample bags and dispense one bag at a time during sampling operations. In order to allow solo sampling operations, the sample bag dispenser will be carried by hand or mounted to the spacesuit or tool carrier. In this challenge, the focus is finding a simple and reliable design that can dispense sample bags during a lunar spacewalk to aid in sampling operations.

Objective
Design a sample bag dispenser for use during lunar surface sampling operations. The design should focus on ease of use with limited hand dexterity in the spacesuit.

Assumptions

- The subject will be weighed out to lunar gravity (1/6th of Earth's) and can walk on the bottom of the NBL.
- NASA will provide the sample bags for testing at the NBL.
- Sample bags will be made of Teflon film and measure *roughly 9"x9"* when closed. An Aluminum rim will hold the bag open when deformed. To close, the bag opening is rolled down and flags on either side are folded in to keep the bag closed, like closing a bag of coffee beans.
    - The bags will be similar in design to the Apollo Document Sample Bags.
    - See ***Sample Bag Details*** at the end of the document for more specifics.
- The mounting mechanism will be designed separately and is not in the scope of this challenge. An interface requirement is included below.

Requirements

1	The dispenser shall hold 20 sample bags.
2	The dispenser shall allow the crew member to use one hand to open a single sample bag while attached to the dispenser.
3	The dispenser shall allow the crew member to use one hand to dispense a single sample bag at a time.
4	The dispenser shall restrain the sample bags enough to prevent bag damage, deformation, or accidental opening when not in use.
5	The dispenser shall be capable of holding an open bag that will be filled with a sample (up to 2 lbs) prior to dispensing the filled bag.
6	The device shall use only manual power.
7	The device shall fit within a volume of *12" x 12" x 5"*.
8	The device shall have a 4-hole bolt pattern to interface with the Utility Belt. See ***Interface Details*** below.
9	The device must be operable with EVA gloved hands (like heavy ski gloves).
10	The total weight of the dispenser should be less than 3 lbs, not including sample bags.
11	The device must not have holes or openings which would allow/cause entrapment of fingers.
12	The device should be made from only Aluminum 6061, Aluminum 7075, Stainless Steel (any series), or Teflon. Any other materials must get prior approval from the EVA Tools POC*.
13	There shall be no sharp edges on the tool.
14	Pinch points should be minimized and labeled.

*NOTE: If 3D-printing and/or any other materials are necessary to use due to financial reasons or other extenuating circumstances, please contact the EVA Tools POC via email with rationale. An additional load test or drop test will be required for devices with 3D-printed parts.

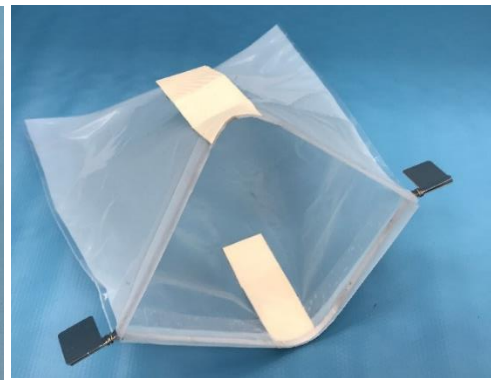
Recommended Considerations

- The crew should never put the gloves inside the sample bag so there is no contamination of the sample.
- The white tabs are large enough to hold onto with the gloves and strong enough to allow opening of the bag.
- The Aluminum rim and flags are thin and meant to be deformable to allow the bag to stay open. The dispenser design and operations should make it so the bags are not accidentally deformed or opened to avoid any cross-contamination between collected samples.

Sample Bag Details

Note: Design of the Sample Bags is currently ongoing. These dimensions are an educated guess of the final design for flight and are subject to change. Because of this, Requirement #7 is also subject to change. Refer to the latest version of this challenge document on the Micro-g NExT website for any updates throughout the semester. Changes will also be relayed during the virtual info-sessions.

Front view



Open bag

Sample going into a bag

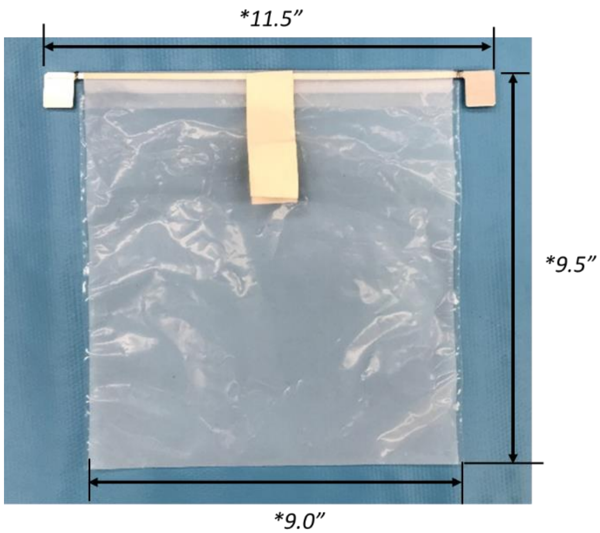
Aluminum rims pushed together to close bag

Bag is rolled down using Aluminum rims

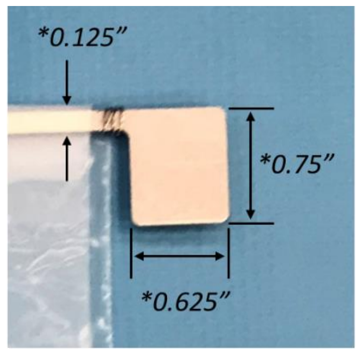
Operations: The white tabs on the outside of the bag and are pulled apart to open the bag allowing the Aluminum rim to deform and keep the bag open. Once the sample is collected, the rim is flattened again and rolled down. The Aluminum square flags connected to the rim are folded in to secure the bag closed. The closure design is like that of a common coffee bean bag or some cookie bags.

Closed bag

Common bag with similar closure method



Bag Dimensions



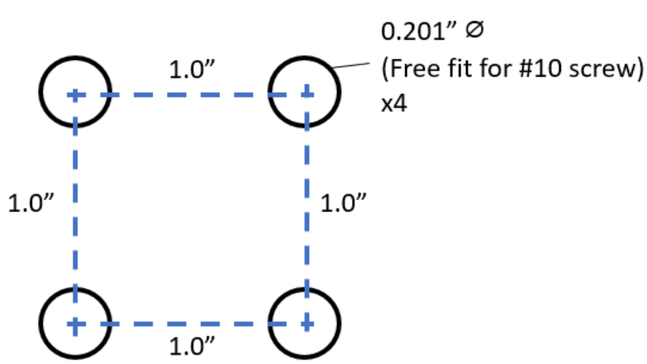
*Aluminum tab is *0.025” thick*

Flag Detail

*These dimensions are subject to change however the overall design will stay the same. The Aluminum flag dimensions are less likely to change than the bag size.

Interface Details

Use the following 4-hole bolt pattern for your device to be able to attach to the NASA-provided interface.



NASA Micro-g NExT

Lunar Surface EVA Operations

Lunar Coring Device

NASA Mission Connection

NASA has been challenged to go forward to the Moon by 2024 with our Artemis Program. Artemis will send astronauts and robots to obtain samples from new locations of the lunar surface, including the lunar South Pole which contains ice. Taking a sample is critical for scientific research, yet drilling and capturing a pristine sample is challenging. Designing an appropriate coring bit, which fits existing tools, which can drill and capture a small core, is important for testing on the Moon and designing sampling mechanisms for other worlds.

Challenge Objective

Design and manufacture a coring bit, stabilizing jig, and sample containment mechanism able to drill into and retrieve a sample core.

Assumptions

- This device will be driven by a NASA provided underwater drill held by divers – example: https://www.nemo-underwatertools.co.uk/product/underwater-divers-drill/
- The subject will be weighed out to lunar gravity (1/6th of Earth's) and can walk on the bottom of the pool.

Requirements

1	The device shall be able to collect cylindrical core samples 0.5" in diameter and 3" deep from concrete or ice.
2	The device shall not extend beyond the plane of the drill chuck toward the diver (all components must be below the drill chuck).
3	The device shall mechanically interface with a 13mm (0.512") drill chuck.
4	The device shall not be externally powered or pressurized.
5	The device shall drill a core, capture the core, and contain the core when the drill is removed from the sample target.
6	The device (all parts, in stowed configuration) shall fit within a 6" diameter x 6" long cylinder.
7	The device (all parts) shall operate underwater.
8	The device (all parts) shall have a dry weight less than 3 lbs.
9	The device shall be compatible with a chlorine water and a salt-water environment.
10	The device shall operate within an environment from 23^{O}F to 86^{O}F (-5^{O}C to 30^{O}C).