MICRO-G NEXT

Neutral Buoyancy Experiment Design Teams

National Aeronautics and Space Administration

NASA

2025 Micro-g NExT CHALLENGES

1 LUNAR OPERATIONS

CONTACT SAMPLING DEVICE

Design a device allowing a suited astronaut to collect a contact sample of regolith on the lunar surface and capture the grain orientation of the surface particles.

2 MICROGRAVITY OPERATIONS

SOFTGOODS ATTACHMENT DEVICE

Design an EVA tool, or tools, that you can use to attach two overlapping pieces of softgoods together while accessing only one side of the material.

3 SEARCH AND RESCUE

SCAN, ACQUIRE, FILTER, EXTRACT & TRACK ORION CAPSULE SEARCH & RESCUE SIGNALS (SAFE-T)

Design an autonomous system that you can use to validate the Orion spacecraft's radio frequency configuration when out of communications range of the larger recovery force.

Learn more at https://go.nasa.gov/micrognext

Microgravity Neutral Buoyancy Experiment Design Teams

(Micro-g NExT) Challenge

2024 – 2025

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Lunar Operations

Contact Sampling Device

Background

NASA is preparing to go to the lunar south pole during the Artemis missions. Artemis III astronauts will collect a variety of geological lunar samples during extravehicular activities (EVAs) to shed light on different scientific areas of inquiry. One such area of scientific interest is investigating the grains which make up the top layer of regolith on the lunar surface. Specifically, scientists will investigate the grain size, material variety, physical distribution, and grain orientation of the top layer of the lunar regolith to gain valuable knowledge about space weathering and the history of the Moon. In order to bring home these unique samples, astronauts will need a special Contact Sampling Device to collect and return the samples to Earth. The area they sample must be relatively undisturbed by EVA activities (e.g., dust lofted by the lander, material kicked by an astronaut walking nearby) to ensure they collect a pristine sample. The device must then be able to close and store the sample for safe return to Earth. Design a reliable and ergonomically friendly device to collect and contain a lunar surface contact sample. NASA has previously collected lunar surface samples in past missions (e.g., Apollo, OSIRIS-Rex). If you choose to use these past missions as inspiration, please apply lessons learned from those missions and demonstrate how your design innovates or improves upon previous designs.

Objective

Design a device allowing a suited astronaut to collect a “contact sample” of the lunar surface — collecting the top 1-5mm of regolith on the lunar surface and capturing the grain orientation of the surface particles. The device must have a glove-compatible closure method to preserve the sample and safely return the sample to Earth. Include a way for scientists on Earth to extract the sample from the device upon return to the sample curation facility. Astronauts will use the device with limited mobility in a space suit, so carefully consider the ergonomics of your device’s operations. The tool will be tested in the Neutral Buoyancy Laboratory (NBL) for overall tool function and concept of operations, as well as in the Simulant Development Lab (SDL) at NASA’s Johnson Space Center in Houston, Texas, for the ability to sample and contain the top layer of regolith.

Focus Areas

Mechanical engineering, materials science, ergonomics, biomechanics, softgoods/textiles, and industrial design.

Assumptions

- We will test the device underwater at the NBL as well as in lunar regolith simulant at the SDL.
- In the NBL, we will weigh the test subject 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 on the floor of the NBL.
- In the SDL, the team will test their own device using lunar simulant. Selected teams will be responsible for their own test plans. The SDL will be responsible for facility-related hazards (e.g., inhalation, handling of simulant).
    - You will test the device in a lunar simulant bin at the SDL.

Hardware to Provide

- One Lunar Contact Sampling Device, 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.
- One Lunar Contact Sampling Device, configured for lunar simulant testing.
    - The ability of the device to pick up and contain a contact sample of the top 1-5mm of lunar regolith will be tested in the SDL, where a lunar simulant will be used.
    - Bring the portion(s) of the tool required for obtaining a regolith sample. If your design includes features for ergonomic purposes, you may bring a simplified version with just the sampling parts.
- ***NOTE:*** *You may choose to use the same hardware for the NBL and simulant testing. However, there will be approximately 24 hours between your test in the pool and in the SDL. 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.*

<u>**Requirements**</u>

Requirement Number	Minimum Acceptable	Desired
Functional Requirements		
1	You should provide a device that is capable of collecting and stowing a sample of the top 1-5mm of regolith on the lunar surface using EVA gloved hands.	We prefer that the device also capture the grain orientation of the surface particles.
2	The device shall allow the sampling surface to be removed upon return to Earth (wearing nitrile gloves or similar).	We prefer that the sampling surface be removed while wearing a spacesuit (using EVA gloved hands).
3	Mass of the tool or suite of tools shall not exceed 10 lbs in Earth gravity.	We prefer that the tool or suite of tools does not exceed 5 lbs in Earth gravity.
4	The **stowed** device shall fit within a volume of 8 in. x 8 in. x 36 in. *Note: The **deployed** device may be any volume as long as it is operable by one person.*	We prefer that the **stowed** device fit within a volume of 8 in. x 8 in. x 16 in. *Note: The **deployed** device may be any volume as long as it is operable by one person.*
5	For a linear-actuating mechanism, the force required to actuate shall not exceed 20 lbf (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 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.*	We prefer that the device also 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 device in Earth gravity when writing your Hazard Analysis.*
8	The device(s), as well as any components that separate from the device(s) during operation must sink in water.	

Requirement Number	Minimum Acceptable	Desired
Material Requirements		
9	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 a material not included on the NBL Approved Materials List and receives approval. The proposed design shall specify all materials used in the provided hardware. **No regular PLA allowed.** Tough PLA is acceptable.	
10	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.	
Safety Requirements		
11	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 3 in., or move away from the user’s hands.	We prefer that the device can meet the challenge functionality with no sharp-edged tools.
12	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.	
13	There shall be no pinch points on the device. Any pinch points that cannot be eliminated shall be labeled per NBL Labeling Guidelines which we will provide at a later date.	
14	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 which we will provide at a later date.	
15	Hazards that cannot be eliminated (e.g., a functional sharp edge) shall be labeled as “Do Not Touch” zones per NBL Labeling Guidelines which we will provide at a later date.	
16	Areas on the device that are intended for the user to hold shall be labeled per NBL Labeling Guidelines which we will provide at a later date.	

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 space suit. Any operations requiring fine motor control in the hands or requiring the astronaut to get into an unnatural body position will be much harder to conduct in a space suit.

Microgravity Operations

Softgoods Attachment Device

Background

Softgoods (textiles) serve important functions in spaceflight. On the International Space Station, one crucial role for softgoods is acting as thermal protection for sensitive equipment. In a series of EVAs, astronauts may need a method to permanently attach pieces of softgoods together to protect the junction between a pre-existing component and a newly installed component. This requires a tool, or tools, astronauts can use to attach two pieces of softgoods together while only accessing the exterior-facing side of the material (i.e., the astronaut cannot reach around/under any fabric or structure to access the inside face of the softgoods). Find a reliable, ergonomically friendly way to attach two overlapping pieces of softgoods to each other during an EVA.

Objective

Design an EVA tool, or tools, that you can use to attach two overlapping pieces of softgoods together while accessing only one side of the material. One fully capable tool is preferred, but you can use a small suite of tools, up to three pieces, to accomplish the task. If your design incorporates any functional sharp edge(s), you must include a method to cover, retract, or otherwise prevent accidental contact between the user and the functional sharp edge. Astronauts will use the device with limited mobility in a space suit, so carefully consider the ergonomics of your device's operations. We will test your device(s) for functionality in the NBL.

Focus Areas

Mechanical engineering, softgoods/textiles, materials science, ergonomics, biomechanics, and industrial design.

Assumptions

- We will test the device underwater at the NBL. Selected teams will be responsible for their own test plans. The NBL will be responsible for facility-related hazards (e.g., drowning, barotrauma).
    - We will weigh the test subject out to near-neutral buoyancy (simulating micro-gravity).
    - The test subject will be stabilized with their feet in a fixed restraint, allowing them to react to small amounts of load. They will have two free hands.
    - 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 provide a test fixture with fabric stretched over a frame. Additionally, a second free-floating piece of fabric is to be attached.
- We will provide a document with test fixture information as well as the fabric type/thickness at a later date.

Hardware to Provide

- One Microgravity Softgoods Attachment Device (or one suite of devices) configured for NBL testing.
    - NASA will provide the test fixture, including the softgoods to be attached. Additional information regarding the test fixture will be provided at a later date.

Requirements

Requirement Number	Minimum Acceptable	Desired
Functional Requirements		
1	You should provide a device, or suite of devices, capable of attaching a layer of fabric to another piece of fabric mounted on a frame while only accessing the front/outer face (not the back).	
2	You must meet the challenge functionality while using no greater than three tools in total.	We prefer that you meet the functionality with only one tool.
3	Mass of the tool, or suite of tools, shall not exceed 10 lbs in Earth gravity.	We prefer that the tool, or suite of tools, does not exceed 5 lbs in Earth gravity.
4	The **stowed** device shall fit within a volume of 12 in. x 12 in. x 12 in. If your solution includes more than one device, all devices must fit together in this volume. *Note: Any **deployed** device may be any volume as long as it is operable by one person.*	
5	For a linear-actuating mechanism, the force required to actuate shall not exceed 20 lbf (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, and any removable components, shall have a tether attachment point diameter of 1 in.	
8	The device(s) shall pass a 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. We expect 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 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, we expect you to provide additional stress analysis in the spring semester.*	We prefer for the device to also pass a stress analysis for a bump load of 30 lbf on any part of the tool. *Note: While it is not a requirement, please consider the implications of dropping the device in Earth gravity when writing your Hazard Analysis.*
9	The device(s), as well as any components that separate from the device during operation, must sink in water.	We prefer that the device(s) be neutrally buoyant to mimic micro-gravity (i.e., does not sink nor float).

Requirement Number	Minimum Acceptable	Desired
Material Requirements		
10	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 a 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.	
11	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.)	
Safety Requirements		
12	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.	We prefer that the device can meet the challenge functionality with no sharp-edged tools.
13	All functional sharp edges must remain outside a “keep out zone” of 3 in., or move away from the user’s hands. *Note: Your design may utilize some type of tool to fix the 2nd piece of fabric in place, or have the user hold the fabric in place. Plan accordingly whether use of your device(s) is a one or two-handed operation.*	
14	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.	
15	There shall be no pinch points on the device. Any pinch points that cannot be eliminated shall be labeled per NBL Labeling Guidelines which we will provide at a later date.	
16	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 that cannot be eliminated shall be labeled per NBL Labeling Guidelines which we will provide at a later date.	
17	Hazards that cannot be eliminated (e.g., a functional sharp edge) shall be labeled as “Do Not Touch” zones per NBL Labeling Guidelines which we will provide at a later date.	

18	Areas on the device that are intended for the user to hold shall be labeled per NBL Labeling Guidelines which we will provide at a later date.	

<u>Additional Considerations</u>

- 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 space suit. Any operations requiring fine motor control in the hands or requiring the astronaut to get into an unnatural body position will be much harder to conduct in a space suit.

SAFE-T:

Scan, Acquire, Filter, Extract & Track
Orion Capsule Search & Rescue Signals

Background

NASA has been challenged to go forward to the Moon with our Artemis Program, using Orion as the spacecraft to transport the crew. As post-landing crews approach the Orion capsule, limited real-time information is available pertaining to the status of beacon transmissions, including swept-tone homers (121.65 MHz), and Search and Rescue Satellite-Aided Tracking (SARSAT) satellite communication signals. This challenge allows for the development of team-carried portable recovery equipment to determine if the capsule is radiating on either frequency, while allowing for future extensibility as a low-cost portable search and rescue (SAR) signal detector for volunteer search and rescue organizations. The system will allow for ground SAR and recovery responders to validate the capsule radio frequency (RF) configuration when out of communications range of the larger recovery force.

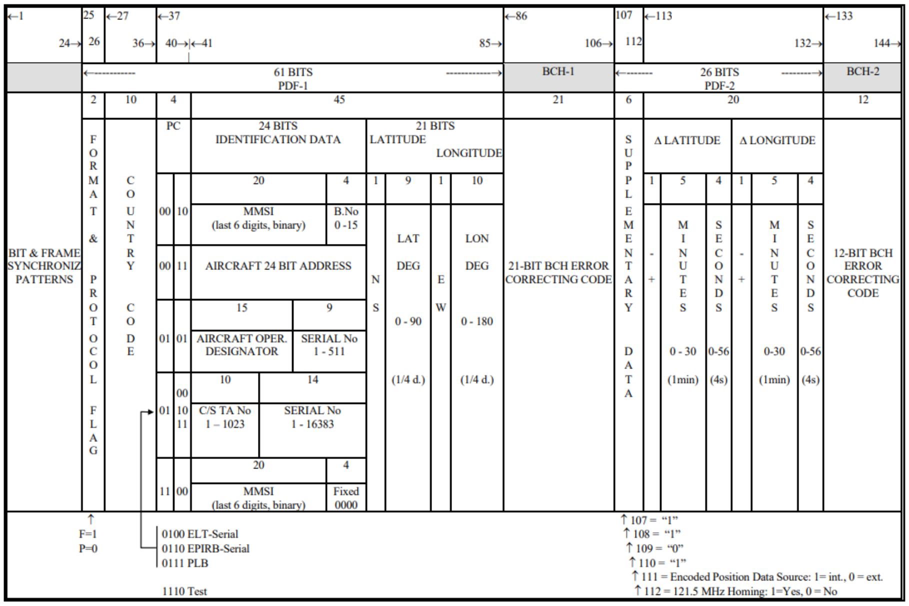
Objective

Design an autonomous system supporting open-ocean SAR situational awareness of varying SAR RF beacons used in the Orion landing and recovery post-landing phase capable of meeting the following requirements:

Functional:

- Detect and provide notice (via GUI or visual display) of 121.65 MHz swept-tone signals transmitting at 100 mW transmit power.
- Detect, receive, and decode first-generation (FGB) beacon signals transmitted on 406.025 MHz at 5 watts transmit power in the following format:
    - Example Hex Packet: FFFE2F970E00800127299B1E21F600657969

	Bit Synchronization	Frame Synchronization	First Protected Data Field (PDF-1)				BCH-1	Second Protected Data Field (PDF-2)	BCH-2
Unmodulated Carrier (160 ms)	Bit Synchronization Pattern	Frame Synchronization Pattern	Format Flag	Protocol Flag	Country Code	Identification or Identification plus Position	21-Bit BCH Code	Supplementary and Position or National Use Data	12-Bit BCH Code
Bit No.	1-15	16-24	25	26	27-36	37-85	86-106	107-132	133-144
	15 bits	9 bits	1 bit	1 bit	10 bits	49 bits	21 bits	26 bits	12 bits



- Provide “short data burst” notification of 406.025 MHz beacon detection to an operator display (e.g., via wired connection to a laptop, via built-in user display).
    - Text message on screen / graphical user interface (GUI) with following information:
        - Country Code: 10 bits, bits 27-36 (e.g., USA).
        - Beacon Hex ID: bits 26 through 85 with default values in PDF-1.
        - Encoded Location: 20 bits, bits 113-132.

Physical

- Electronics/processing elements fit within a water-resistant enclosure for use on the pool deck and are sized to fit within a Pelican brand 1400 Case (11.81 x 8.87 x 5.18 in interior size).
- System can be powered by external power cable or commercial off the shelf rechargeable battery.
- Antenna(s) should be external to the processing case and mounted on a portable tripod or stand and sized to receive 121.65 MHz and 406 MHz signals.
    - Example for 121.65 MHz signal receive antenna — https://www.mouser.com/ProductDetail/TE-Connectivity-Laird-External-Antennas/EXB118BNX?qs=EU6FO9ffTwd%252BxudbOKPZpw%3D%3D
    - Example for 406.025 MHz signal receive antenna — https://www.newark.com/l-com/lcanrbd1030/rf-antenna-400-to-470mhz-2-5dbi/dp/78AK2080

Cost/Project Management

- Use commercial off-the-shelf hardware/software to the greatest extent possible (e.g., laptops, Raspberry Pi / Arduino for on-board computing)
- Teams should focus on programming and electrical engineering elements of the design challenge. These require some undergraduate-level experience in programs such as Python and the use of commercial software defined radios.

Focus Areas and Disciplines

This challenge is primarily an electrical engineering/software engineering-focused effort, including the following focus areas and disciplines:

- **Software Engineering / Coding** — students should be proficient in free/open-source software tools (e.g., Python, C++) and be able to use toolsets within such programming languages appropriate for digital signal processing and message decoding.
- **Single-Board Computer Programming** — students should have some basic experience with single board computers (e.g., Raspberry Pi, Arduino) for physical hosting of software scripts and radiofrequency data processing due to portability requirements.
- **Low-Cost Software Defined Radio (SDR) Use** — students should, or be able to, learn how to use software defined radios, such as the ADALM PLUTO, to receive radio signals. NASA team mentors can assist a great deal in SDR use.
- **Basic Electronics Circuitry —** basic electrical engineering skills for prototype circuit board development may be required for overall system packaging, etc.

Team composition should include students strong in electrical engineering and software coding, as the challenge is primarily electrical engineering/software engineering focused.

Assumptions

This challenge assumes that NASA will provide the following items:

- Reference software and hardware simulating a first-generation beacon with formatting similar to the test beacon you should use during the NBL test week. NASA will provide this software to students in the January 2025 timeframe for on-campus testing. The current assumption is an ADALM PLUTO SDR transmitter and associated open-source software for use by student teams.
- Training/test beacon(s) provided during the NBL test week.
- 121.65 MHz transmissions will occur in a constant swept-tone manner for 7 minutes at 100mW strength.
- 406.025 MHz transmissions will occur every 53 seconds for 7 minutes for a total of 7 bursts.
- NASA SAR Team will provide examples of beacon messages for decoding for specific NBL test case.

Requirements

Requirement Number	Criteria
Safety Requirements	
1	Antenna mount(s) shall use commercially available tripod systems with demonstrated stability appropriate with any student-developed camera systems.
2	Processing hardware shall be splash proof for poolside use.
3	The SAFE-T system shall power on and begin operations via single switch throw/actuation.
Operational Requirements	
1	Detect 121.65 MHz swept-tone signal and provide visual cue (GUI, LED light, etc.) to user.
2	Detect and decode 406.025 SARSAT training signal and provide contents overview to user.

3	Provide “short data burst” notification of object detection to an operator laptop or built-in screen.
	• Textual message —
	    • Country Code: 10 bits, bits 27-36 (e.g., USA)
	    • Beacon Hex ID: bits 26 through 85 with default values for PDF-1
	    • Encoded Location: 20 bits, bits 113-132
	    • Time received

4	The SAFE-T control system shall not require external calibration or warmup time greater than 60 seconds from control system power-on.
5	**OPTIONAL**: The SAFE-T system/software shall generate a historical KML file with the textual messages and encoded locations to view in Google Earth.

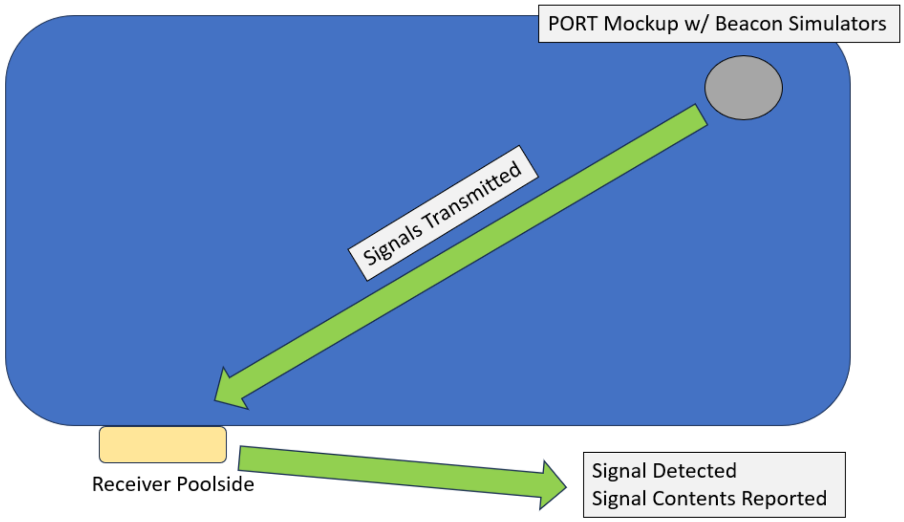
Anticipated Costs/Supplies Needed

- Single Board Computer (Raspberry Pi, Arduino, etc.) — ~$100.00 – $150.00
- Low-Cost Software Defined Radio (ADALM Pluto, etc.) — ~250.00
- UHF/VHF Antenna — ~ $150.00
- Pelican Case / enclosure — ~$125.00

Test Setup

Students will locate their receivers on a worktable poolside on the far end of the PORT mockup with a NASA's Goddard Space Flight Center SAR-provided beacon simulator located on the PORT capsule mockup. Students will turn on their receivers, and the clock will start.

- Students shall detect 121.65 MHz and detect/decode 406.025 signals within 3 minutes of start time.
- Proceed to monitor and detect signals for a 7-minute time period after first detection, for a total reception time of 10 minutes.
- The PORT mockup may be rocked/moved via wave motion to simulate considerations of RF link challenges in the real world.

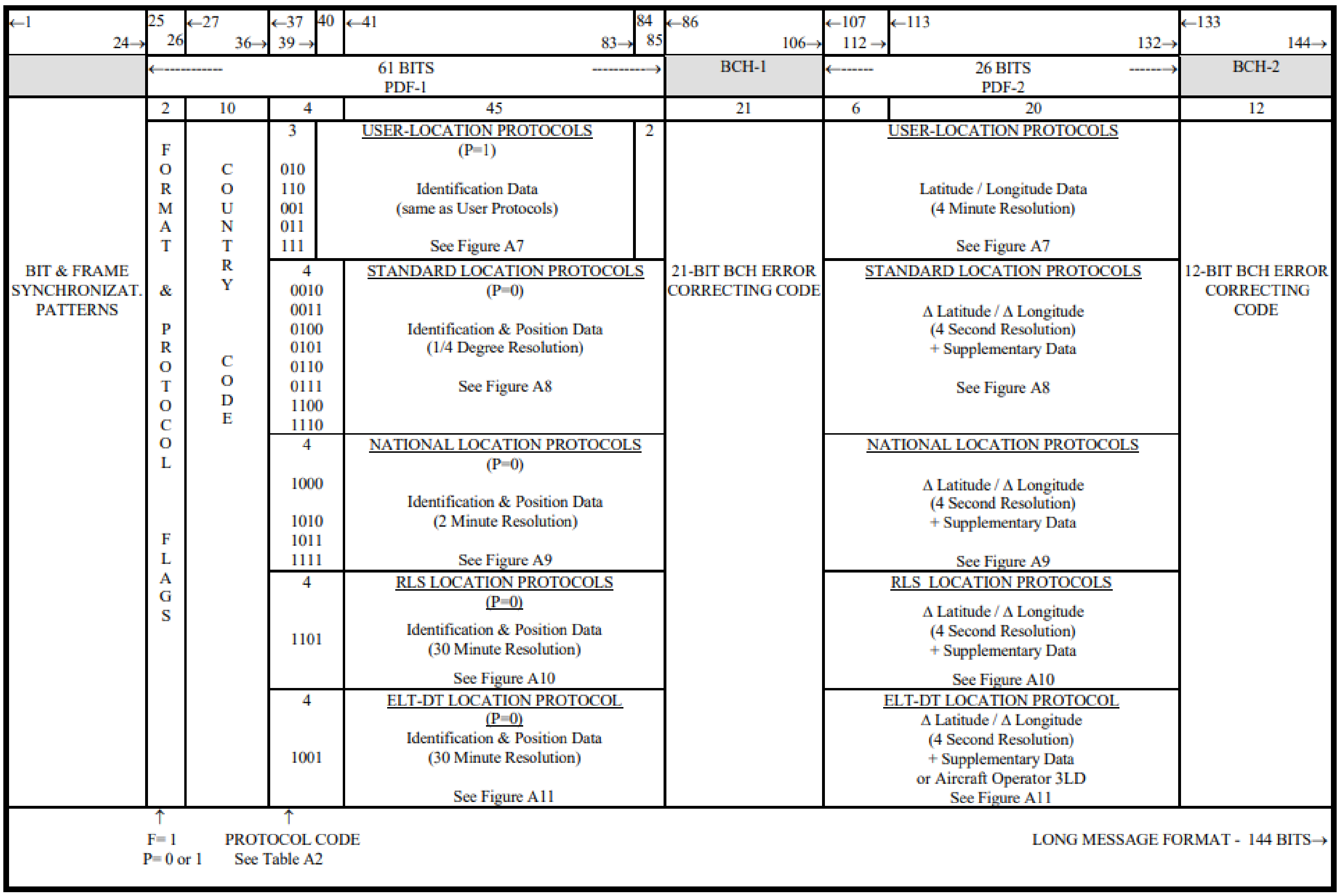


Capabilities that will be observed (listed in order of priority):

1. The SAFE-T system is entirely self-contained (i.e., no external laptop required) and the user interfaces are directly on the processing unit (i.e., an LED/LCD screen on a Raspberry Pi).
2. Overall time to first detection of 121.65 MHz signal from power-on of student devices.
3. Generation of KML files with encoded locations from 406.025 MHz message signal.
4. Determination of when 121.65 MHz signals cease transmitting.
5. Number of 406.025 MHz messages received.

Figure A2: Data Fields of the Long Message Format

	Bit Synchronization	Frame Synchronization	First Protected Data Field (PDF-1)				BCH-1	Second Protected Data Field (PDF-2)	BCH-2
Unmodulated Carrier (160 ms)	Bit Synchronization Pattern	Frame Synchronization Pattern	Format Flag	Protocol Flag	Country Code	Identification or Identification plus Position	21-Bit BCH Code	Supplementary and Position or National Use Data	12-Bit BCH Code
Bit No.	1-15	16-24	25	26	27-36	37-85	86-106	107-132	133-144
	15 bits	9 bits	1 bit	1 bit	10 bits	49 bits	21 bits	26 bits	12 bits



Binary Range	Binary Content	Field Name	Decoded Value
1-15	111111111111111	Bit-synchronization pattern consisting of "1"s shall occupy the first 15-bit positions	TRUE
16-24	000101111	Frame Synchronization Pattern	Normal beacon operation
25	1	Format Flag	Long Message
26	0	Protocol Flag	Location, further information provided in "Protocol Code"
27-36	0101110000	Country code:	United States - 368
37-40	1110	Protocol Code	Standard Location Protocol - Test
41-64	000000001000000000000001	Test protocol	No Decode information in bits 41 to 64
65-74	0010011100	Latitude (PDF-1)	39 Degrees 0 Minutes North (39.0)
75-85	10100110011	Longitude (PDF-1)	76 Degrees 45 Minutes West (-76.75)
86-106	011000111100010000111	BCH-1 error correcting code	BCH-1 code in message matches the recalculated BCH-1 from the PDF-1 field
107-110	1101	Validity	107-110 should be 1101
111	1	Encoded position	Encoded position data is provided by an internal navigation device
112	0	121.5 Mhz Homing Device	Not included in beacon
113-122	0000000001	Latitude offset	0.0 minutes 4.0 seconds (negative)
123-132	1001010111	Longitude offset	5.0 minutes 28.0 seconds (positive)
133-144	100101101001	BCH-2 error correcting code	BCH-2 code in message matches the recalculated BCH-2 from the PDF-2 field
		Composite location	38.999 -76.841

Recovery of Beacon HEX ID:

Each beacon has a unique 15-character hexadecimal identifier. These 15 Hex characters are known as the HEX ID. The beacon identification comprises bits 26 through 85 of the packet message. However, the position data bits in PDF-1 are set to certain default values. These default values are:

1. All bits in degrees fields are set to “1”, with N/S, and E/W flags set to “0’
2. All bits in the minutes field are set to “0”, with offset direction signs set to “1”
3. All bits in the seconds field are set to “1”

This will give you the recovered HEX ID of the beacon. For the example packet given, the HEX ID is 2E1C010002FFBFF.

Example beacon decoder app:
https://decoder2.herokuapp.com/decode