National Aeronautics and
Space Administration

MISSION DESCRIPTION

NASA Spacesuit User Interface Technologies for Students

Date: September 12, 2022

National Aeronautics and Space Administration

Lyndon B. Johnson Space Center

Houston, Texas 77058

Background

As NASA launches the Artemis program for sustained human presence on the lunar surface and ultimately, Mars, engineers are considering what technology will best aid astronauts to safely and successfully complete science and exploration missions.

In a lunar extravehicular activity (EVA), or moonwalk scenario, crewmembers don a next generation spacesuit and egress the lander from the airlock. Their tasks include exploring surface terrain, conducting science and engineering research, and interacting with various payloads and lunar assets. Assets within this environment include the spacesuit, life support systems, rovers, geology tools, human landers, power systems, science payloads, and habitats. Each of these agents within the lunar environment relay valuable data that, if visually displayed to the astronaut via an augmented reality (AR) display, could transform their ability to live and work in space. A visual display system in the form of augmented reality shows promise to enhance task performance, workload, and situational awareness[1].

Today, the Mission Control Center at NASA's Johnson Space Center in Houston relays all pertinent information to the crew via a voice loop. In the future, communication delays upwards of 20 minutes to the surface of Mars will require crewmembers to have more autonomy. Artemis missions aim to develop breakthrough technologies enabling a sustained presence of astronauts on the lunar, and ultimately Martian, surface.

The NASA Spacesuit User Interface Technologies for Students (SUITS) challenge is calling on college students throughout the country to build software and AR design solutions to inspire future displays for crewmembers in later Artemis missions.

Through this challenge, college student teams will develop proposals for an AR software application for a commercial device, e.g., Microsoft HoloLens 2 or Magic Leap, for moonwalks. Student teams submitting the top proposals will be selected to develop their software, be mentored by NASA experts, and test their devices in an analog mock EVA scenario at Johnson in May 2023 where they will showcase their work to NASA, university and industry partners, and participate in student and NASA speaker panels.

1 Mitra, P., "Human Systems Integration of an Extravehicular Activity Space Suit Augmented Reality Display System" (2018). *Theses and Dissertations*. 2517. https://scholarsjunction.msstate.edu/td/2517

Mission Objectives

The main goal for NASA SUITS is creating an innovative spacesuit user interface (UI) leveraging AR. The UI demonstrates how AR can be used in a crewmember's display during EVA operations in a non-obtrusive way. The design may also implement peripheral devices such as control devices, navigation sensors, network-connected devices, robotics, cameras etc.

The test-week scenarios provide evaluators with a detailed lunar analog environment and resources to assess submitted designs. Teams should develop products tailored to the mission tasks specifically outlined in this mission description.

See more information on NASA Artemis science objectives.

Technical Objective

Develop a UI, using the Microsoft HoloLens, or other approved AR device, enabling astronauts to finish tasks more efficiently by providing a set of audible and visual instructions and tools via the display environment.

Requirements

1	Design should work in harsh lighting (bright light, no light, low angle light etc.) and outdoor conditions.
2	The device must be able to access and display the telemetry stream data.
4	A caution and warning system must be implemented to inform the astronaut about a spacesuit anomaly.
5	In case of an interruption, the astronaut must be able to continue the task on hand seamlessly.
6	The UI shall assist the astronaut during navigation.
7	The UI shall display necessary EVA task instructions.
8	The UI design should not distract the user or crowd their field of view with non-critical information.

Peripheral Device Requirements

These requirements only apply to the development of peripheral device.

1	Any external or additional device must be presented at the software design review (SDR) and approved by the NASA SUITS team.
2	The device shall communicate with the AR device.
3	Any removable components shall have a tether attachment point.
4	Devices must not have holes or openings which would allow/cause entrapment of fingers.
5	There shall be no sharp edges on the device.
6	Pinch points should be minimized and labeled.
7	Electrical design must meet the additional requirements.

EVA Description

The EVA will be conducted at night in the rock yard at Johnson, as shown in Figures 1a and 1b. This location is selected because it can mimic Martian and lunar terrain. Low-angle lights will be placed throughout to simulate the Sun-angle on the south pole of the Moon. This analog environment simulates some lunar EVA conditions expected during the Artemis missions.

Figure 1a: Overhead view of the JSC Rock yard

Figure 1b: Rock yard at night with simulated lunar lighting

The EVA will consist of four major components: egress, geology, rover commanding, and navigation.

Using instructions and tools from the team-designed UI, the design evaluator will conduct egress procedures in a mock airlock by interfacing with the Umbilical Interface Assembly (UIA). Next, they will exit the airlock and navigate the test site with the guidance of the test conductor, dropping waypoints as a breadcrumb trail for later return navigation. Upon arrival at the geology site, they will perform a mock spectrometry task using a radio-frequency identification (RFID) sensor and receive scan data from the telemetry stream. They will then pilot and command the rover. Next, they will navigate their return to the airlock without the assistance of the test conductor, instead following the breadcrumb waypoint trail they made on the outbound trip. They will perform more spectrometry scans at geological points of interest as they return. The test is complete when the design evaluator successfully navigates back to the airlock location. A high-level overview of the lunar EVA simulation can be seen in Figure 2.

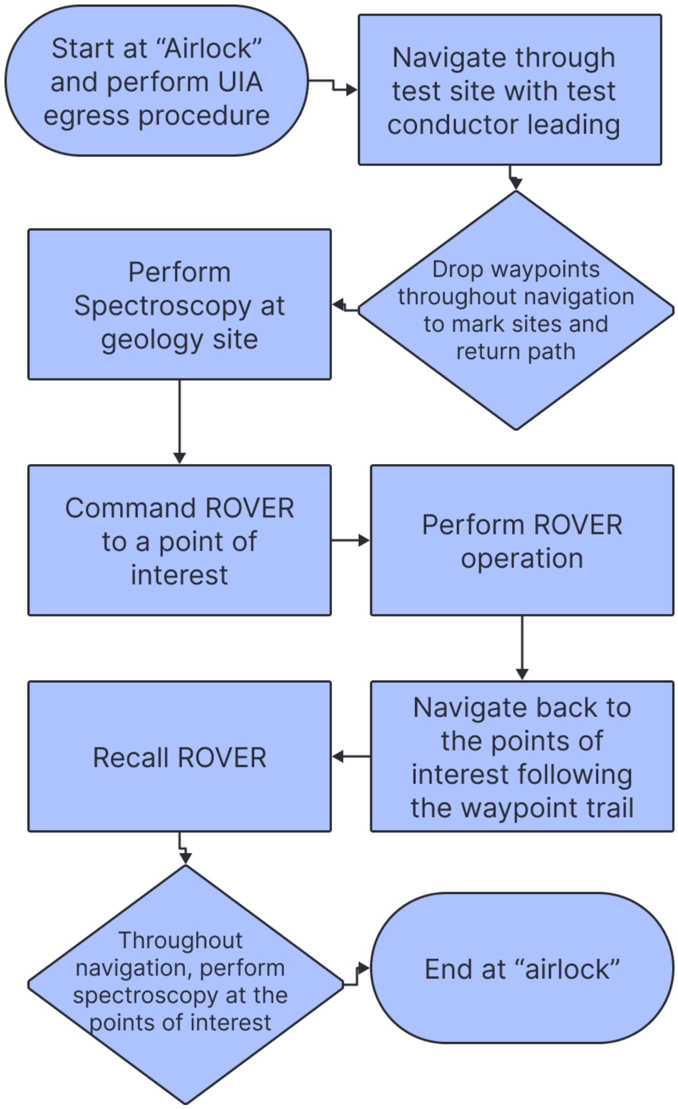

Figure 2: Lunar EVA Scenario

Provided Systems and Equipment

ROVER

The Remotely Operated Vehicle in Extended Reality (ROVER) is an autonomous rover capable of Simultaneous Location and Mapping (SLAM) via Lidar. NASA will provide the rover and all necessary features for the rover to move autonomously through the terrain of the test site. It is up to the team to decide how to communicate with the rover via the telemetry stream. The team is also responsible for choosing how to direct the rover on where to go using their head-mounted display through voice commands, pointing, etc.

VISION Kits

NASA provides the Virtual Instrument for Simulating Inertial Objects (VISION) kits which will simulate lunar vehicles, various EVA equipment, and points of interest. The crew member wearing the head-mounted display is required to have a VISION kit on them for the rover recall function and various other tasks. The VISION kit contains a Raspberry Pi with global positioning system hardware, an inertial measurement unit, an external antenna, and a power supply. Data streamed from the kit includes inertial measurement and location data. For example, the provided data could include its current position, in world and local coordinates, its local speed, and its bearing. The team is responsible for displaying the information given to them via the telemetry stream.

Spectrometer

NASA provides the spectrometer, which selects simulated geological data from a database when a rock with an RFID tag is scanned. The simulated geological data is then sent via the telemetry stream back to the user. The team will display the geological data of each rock with the head-mounted display and store a rock onboard the rover.

UIA

The Umbilical Interface Assembly (UIA) features multiple switches teams will manipulate to match the desired configuration for egress. These switches feed into the telemetry stream, allowing teams to receive real-time feedback on their position. Teams are encouraged to explore solutions such as AR procedure displays, computer vision, and telemetry representation to assist in completing the procedure.

EVA Components

Step 1: UIA Egress Procedure

The design evaluator begins at a mock airlock. Given the desired configuration of the switches on the UIA, the design evaluator uses the AR display to complete the egress procedure on the UIA. The UIA is connected to the telemetry stream to receive readings of the status of the switches. The UIA is provided by the SUITS team.

Step 2: Site Navigation

The test conductor leads the design evaluator around the test. Throughout the test, the local and world positions are streamed to the design evaluator via their VISION kit, which is connected to the telemetry stream and suit vitals. The VISION kit is provided by the SUITS team. Your team's software solution drops waypoints along the way to leave a breadcrumb trail. This trail will be used later for return navigation back to the airlock.

Step 3: Geological scanning

After the test conductor guides the design evaluator to the last site, the design evaluator will find rocks with RFID tags. The design evaluator scans the rock using the provided spectrometer; the data from the scan selects simulated geological data from a database which is sent via the telemetry stream to the UI.

Step 4: ROVER

The design evaluator will command ROVER, provided by the NASA SUITS team, to navigate to a location where it will perform an operation. The design evaluator will then instruct the rover to navigate back to its position.

Step 5: Return Navigation

The design evaluator uses the previously created trail of waypoints to navigate around the site stopping on the way to scan any RFID rocks they find using the spectrometer. The scenario is complete when they arrive back at the airlock.

Telemetry

The telemetry stream is provided via a Unity Library, which teams will import into their project. Teams are placed in rooms with data isolated in each room. Each room has a shared state. Devices must be capable of accessing data from the telemetry stream and displaying the states of the following assets to the design evaluator at any time:

- ROVER telemetry
- Location data logger: VISION student kit and rover positional data
    - World position floats
        - Latitude and longitude
        - Altitude
        - Bearing
    - Local position and speed floats: X, Y, Z coordinates with respect to a calibration point
- Spectrometer
- UIA
    - Booleans representing the position of the switches
- Team head-mounted display data stream
    - Floats and strings representing values of suit telemetry and simulated biometric data
    - Correct ranges are provided for anomaly detection

Concept of Operations

Teams are required to submit a concept of operation (Con-Ops), thoroughly providing scenario depictions and a detailed outline of features intended to be built into the software. It should specify how the design would be used in that scenario.

Con-ops Requirement #1 – Assumption: Describe the team's assumptions for how an Artemis crew will undergo an EVA.

Con-ops Requirement #2 – Claim: Describe what the team is claiming to build and how that product will fit into the EVA scenario described above. Explain why features were prioritized in your design.

Con-ops Requirement #3 – Workflow: Outline a workflow demonstrating the specific capabilities of each UI feature and its usage during an EVA.

Project Management

Teams are required to submit a detailed project management plan for tracking team progress and deadlines. Good project management includes a plan to track team contributions, timelines for feature development, and how each feature contributes to a part of the mission description in priority order. Development plans, such as Agile, and scheduling tools like Kanban boards and Gantt charts, are encouraged as a timeline/task dependency tool but are not required. Teams are also encouraged to propose other unique solutions to project management.