MISSION DESCRIPTION

NASA Spacesuit User Interface Technologies for Students (SUITS)
2021-2022

Background

NASA will turn science fiction into science fact as we make new discoveries, advance technologies, and learn to live and work on the Lunar surface. As part of the Artemis program, NASA will land the first woman and first person of color on the Moon and establish long-term lunar science and exploration capabilities. The requirements for the next-generation lunar spacesuit include a suit visual display and control system.

This system aims to provide augmented reality (AR) access to informatics to enable interfacing with lunar payloads, support science work, visualize consumables, streamline communication, and navigate terrain. The development of visual informatics display systems enables NASA to improve and innovate optics solutions within the emerging AR field, making future extravehicular activities (EVAs) more efficient and effective. Teams will create, design, and implement software to simulate spacesuit displays within an AR environment using a head mounted device (HMD) such as the HoloLens2 or Magic Leap.

Teams will participate in a design review in the spring to determine the teams selected for in-person testing at NASA's Johnson Space Center from May 19-24, 2022. The in-person testing opportunity is pending COVD-19 health and safety guidelines. NASA scientists and engineers will evaluate and provide feedback and advice on devices during test week.

Mission Objectives

The primary objective for NASA SUITS is to develop a user interface (UI) utilizing an HMD in augmented or mixed reality to assist extravehicular crew members perform navigation and system state monitoring tasks during a lunar EVA, or Moonwalk. The HMD may also include peripheral devices (i.e. hand controls, unique localization/navigation sensors, secondary indicators, virtual reality component, an app, cameras, etc.). NASA SUITS will provide a specific lunar environment and resources for design evaluators to test student designs during test week, making it possible for teams to design for the lunar exploration tasks defined in this Mission Description. The AR device must address all primary objectives and may also address any secondary objectives in addition to the primary objectives.

- **Primary Objective –** All teams must meet these requirements.
    - **Navigation:** The AR device must accurately guide the user in real-time and navigate between multiple planned and unplanned locations during an EVA. This includes long-range

navigation (from point A to point B), short-range navigation (obstacles avoidance), and search-and-rescue navigation. Teams use data from their HMD internal sensors (local device coordinates), standard navigation algorithms, appropriate imagery (for recognition/camera vision needs), and any other external data and information available to help users localize their position while navigating within the lunar environment.

- **Terrain Sensing:** The system must localize itself to the surrounding environment to assist crew members with EVA responsibilities, such as navigation and geology. Teams use data from HMD sensors, the HMD camera, or additional peripherals.
- **EVA System State:** The AR device must have the ability to interact with the designated suit telemetry stream and display vitals to the user.
- **User Interface and Controls:** The AR system must include a responsive, intuitive user-interface that displays all necessary information for the crew member. A control method component, which may be a unique implementation or standard to the chosen AR device, must be well integrated with the user interface and must allow the user to execute EVA tasks efficiently and effectively.

- **Secondary Objectives** – Teams may meet any secondary objectives on top of the primary objectives.
  - **Tele-Robotics (for returning teams):** As an auxiliary goal, secondary to the AR device, returning SUITS teams may develop a robotic assistant aiding the EVA in either reconnaissance or science objectives while communicating with the AR device. The robot must not be attached to the crew member.
  - **Peripheral Devices:** Some intriguing designs from the previous year were enabled by teams exploring the capabilities afforded by peripheral devices including light detection and ranging sensors, spectroscopy sensors, navigation beacons, a helmet-mounted light, and a push-button control module. We encourage teams to include peripheral devices to aid their AR device.
  - **Geology:** As geological research is one of the primary reasons for sending crew to the Moon, we encourage teams to develop features in their AR device that aid in surface geology. This includes features that help sampling activities, recording field notes, or terrain surveying.

MISSION OBJECTIVE DETAILS

Navigation

There is a capability gap for a navigation solution to be able to support and sustain future planetary surface operations. An ideal lunar navigation system helps the crew locate themselves on the surface of the Moon at all times, navigate safely to EVA destinations, understand geology sample acquisition locations, traverse through shadowed regions, avoid hazards that could impede traversing (give the user awareness of mountainous crater regions, traverse stark contrast lighting conditions, etc.), and contribute to search and rescue scenarios. Student teams use data HMD internal sensors, local device coordinates, standard navigation algorithms, pre-planned waypoints, geotagging, path planning, sensor networks, cameras, and any other data and information available to help users navigate the simulated EVA analog. The navigation solution goals include the following:

- **Navigation Capability #1 – Long-range Navigation:** Users must be able to choose a destination and navigate to it using an AR device. This includes navigating from point A to point B, where the two points can be the lander, a geology site, or any other point of interest in the EVA. It also includes selecting a chosen location in the user's visual field and navigating to it. NASA will not provide a navigational data stream, only a starting point and a list of locations with their respective coordinates. Designs must be flexible enough to change this list of locations any time before or during the test.

- **Navigation Capability #2 – Short-range Navigation:** Short range navigation involves the AR device providing hazard avoidance information to crew on lunar traverses. Lunar surface obstacles include boulders, tripping hazards, ravines, shadowed regions, and steep slopes. Navigation Capability #2 challenges you to use the capabilities of your AR and peripherals devices to warn the crew member about these hazards and offer possible navigation solutions around them.

- **Navigation Capability #3 – Lunar Search and Rescue (LunaSAR):** Emergency scenarios on the Moon are heightened due to the harsh conditions on the Moon, including lack of atmosphere, extreme temperatures, and distance from Earth. Accordingly, the EVA community puts great thought into lunar search and rescue scenarios along with the procedures and technologies necessary. During this year's analog test, teams must complete LunaSAR tasks according to a specific scenario.
    - **Scenario:** Your fellow crew member on EVA has an emergency. You receive a message from the crew member's beacon relaying the type of emergency and information about the crew member's location. This data communicates through a telemetry stream via a URL run by NASA; therefore, your HMD must receive this data from the stream in JSON format and notify the user of this emergency event. The task is to navigate to the distressed crew member as quickly and safely as possible, using the location data and your system's navigational features. The LunaSAR project team at NASA develops the beacon communication system to enable search and rescue during future Artemis missions.
    - **LunaSAR Task A: Navigate to distressed crewmember or distress beacon location.**
        - Display relative position and direction of travel to distressed crew member based on data received and calculate and display relative position of rescuer to distressed crew.
        - **Base Config/Setup:** NASA provides scripted beacon messages students access and parse into usable AR cues to display.
    - **LunaSAR Task B: Perform bi-directional text messaging demonstration using LunaSAR compliant messaging structure.**
        - Provide user interface to send short pre-formatted text messages between crew member in distress and rescue team.
        - **Base Config/Setup:** NASA provides scripted beacon messages from distressed crew that students access and parse into usable AR cues, then select responses and respond with LunaSAR-compliant message (i.e. take local GPS location, convert into NMEA format, and generate a response formatted like a LunaSAR transmission, transmitted to mission control).
    - **LunaSAR Task C: Display LunaSAR-compliant messaging from distressed crew.**
        - Display incoming messages from distressed crew. Example content: display an alert status when a beacon activation is detected.
        - **Base Config/Setup:** NASA provides beacon messages with varying locations and content for display, with varying distress conditions (i.e. suit issue, injury, "I'm OK") formatted into message for teams to decode and display.

Terrain Mapping

Real-time information about the lunar terrain is crucial during lunar EVAs. Crew may incorrectly perceive important features of surrounding terrain at the lunar south pole due to lighting conditions—the Sun's low angle of attack with the horizon, darkness in craters, lack of vivid colors, and extremely long shadows. This adversely affects the crew's innate navigational capabilities and the chance to scout for science sampling sites. Designs must use sensors on the AR device or peripheral devices to aid the crew in sensing the environment and mapping the surrounding terrain.

EVA System State

In this use case, a crew member on the lunar surface interfaces with a display and control unit during an EVA. Suit vitals convey crucial information to the crew such as informing them of when to return to a pressurized environment if an anomaly occurs. The HMD must display all the information associated with these factors to ensure the safety of the crew and the success of the mission. All data communicates through a telemetry stream via a website run by NASA; therefore, your HMD must receive this data from the stream in JSON format and display suit critical information unobtrusively. More information regarding this website will be released after NASA selects the teams for in-person testing.

User Interface and Controls

The user interface is responsive, intuitive, and unobtrusive. It can display all information relevant to the EVA, while also being easy to use without extensive training. Further, teams must design and implement a control scheme to closely integrate with the UI. Today, NASA relies on Mission Control Center command and control to execute EVA operations. Teams must choose or develop a controls method allowing the user to interact efficiently and effectively given EVA constraints (e.g. pressurized and bulky gloves, interacting with a display while executing dexterous tasks, un-interrupted critical communication loops if executing voice control, etc.)

Additionally, teams must consider the shift in autonomy leading up to new operational control schemes, which is critical as we explore the Moon and Mars. While developing a controls method for the visual informatics display system, teams must consider each agent in the EVA system (mission control, two extravehicular crew members, and intravehicular operators), and the appropriate operator responsibility and authority. Find a creative and dynamic solution to control the astronauts' HMDs and how they might interact with remote support.

Tele-Robotics for Returning SUITS Teams

Teams previously participating in an onsite SUITS test day may choose to develop a robot which remotely communicates with the AR device. This robot can aid in navigation, search and rescue, terrain mapping, geology, or any aspect of the EVA that you see fit. This robot may or may not be mobile, may or may not have a camera, and may or may not resemble a rover. These design decisions are left to the team assuming they follow the requirements below:

- The development of this robot is auxiliary and must, in no way, negatively affect the quality of the AR device. It has a lower priority in both scope and development time than the AR device.
- The robot cannot be attached to the crew member.
- Communication must exist at least one way between the AR device and the robot (to or from the robot). Preferably there is communication both to and from the robot.
- It may not be controlled by someone who is not the crew member.

Details Regarding Peripheral Devices

AR devices may not have all the capabilities needed for your design to fulfill the requirements above. We encourage teams to add a peripheral device to designs. Previous examples include light detection and ranging sensors, spectroscopy sensors, navigation beacons, a helmet-mounted light, and a push-button control. The peripheral device can aid in any mission objective or other aspect of EVA that you see fit.

While it is recommended peripheral devices communicate with your AR device in some way, it is not required; however, peripheral devices must meet the following requirements:

- Any external or additional device must be approved by NASA prior to the test week.
- Any removable components must have a tether attachment point.
- All tools must be operable with EVA gloved hands (like heavy ski gloves).
- Devices must not have holes or openings which allow entrapment of fingers.
- There must be no sharp edges on any tool.
- Pinch points should be minimized and labeled.

Details Regarding Geology Solutions

Geological research is one of the primary reasons for returning crew to the lunar surface. Your AR device should have features to facilitate and increase the efficiency of this research during EVAs. Consider features which help both science sampling activities and geological surveying activities. Sampling features include, but are not limited to:

- Displaying science sampling instructions.
- Providing a unique method for taking field notes (i.e. voice, video, photos/imagery, dictation, animations, other new and creative methods).
- Taking photographs of the excavation site and geology samples.

Surveying involves drawing geological information from the landscape and picking future sampling locations; this process is an ideal candidate for some level of automation. During the analog test, the crew is asked to pick one sampling location themselves.

NASA-Provided Materials

- Physical test bed for lunar analog mission.
- Refined requirements for lunar analog test site.
- EVA system state telemetry stream URL and data (all data is generated as JSON [JavaScript Object Notation] code through API).
- Search and rescue task message content and format.
- NASA mentor for each team.
- Wireless communication network.