MISSION DESCRIPTION

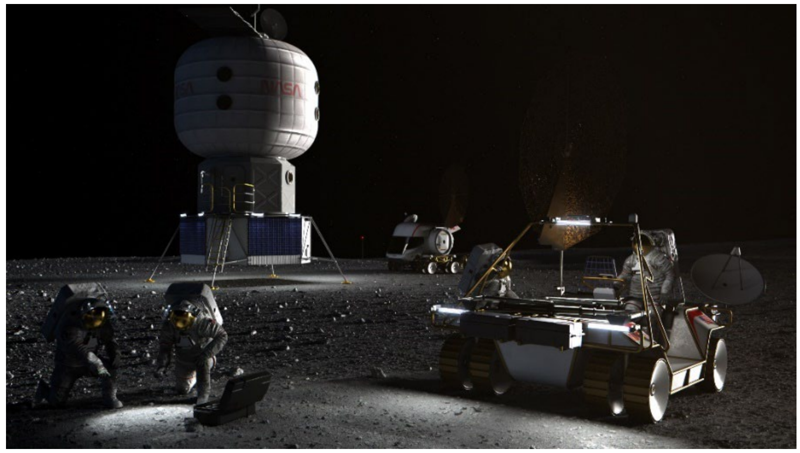
NASA Spacesuit User Interface Technologies for Students (SUITS) Software Design Challenge

2024-2025

INSPIRE - ENGAGE - EDUCATE - EMPLOY
The Next Generation of Explorers

Contents

1. Background



NASA SUITS (Spacesuit User Interface Technologies for Students) is a software design challenge in which college students from across the country help design solutions for future spaceflight needs. NASA's Artemis missions seek to land the first woman and first person of color on the Moon, as well as build towards a sustained human presence on the Moon and, ultimately, Mars. This means engineers are actively developing technologies needed to assure successful completion of science and exploration missions. Created as a collaboration between the Extravehicular Activity and Human Surface Mobility Program (EHP) and the Office of STEM Engagement, NASA SUITS is entering its eighth year of connecting students to authentic engineering challenges.

A sustained human presence on the lunar surface will require us to reimagine how spacewalks are conducted. This includes digital information in the form of displays and interoperability between spacesuits and rovers. NASA will also need to use artificial intelligence and edge computing to reach our full exploration potential.

In NASA SUITS, we expect teams to design a crew autonomy enabling system and user interface (UI). Teams will submit a proposal for ***both*** spacesuit and pressurized rover (PR) systems and displays. If selected, we will assign teams one of the two assets to focus on. We will then match these teams with other teams to demonstrate the interoperability of the lunar assets. Teams may design their spacesuit display with their choice of device, however, any HMDs (head-mounted displays) for the spacesuit must be passthrough augmented reality. The pressurized rover is virtual and operates in a virtual environment, integrating NASA's Digital Lunar Exploration Sites Unreal Simulation Tool (DUST).

Student teams who submit the top proposals will be selected to develop an interface and background software, be mentored by NASA experts, and test their devices in a mock EVA (extravehicular activity) scenario at NASA's Johnson Space Center in Houston, in May 2025, where they will showcase their work to NASA engineers.

2. Mission Concept

NASA SUITS is creating a lunar EVA scenario for 2025. Teams are responsible for their UI, display device, and background software. Testing will take place after dark at the JSC Rock Yard. Therefore, teams will need to accommodate for lighting factors in the display systems, especially if they use an HMD. The rockyard consists of a pulverized granite base with scoria boulders up to 1m and craters up to 2m deep and 20m in diameter.

The scenario takes place with two teams participating at a time, with each assigned to either the pressurized rover or the spacesuit components. Each team will have their own design objectives but will need to work together throughout the challenge to meet interoperability goals.

Each team will be connected to a telemetry stream specific to their assigned lunar asset. Teams will need to coordinate with their partnered team to develop an interoperability system, independent of the assigned telemetry, which enables the sharing of information and data with each other.

2a. Pressurized Rover

The Pressurized Rover team will need to develop a display and control system for the rover operating in the virtual DUST environment. We are specifically looking for the teams to use autonomous systems as they navigate the rover from one location to another.

2b. Spacesuit

The spacesuit team will need to deploy their solution for two EVA crewmembers. This solution can be two of the same device or two different devices. For example, two HMDs, two tablets, or one of each. If this will create an undue burden on a team, we can work with them post-selection on an alternative solution. The EVA crewmembers will be referred to as “EV,” or “EV1” and “EV2” if differentiated.

2c. Mission Tasks

Rover Navigation

The scenario begins with the PR team demonstrating their display and crew autonomy system as they navigate the rover from a starting location to the designated worksite(s).

PR features evaluated at this point include autonomous best path planning, hazard avoidance, consumable resource usage, and estimates of remaining resources when the destination is reached. Additionally, teams should provide estimates of turn around points at which the rover will need to return to base or risk depletion of limited resources. When provided with a point of interest, teams should use predictive modeling to provide a decision support system for crew to optimize resource usage and reduce cognitive load.

At a certain point, the team will receive notification that a simulated Lunar Terrain Vehicle has identified an area of geologic interest. The PR team will then navigate to that location.

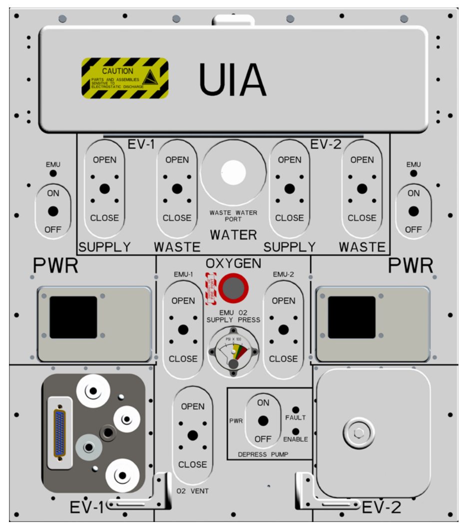
Upon arrival, the crewmembers will prepare for egress. The Umbilical Interface Assembly (UIA) will be part of the airlock in the PR. Therefore, the consumables used to prepare the spacesuit will be taken from the PR's resources and should be taken into consideration.

The crewmember in the PR will also support the EVs as they proceed through the rest of the scenario.

Please reference the requirements section for more detailed PR system implementation requirements.

Egress

Egress occurs when the crewmembers exit the airlock to begin the EVA. Several steps must take place inside the airlock to ensure the crewmember can safely egress.



The goal of this task is to demonstrate effective and efficient methods for completing the UIA procedures used to initiate an EVA by preparing and checking the spacesuit's portable life support systems.

The EV will use information from their display to complete procedures for the UIA. The EV will interface with tactile switches on the UIA in accordance with provided procedures. Upon successful completion of the egress task, the EV will move on to the navigation portion of the EVA.

Teams decide the most effective method for communicating and accomplishing these procedures. This can be a text checklist, computer vision, voice commands, a combination, or none of those listed. The UIA's switch state will be provided by the PR's Telemetry Stream Server (TSS) which should be accessible to the EV via interoperability. A sample of procedures is in Appendix A but is subject to change as we approach test week.

EV Navigation

The purpose of EV navigation is to ensure the crewmember(s) can traverse between stations safely and efficiently. The goal is to implement a software system for tracking crew and scientific assets in the field, as well as aid crew members as they navigate the lunar surface. This includes a system for detecting and navigating environmental hazards under lighting conditions like what you might experience at the lunar south pole. An animation of sample lighting conditions is available here. The system should provide real-time alerts and recommend immediate actions such as alternate routes.

Upon completion of each task, the EV will walk from their current station to the next designated station. The EV will use information provided in their display to physically navigate between these stations.

Teams will design a navigation solution that is effective and non-obtrusive. This navigation solution needs to allow for flexibility in the EVA as destinations can change. For the UI, teams shall design a 2D mini-map navigation aid. Teams may also include a 3D map, computer vision destination waypoints, and/or path indicators.

Throughout all aspects of the EVA, the crewmember should be able to use interoperability features with the PR.

Geologic Sampling

The UIs will also help meet science objectives. Teams will achieve this by collecting samples with both human and robotic assets. The goal of this task is to demonstrate how your system can increase crewmember efficiency and reduce cognitive load.

The EV will use a simulated XRF (X-ray Fluorescence) spectroscopy sensor to scan the chemical make-up of rock samples for potential collection. The EV will scan several samples and perform collection tasks of desired samples.

This mock XRF sensor uses RFID (radio frequency identification) of selected samples sent to the TSS, which then sends XRF data to the user. Teams should access and display this data as they see fit. We recommend researching field geology techniques and integrating them into the concept and data collection model. Teams may choose to use The Look ODD Process. Interoperability would allow the PR to view data as it is collected.

Ingress

An EVA is not complete until the crewmember has arrived safely back inside their spacecraft or habitat. Ingress is the process of returning to the airlock. Once the crewmember has completed all EVA tasks, they will begin the ingress portion of the EVA.

Upon completion of the final task of the EVA, the EV will begin ingress. The EV will follow navigation cues and instructions to follow the best path for return to the airlock. The EV will conduct final procedures with UIA when they arrive to the airlock.

Teams will decide the most effective method for navigating back to the airlock. The UI shall provide a "breadcrumbs" feature for retracing a path. The ideal implementation would provide the shortest, safe path back to the airlock.

3. NASA Provided Systems and Equipment

3a. TSS

The TSS is a server that provides simulated telemetry values for each of the lunar assets. This stream is divided into two feeds, and each team will have access to a specific feed, as detailed in the table below. To achieve interoperability goals, teams will need to coordinate the transfer of telemetry across assets.

NASA will provide a Unity/Unreal plugin to assist in integrating the TSS with your project. Your device must be able to retrieve the following information from the TSS and display it at any time:

Telemetry feed to Pressurized Rover	Telemetry feed to EV/Spacesuit
• Pressurized Rover telemetry • Lunar Terrain Vehicle telemetry • UIA	• Spacesuit telemetry • XRF Spectrometer • Display Control Unit (DCU)

3b. UIA

The UIA features multiple switches that teams will manipulate to match the desired configuration for egress. These switches feed into the telemetry stream via Booleans, allowing teams to receive real-time feedback on their position. We encourage teams to explore creative solutions to display procedures, computer vision, and telemetry representation to assist in completing the procedures. UIA telemetry will be provided to the PR, which will in turn share the data with the spacesuit via interoperability built by the teams.

3c. Spectrometer

NASA provides the simulated XRF spectrometer, which selects simulated geological data from a database when a rock with an RFID tag is scanned. The geological data is then sent via the telemetry stream back to the user. The team will display the geological data of each rock as part of their geology sampling procedures and data collection. XRF telemetry will be provided to the spacesuit, which will in turn share the data with PR via interoperability built by the teams.

3d. Lunar Terrain Vehicle

NASA will provide the Lunar Terrain Vehicle (LTV) and framework for the LTV to move through the terrain of the test site. The team is responsible for receiving and displaying telemetry from the PR TSS for the LTV.

3e. Display and Control Unit

The Display and Control Unit (DCU) features multiple switches which allow the EV to interact with different systems of the space suit. These switches feed into the telemetry stream, allowing teams to receive real-time feedback on their position. The DCU also allows the EV to handle any errors related to these systems. The version provided does not have an integrated display, rather your spacesuit display will handle this information via the TSS.

The systems controlled by the DCU include:

- Battery (Local/UMB)
- Oxygen (Pri/Sec)
- Comms (A/B)
- Fan (Pri/Sec)
- Pump (Open/Close)
- CO_2 (A/B)

The DCU contains a Raspberry Pi with a positioning system. The team is responsible for displaying the information given to them via the telemetry stream. NASA will provide a method for simulating the DCU location system to assist with the teams' development.

4. Requirements

Please read and follow the requirements thoroughly. These requirements may evolve following team selection.

Note: In the requirements sections below:

Shall = required for minimally viable product

Should = requested features, but secondary priority

May = potential stretch goals for development

4a. Pressurized Rover Requirements

1. Pressurized Rover control:
   a) Shall develop system for controlling the rover in the virtual DUST environment.
2. Spacesuit Telemetry:
   a) The UI shall display crewmember biomedical data. This data shall be easily accessible.
   b) The UI shall display spacesuit system state data. This data shall be easily accessible.
   c) The UI should display crewmember camera feed.
   Note: this data will come from your partnered team as part of the interoperability requirements.
3. LTV Telemetry:
   a) The UI shall display the LTV native camera feed.
   b) The UI shall display the LTV telemetry. This data shall be easily accessible.
4. Task Procedures:
   a) The UI shall display procedures for tasks. All procedures shall be easily accessible.
5. Scientific Data:

a) The UI shall display XRF sensor data when the data has been collected by the EV in the field.
b) Teams may store this data for recall.

6. Map:
   a) The PR UI shall include a live 2D map for tracking human and scientific assets.
   b) Spacesuit location:
      i) The map shall track crewmembers' locations live for the duration of the EVA.
      ii) The map may draw the EV's projected and traversed path.
   c) LTV Location:
      i) The map shall track the LTV's location for the duration of the EVA.
      ii) The map may draw the LTV's projected and traversed path.
   d) Points of interest:
      i) The map shall display all designated points of interest.
      ii) The map shall update to show any added points of interest by the EV or PR.
      iii) The map shall allow the user to add points of interest and share with EV.
   e) Pins:
      i) Shall implement feature for dropping pins on map.
      ii) Dropped pins shall sync across interfaces (PR, EV).
      iii) Pin labels should be customizable.
   f) Caution and Warning:
      i) The UI shall feature a caution and warning system.
      ii) The caution and warning system shall alert PR when any telemetry enter off-nominal ranges.
   g) Display Mission Timers:
      i) The UI shall display the mission elapsed time.
      ii) The UI shall display the elapsed time at each station throughout the EVA.
      iii) All mission timers shall adhere to standards and constraints provided to selected teams.
7. Autonomous Navigation System:
   a) Shall determine best path.
   b) Shall detect and avoid obstacles.
   c) Shall receive updated destinations from TSS and other team (EV).
   d) Shall provide map showing all lunar assets.
   e) Shall track rover speed, angle, and heading.
8. Autonomous Resource utilization:
   a) Shall track life support systems and their health.
   b) Shall track rover resource such as power use and provide predictive analytics throughout the EVA.
   c) Shall provide real time updates as necessary through caution and warning system.

4b. Spacesuit Display Requirements

1. EV Telemetry:
   a. The UI shall display EV's own suit and biomedical data.
   b. The UI shall display accompanied EV's suit and biomedical data.
2. Map:
   a. The UI shall display a 2-dimensional map.
   b. The map shall display points of interest.
   c. The map shall display location of live assets and other crew members.

   d. The UI may display 3D map of the environment.
3. Procedure list:
   a. The UI shall display correct procedures for each station of the EVA.
4. Navigation:
   a. The UI shall implement a "breadcrumb" feature for navigational use.
      i. This feature will allow the user to backtrack to the airlock.
   b. The UI should implement a best path navigation feature.
   c. The UI may offer navigation aids to points of interest.
   d. The UI shall provide predictive maximum range based upon spacesuit life support usage and limitations.
5. Drop Pins:
   a. The design shall provide the user the ability to drop a pin on the map at any point during the EVA.
6. Caution and Warning:
   a. The UI shall feature a caution and warning system.
   b. The caution and warning system shall alert the user if his/her spacesuit or biometric telemetry enter off-nominal ranges.
   c. The caution and warning system shall alert the user if accompanied EV's suit or biometric telemetry enter off-nominal ranges.
   d. The UI may feature a digital switching solution for the DCU.
7. Scientific Data Reporting:
   a. The UI shall alert the user when a sample is scanned.
   b. The UI shall alert the user when the sample is being analyzed.
   c. The UI should display spectroscopy analysis to the user when the sample is scanned.
   d. The UI shall alert the user when the analysis is complete.
   e. The UI shall alert the user when he/she may proceed to next scan.
   f. The UI may include fields for the user to complete as part of a field geology collection process.

4c. Interoperability Requirements

1. Shall share telemetry between both assets.
2. Shall provide caution warnings across both assets.
3. Waypoints, asset location, and POIs.
4. Scientific Data Reporting.
5. Camera stream from EV to PR display.

4d. Peripheral Requirements

These requirements shall 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 should communicate with teams' device(s) outside of the TSS, (i.e., Bluetooth).
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.

Appendix A: Sample UIA Procedures

EVA Egress

Connect UIA to DCU and start Depress

UIA and DCU	1.	EV1 and EV2 connect UIA and DCU umbilical
UIA	2.	EV-1, EV-2 PWR – ON
BOTH DCU	3.	BATT – UMB
UIA	4.	DEPRESS PUMP PWR – ON

Prep O2 Tanks

UIA	1.	OXYGEN O2 VENT – OPEN
HMD	2.	Wait until both Primary and Secondary OXY tanks are < 10psi
UIA	3.	OXYGEN O2 VENT – CLOSE
BOTH DCU	4.	OXY – PRI
UIA	5.	OXYGEN EMU-1, EMU-2 – OPEN
HMD	6.	Wait until EV1 and EV2 Primary O2 tanks > 3000 psi
UIA	7.	OXYGEN EMU-1, EMU-2 – CLOSE
BOTH DCU	8.	OXY – SEC
UIA	9.	OXYGEN EMU-1, EMU-2 – OPEN
HMD	10.	Wait until EV1 and EV2 Secondary O2 tanks > 3000 psi
UIA	11.	OXYGEN EMU-1, EMU-2 – CLOSE
BOTH DCU	12.	OXY – PRI

Prep Water Tanks

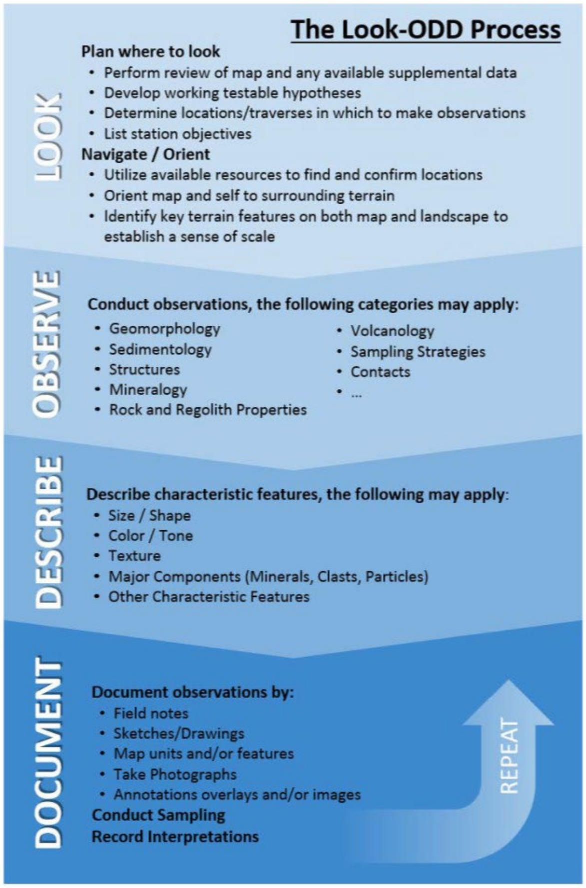
BOTH DCU	1.	PUMP – OPEN
UIA	2.	EV-1, EV-2 WASTE WATER – OPEN
HMD	3.	Wait until water EV1 and EV2 Coolant tank is < 5%
UIA	4.	EV-1, EV-2 WASTE WATER – CLOSE
UIA	5.	EV-1, EV-2 SUPPLY WATER – OPEN
HMD	6.	Wait until water EV1 and EV2 Coolant tank is > 95%
UIA	7.	EV-1, EV-2 SUPPLY WATER – CLOSE
BOTH DCU	8.	PUMP – CLOSE

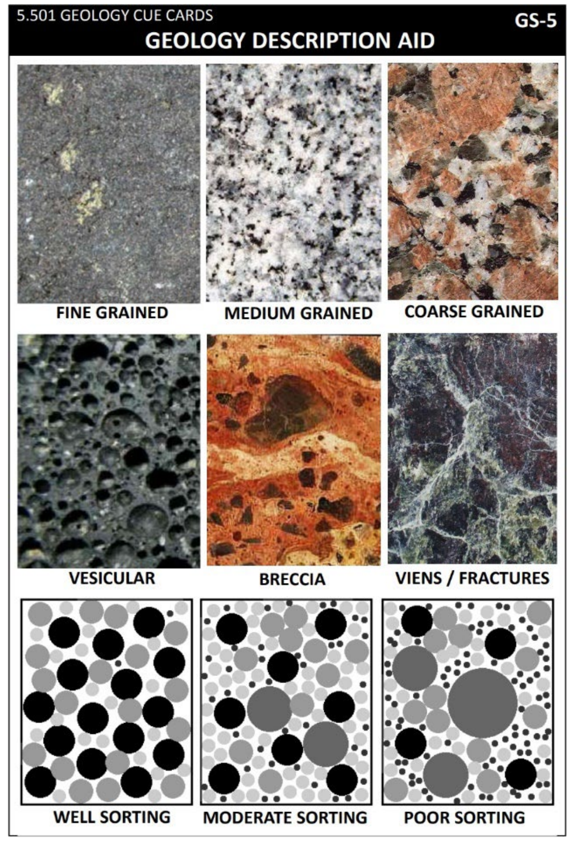
END Depress, Check Switches and Disconnect

HMD	1.	Wait until SUIT P, O2 P = 4
UIA	2.	DEPRESS PUMP PWR – OFF
BOTH DCU	3.	BATT – LOCAL
UIA	4.	EV-1, EV-2 PWR - OFF
BOTH DCU	5.	Verify OXY – PRI
BOTH DCU	6.	Verify COMMS – A
BOTH DCU	7.	Verify FAN – PRI
BOTH DCU	8.	Verify PUMP – CLOSE
BOTH DCU	9.	Verify CO2 – A
UIA and DCU	10.	EV1 and EV2 disconnect UIA and DCU umbilical

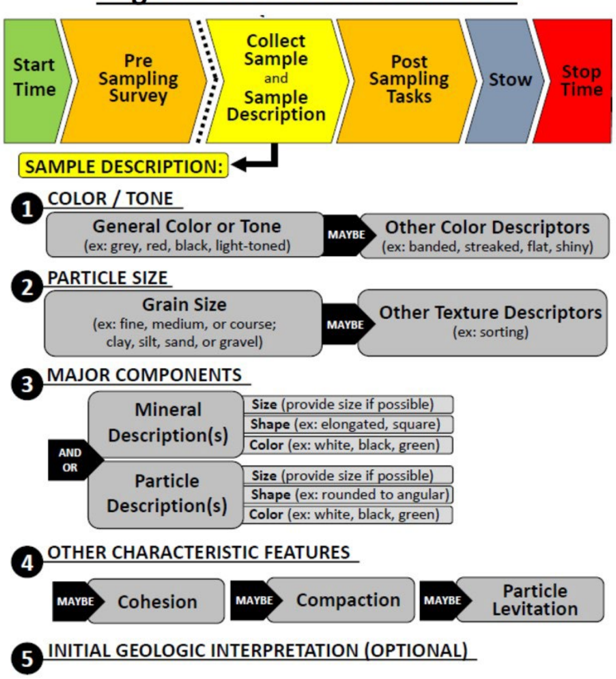
Appendix B: Geology — The Look ODD Process

The following cue cards may be used to inspire your geologic sampling process.





Regolith Collection Procedures



Rocks Collection Procedures