**Introduction to the SUITS Program**

The NASA Spacesuit User Interface Technologies for Students (NASA S.U.I.T.S.) Design Challenge is a mission-driven project in which university student teams design and create spacesuit informatics using an augmented reality (AR) Microsoft HoloLens platform. **Informatics** are the avionics of a spacesuit which help an astronaut become more efficient and effective during a spacewalk, often in the form of visual displays. The student-designed visual display and audio environments will present information to aid astronaut subjects in performing simulated Extravehicular Activity (EVA) tasks. After developing their environment, selected student teams will have the opportunity to travel to NASA Johnson Space Center to test their prototypes in an on-site facility.

**Introduction to NASA’s Advanced Spacesuit Informatics System**

During a spacewalk, an astronaut’s job involves focus, direction, and communication. Currently, an EVA crewmember communicates details about all tasks by means of a voice connection with mission control, an EVA partner, and an intravehicular (IVA) crewmember (an astronaut inside the pressurized spacecraft). For years, voice has been the only means of communicating during a spacewalk. However, NASA is developing innovative helmet-based displays which can perform this function much more efficiently, leading to less voice conversation, and a more proficient system. These displays align with the Informatics Subsystem of NASA’s Advanced Spacesuit.

At JSC, the Advanced EVA Development team is working to develop a spacesuit for astronauts to use for future missions which travel further from Earth than ever before. The Exploration Extravehicular Mobility Unit (xEMU) will be designed for spacewalks in microgravity or on the lunar surface and will kick-start the design of future Mars spacesuits. Because of its bold mission requirements, the xEMU will have several technological upgrades that have never been used in space. One of these upgrades is the introduction of an Informatics subsystem.

The xEMU’s Informatics subsystem will include many new capabilities that will make astronauts more resourceful and autonomous during EVAs, which is essential as missions move further and further away from ground support, both literally and figuratively. The crew will need to be *more autonomous*, and need more assistance from modern technology similar to the devices that make humans more autonomous on Earth. The Informatics subsystem will include new cameras, lights, a navigation system, and crew interfaces, including an electronic display which will display task procedures, schedules, pictures, schematics, videos, suit status, suit performance info, and other essential information.
The biggest design challenge for the Informatics subsystem is working out how best to interface with the human. What is the best design of robust, space-rated hardware that can stand up to years of use in a demanding deep-space environment, while keeping an astronaut safe? How do we best use emerging AR technologies to process and present data to a spacewalker in effective and intuitive ways? Which spacesuit data are the right data to sense, collect, and transmit? What will be the user experience of our future astronauts as they walk across the surface of Mars? These are the questions that NASA is only beginning to answer, and **WE WANT YOUR HELP**.

**Test Objectives**

The objective of the SUITS activity is to complete an EVA-simulated task while utilizing the HoloLens as an aid to instruct the user. The task may require dexterity, physical activity, and moving between various points within a room. A set of instructions are to be presented to the user via the display environment (audibly, visually, etc.) in order to complete the task most efficiently.

**Initial Test Guidance**

- The test subject conducting the EVA will be standing in a room with access to an EVA task board.
- The test subject will be wearing gloves (to limit dexterity) and a tether belt.
- One team member will be available as a support role during the EVA to read instructions and act as Mission Control.
- The test subject will be using a HoloLens during the EVA.
- Any external tools or additions to the HoloLens test setup must be **approved by NASA points of contact**.
- Teams will use Unity and C# to program interfaces. As this is necessary for compatibility with NASA provided data.
- NASA will provide subsets of data for the interface. This data will include spacesuit and biomedical data points, a set of instructions to complete the EVA tasks, and possibly other items available for processing by the user interface.
- The interface must be adaptable to multiple situations and sets of data.
- The team will have a set amount of time prior to the competition to incorporate the NASA data into the interface design.
- Teams will run through a procedure with communication to “ground control” with a specified latency with mission critical updates from ground control.

**Test Scenario**

Each student team will load their environment onto a HoloLens that will be worn by a test subject. After starting the environment on the HoloLens, the test subject will run through a procedure that involves completing a number of tasks. The procedure will include all the necessary information to complete the tasks; however, the Informatics environments developed by the student teams should aim to aid the test subject. The goal is to provide the
test subject information that makes them more efficient at completing a given task, without becoming a distraction.
The following tasks may be completed as part of the procedure:

- Providing suit information to ground control
  - This will involve a person reporting to the subject to provide information about a specific suit parameter. For instance, the question might be “What is your suit pressure?” or “How much battery life do you have left?”
  - The subject must be able to find this information in their display system, and deliver the information to “ground control,” in this case, their partner.

- Various tasks with the EVA task board
  - Removing and reinstalling fuses with provided tools;
  - Operating keys and unlocking locked cases;
  - Installing cables into outlets with correct orientation
  - Cable routing

Example Procedure Format:
1. Locate battery pack. Ensure that it is switched **ON**. Connect battery to load marked **BATTERY POWERED**.
2. Notate and verbally record that the **POWERED** light is enabled and lit.
3. Locate the key in **STORAGE** labeled “BREAKER BOX.” Use BREAKER BOX key to open compartment labeled “BREAKER BOX.”

These tasks are made to simulate an EVA as accurately as possible on Earth. As a result, participants will be suited as such, wearing items such as bulky gloves or a tethered belt, for example. Outside distractions, stressors, and lighting changes may also be introduced in order to better simulate an EVA environment.
Figure 1. Shows the inside of an EVA taskboard. A similar grouping of tasks may need to be completed when students showcase at JSC.

Figure 2. Example of tools used to complete the tasks required in the EVAs.
Figure 3. JSC intern Sarah Kuchel uses HoloLens as a guide to complete the EVA task.

**NASA Testing Logistics**

Once student teams arrive at JSC, they will participate in two test days during the five-day, onsite experience.

- **Day One (No Testing):** Arrivals, Welcomes, & Center and Facility Orientation
- **Day Two Testing:** A test subject will wear a HoloLens loaded with the student team’s environment. The subject will then complete a variety of tasks while following a procedure. The goal for the student teams is to develop a display and auditory environment that aids the test subject in performing these tasks as efficiently and correctly as possible. The test subject will give student teams feedback on their displays and the teams will be given time to implement changes to their design if needed.
- **Day Three (No Testing):** Optimizing design solutions
- **Day Four Testing:** Another test subject will perform the same series of tasks with the team’s updated environments.
- **Day Five (No Testing):** Wrap up activities and release
Program Deliverables
Specific program deliverable requirements will be available via a separate document titled: NASA SUITS 2018 Proposal Guidelines. General team deliverables will include:
- Proposal Reports
- Project Schedule
- Code and Custom Asset
- Outreach Plan
- Final Report
INTRODUCTION: Astronauts perform EVAs or Extravehicular Activities on the International Space Station. To improve efficiency and safety, astronauts train for months. Each task is scripted through what is called an EVA Checklist. These checklists are usually abbreviated and printed onto a small Cuff Checklist that the astronaut wears during space walks as shown in Figure 1. Below is the checklist for a simulated problem that an astronaut could encounter during a spacewalk. Familiarize yourself with the problem, and when ready begin the exercise.

Figure 1 Left: Checklist wrist cuff used by astronauts. Right: Mirrored wrist cuff used by astronauts. Courtesy of www.nasa.gov

Figure 2 Air Scrubber panel simulator.
EVA Schematic and Storage Area Contents:
(All items must be tethered or securely fastened during EVA operations.)

**Astronaut / EVA 1 Prep:** Put on the EVA Belt and Gloves

**CapCom Script:** “EVA 1, this is Houston Mission Control. Please be advised, an electrical short has damaged the power supply line to the Carbon Dioxide sensor on the main air-scrubbing unit for the International Space Station. There is now a fault alarm signaling and the air scrubbing unit is locked in the “OFF” status. This allows Carbon Dioxide to overtake the smaller auxiliary air scrubbing units. You must reroute the temporary battery supply power around the damaged circuit and then disable the alarm. We are a go to proceed with the rerouting procedure. Please confirm you are a “GO” to perform this procedure.”
Disabling Alarm Procedure
1. On the **RIGHT** side of the **EVA Kit**, locate and use the **PANEL ACCESS KEY** to unlock the **PANEL ACCESS DOOR LOCKS**.
   **CAUTION:** The keys are on a tension-spring cable.

2. Carefully return keys to the side of the EVA kit.

3. Insert your fingers in the **CENTER OPENING** and secure the **PANEL ACCESS DOOR** in an **OPEN** position.
   **WARNING:** Door can accidentally close.

4. On your belt, use the **BLUE CARABINEER** to securely tether to the **TETHER CABLE** inside the **STORAGE**.
   **CAUTION:** Notice the TETHER CABLE is adjustable.

5. Locate the **E-STOP** button and gently press down to temporarily disable the alarm.

6. Locate the **FUSIBLE DISCONNECT** box and tether the **BLUE CARABINEER** to the **TETHER CABLE**.

7. Remove the **BLUE CARABINEER** from the **FUSIBLE DISCONNECT** box and transfer it to **STORAGE**.

8. Open the **FUSIBLE DISCONNECT** box and secure the lid in the open position.
   **CAUTION:** Pull the locking tab toward **STORAGE** with the index finger while lifting the cover with the thumb.
9. Locate the BLACK DISCONNECT and tether it to the TETHER CABLE.

10. Remove the DISCONNECT and place it in STORAGE. **CAUTION:** Pull up with the index and middle fingers while pushing down on the FUSE ACCESS PANEL with the thumb.

11. Tether the FUSE ACCESS PANEL to the TETHER CABLE.

12. Remove the FUSE ACCESS PANEL by pulling straight up.

13. Place the FUSE ACCESS PANEL into STORAGE.

14. Tether the ALARM FUSE to the TETHER CABLE.

15. In Storage, locate the BLUE FUSE PULLER.

16. Use the BLUE FUSE PULLER to remove ONLY the ALARM FUSE. **CAUTION:** Rock the ALARM FUSE with the FUSE PULLER when pulling up.

17. Return the ALARM FUSE and the FUSE PULLER to STORAGE.
18. In STORAGE, locate the FUSE ACCESS PANEL and reinstall it into the FUSIBLE DISCONNECT box.

19. Remove the FUSE ACCESS PANEL tether from the TETHER CABLE and stow inside. **WARNING:** All tethers are under spring tension and can retract quickly.

20. In STORAGE, locate the DISCONNECT and reinstall it into the FUSIBLE DISCONNECT box. **CAUTION:** The DISCONNECT must read “ON” in the upper right corner to restore conductivity.

21. Remove the DISCONNECT tether from the TETHER CABLE. **WARNING:** All tethers are under spring tension and can retract quickly.

22. Close the FUSIBLE DISCONNECT box cover.

23. In STORAGE, use the BLUE CARABINEER to clip and lock the FUSIBLE DISCONNECT box cover.

24. Remove the BLUE CARABINEER’s tether from the TETHER CABLE. **WARNING:** All tethers are under spring tension and can retract quickly.

**End Of Disabling Alarm Procedure**
Rerouting Power Procedure
1. Locate the **Aux. Power Input**

2. Locate **BATTERY PACK** and tether to **TETHER CABLE**.

3. Undo the **BATTERY PACK LEADS** from the **AUX. POWER INPUT**.
   **CAUTION:** Depress the red and black plastic hammers on the side of the **AUX. POWER INPUT** and pull the leads straight up.

4. Remove **BATTERY PACK** from **AUX. POWER INPUT**.

5. Locate the **ON/OFF** switch on the back of the **BATTERY PACK** and switch it to the **OFF** position.

6. Place the **BATTERY PACK** into **STORAGE**.

7. In **STORAGE**, find the replacement **BATTERY PACK**.

8. Locate the **ON/OFF** switch on the back of the **BATTERY PACK** and switch it to the **ON** position.

9. Attach the replacement **BATTERY PACK** onto the **AUX. POWER INPUT** by the Velcro.

10. Insert the **BATTERY PACK** leads back into same colored ports.
   **CAUTION:** Depress the red and black plastic hammers on the side of the **AUX. POWER INPUT** and push leads straight into their ports.

11. Conduct a **GENTLE PULL TEST** on the wires.

12. Remove the **BATTERY PACK** tether from the **TETHER CABLE**.
   **WARNING:** All tethers are under spring tension and can retract quickly.

13. In **STORAGE**, locate the **GRAY 220 Volt PLUG**.

14. Install it into the **POWER OUT**.
**CAUTION:** Outlet and plug mate are stiff, ensure the full engagement of the plug into the outlet.
15. Locate the metal **BUSS BAR** and verify there are **BLACK, GREEN & WHITE BUSSES**, each with 2 openings.

16. Insert the **WHITE 220 VOLT LEAD** into the **LEFT WHITE BUSS** opening and **GENTLY TIGHTEN** the thumbscrew.  
**CAUTION:** DO NOT over tighten the thumbscrew.

17. Insert the **GREEN 220 VOLT LEAD** into the **LEFT GREEN BUS** opening. 
**CAUTION:** DO NOT over tighten the thumbscrew.

18. Insert the **BLACK 220 VOLT LEAD** into the **LEFT BLACK BUS** opening. 
**CAUTION:** DO NOT over tighten the thumbscrew.

19. Make sure the **METAL LEADS** are not sticking out the **BACK** of the **BUSS BAR**.

20. Conduct a Gentle **PULL TEST** on each cable.

21. In **STORAGE**, locate the **110 VOLT PLUG** and install it into **POWER IN**. 
**CAUTION:** Lift cover with one hand while installing PLUG into the outlet with the other. The lid is spring-loaded.
22. Insert the **WHITE 110 VOLT PLUG LEAD** into the RIGHT WHITE BUS opening.  
**CAUTION:** DO NOT over tighten the thumbscrew.

23. Insert the **GREEN 110 VOLT PLUG LEAD** into the RIGHT GREEN BUS opening.  
**CAUTION:** DO NOT over tighten the thumbscrew.

24. Insert the **BLACK 110 VOLT PLUG LEAD** into the RIGHT BLACK BUS opening.  
**CAUTION:** DO NOT over tighten the thumbscrew.

25. Conduct a Gentle **PULL TEST** on each cable

26. In **STORAGE**, locate the **E-STOP KEY**.

27. Insert the **KEY** into the **E-STOP** and **TURN** to the **RIGHT** and the button will pop up.

28. Remove the **KEY** and place it in **STORAGE**.
29. Locate the **AUX. POWER SWITCH** on the **POWER IN** box and switch it to the “ON” position.

30. Can you please confirm YES or NO that the **SYSTEM GO** indicator light is **GREEN**?

31. IF GREEN, read this script:

   EVA 1, this is Houston Mission Control. Congratulations. PHALCON is reporting that they are reading a successful power restoration on their console. You are a go to untether from the **TETHER CABLE** and return to space station. Mission Control out.

32. IF NOT GREEN, read this script:

   EVA 1, this is Houston Mission Control. PHALCON confirms and is not able to report a successful power restoration on their console. EVA-1, please be advised that we have prepared some trouble-shooting steps for you to conduct on a future spacewalk.
**Clean up**

1. Engage the E-Stop button
2. Disconnect all leads for the 110 Volt & 220 Volt Plug LEADS
3. Unplug the 110V & 220V PLUGS and stow the plugs in the STORAGE AREA
4. Switch the BATTERY PACKS switch to the “OFF” position
5. Ensure all remaining items are either installed securely or tethered in the STORAGE AREA
6. Close the PANEL ACCESS DOOR and lock the door with the keys from the tethering belt to secure the area
7. Return tethering belt and gloves to the instructor

**Troubleshooting**

<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>REASON</th>
<th>CHECK POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm sounds when AUX. POWER SWITCH is switched on.</td>
<td>The wrong fuse was removed.</td>
<td>Replace the fuse that was taken out and remove the ALARM FUSE.</td>
</tr>
</tbody>
</table>
| Nothing happens when AUX. POWER SWITCH is switched on. | There is no power going to the circuit. | - BATTERY PACK is switched “OFF”  
- BATTERY PACK leads are not inserted into their ports  
- 220V PLUG or leads where not installed correctly  
- 110V PLUG or leads where not installed correctly  
- AUX. POWER SWITCH is in the “OFF” position  
- E-STOP is still engaged  
- Batteries in the BATTERY PACK are depleted |