Bradley University's Experimental Augmented Reality Team for the Microsoft® HoloLens 2

2021-2022

NASA SUITS

Improving Reality Through Augmentation

BRADLEY
University

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Introduction

Bradley University brings forth an adept interdisciplinary team whose members study in the Midwest's most innovative technology departments. Together, the team seeks to optimally utilize the most cutting-edge, contemporary, and emerging technologies. Through the Interactive Media, Engineering, and Computer Science departments' collaboration and resources, the team will create an augmented experience that guides the user through space, missions, and procedures.

The University already has quite a bit of experience incorporating technology and common platforms within aerospace environments. The team members have previously worked with NASA on the following projects:

- 3D-Printed Habitat Challenge
- "LUMPI's Space Adventure" Web Game (NASA USIP SFRO Grant)
- MOCSat: Cube Satellite Tracking Mobile App (NASA USIP SFRO Grant)
- NASA SUITS 2018, 2019, and 2021 Challenges

In addition, the team members are a Microsoft HoloLens Certified Developer thanks to the two first-generation HoloLenses that have been purchased through a NASA USIP Grant.

Technical

Abstract

The Bradley University team has begun iterating on the previous build based on the past versions' feedback and the new additions this year's challenge brings. The primary focus is to implement the navigation and terrain sensing functions into the build while maintaining the ease and efficiency of the experience.

The build will keep the design fundamentals of times past but with vast iterative improvements from previous years. The team has a HoloLens 2 and will implement gesture control and functionality. Additionally, the team will continue to have the build acquire configuration information from a database. The vision is for the user to interact with the interface through voice commands and or gestures. This will allow for smooth interaction with the UI and Mission Control simultaneously. An example of how the user can interact with the program is in *Appendix A*. The team will incorporate these philosophies into the navigation and science sampling solutions.

The team will use the server to collect data on navigation. This information would include a heading, elevation, bearing, ETA, points of interest, and PET. The counter would start on the user command, and this acquired data will be fed into the interface and displayed to the user through intuitive displays, guiding the user to their destination with access to all the information.

Design Description

The NASA SUITS project will iterate on the previous designs regarding functionality and features while addressing the mission objectives. The main goal during iteration is to focus on gesture-based navigation that feels natural to use while also streamlining the navigation process. The team will also address potential issues with cognitive overload by designing an adaptive, intuitive heads-up display (HUD). The main processes of the HUD will include a bright color scheme so that it will have enough contrast against the dark backgrounds to be legible during any scenario.

Figure 1 • Navigation

The navigation will be split into two focuses: long-range and short-range. The long-range navigation mostly involves the minimap, compass, and waypoint system, as seen in the bottom part of *Figure 1*.

Using these three elements, a user can set waypoints from point A to point B or mark points of interest. Users can also create a waypoint to a chosen location that is in the visual field.

The short-range navigation utilizes the capabilities of the Microsoft HoloLens 2 and the peripheral headlamp device. The main short-term navigation goals in mind are to provide hazard avoidance capabilities via obstacle highlighting and drop-off scanning. The peripheral headlamp will ensure that the hazard avoidance scanning will work regardless of lighting conditions. The final part of short-term navigation is guiding arrows to a selected waypoint. The arrows will help the astronaut avoid hazards as they guide the astronaut to their selected waypoint.

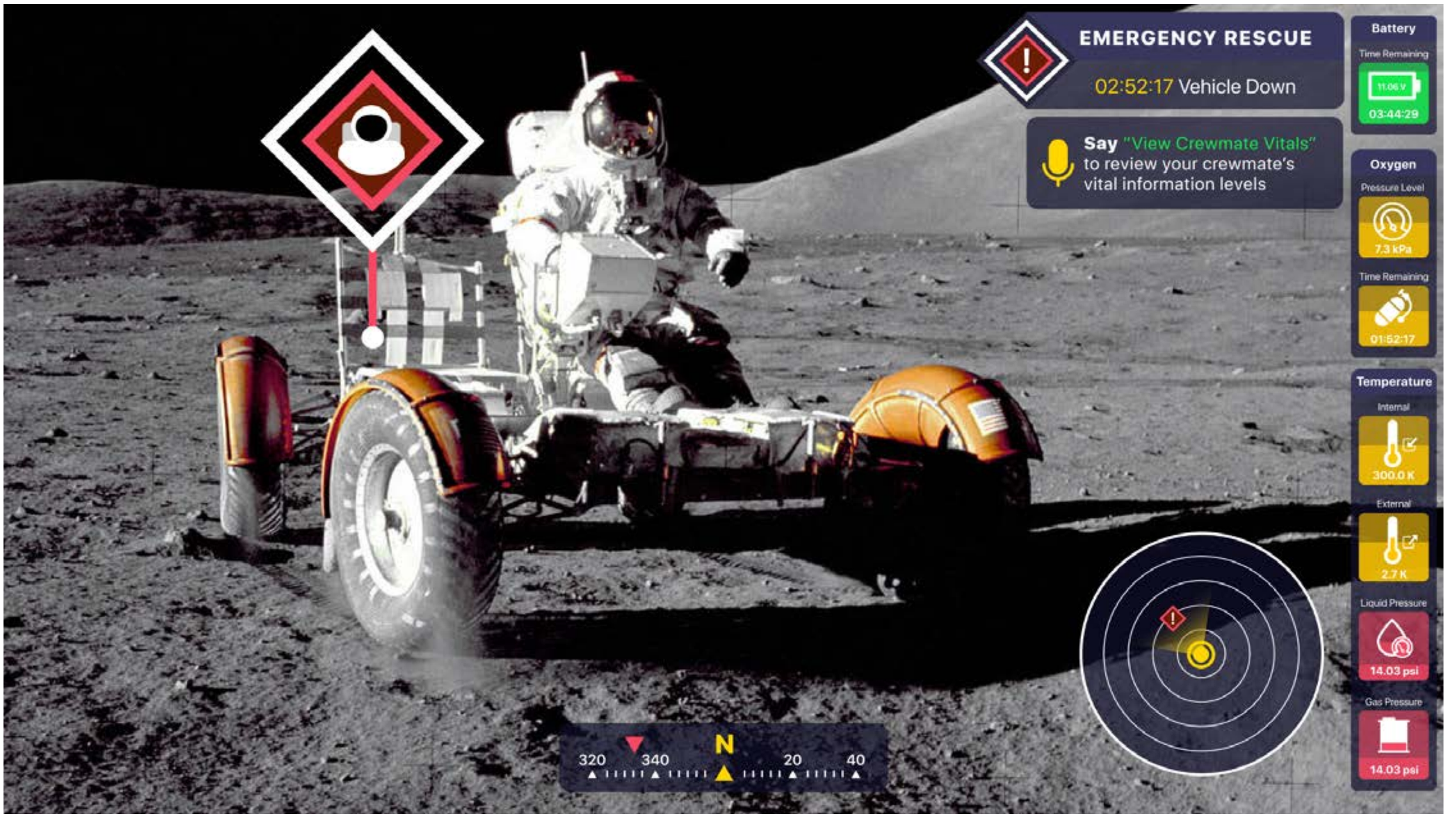


Figure 2 • Lunar Search and Rescue

The final challenge of the navigation interface is Lunar Search and Rescue (LunaSAR). After receiving an urgent distress notification from a fellow crew member, the relative position of the distress signal appears as a waypoint with directions leading to the signal. Additional information is provided, such as the crew member's vitals and the time from when the signal was received. *Figure 2* shows an example of what the HUD would display after receiving the distress signal.

While moving towards the distress signal, communication via voice messaging is possible between the rescuer and the distressed crew member. Voice messaging will incorporate text-to-speech, and the information passed to the rescuer will be added to the HUD if applicable. The LunaSAR objective will include all features from the navigation system as well.

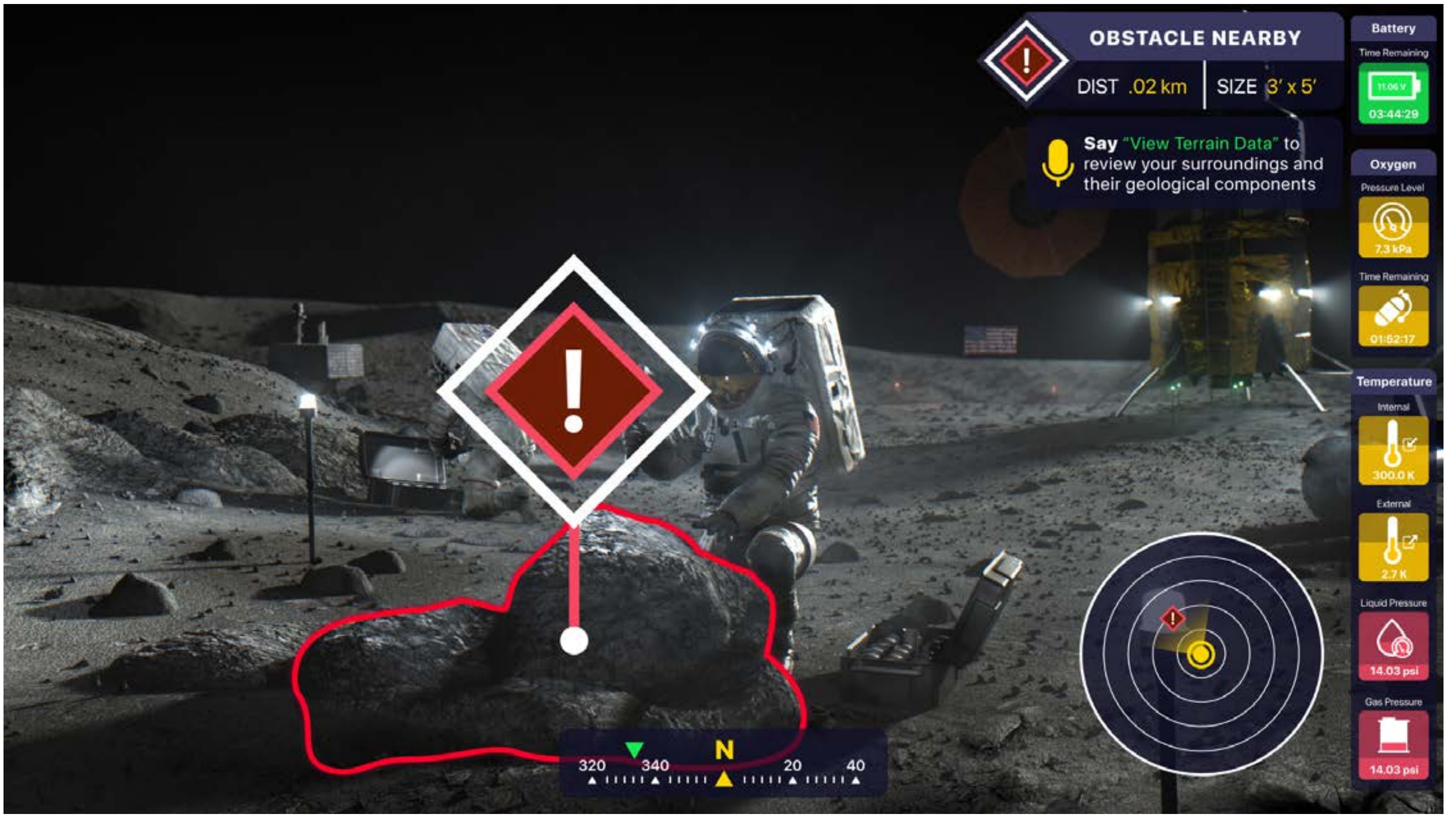


Figure 3 • Terrain Sensing

Similar to short-term navigation, the terrain sensing interface will scan the nearby area for hazards and outline them on the HUD. As seen in *Figure 3*, obstacles will be outlined in red and have a warning waypoint, indicating that this obstacle needs to be avoided. The team will recreate the red outline as a 3D model with contour lines across the crevice. This will also work with the peripheral headlamp to ensure lighting conditions are consistent enough to scan the terrain. Along with mapping hazards, the design will also scout for nearby science sampling sites.

The EVA system state design will inform the astronauts of crucial information, such as oxygen and battery levels, vitals. An icon is also associated with each essential vital. As seen on the right-hand side of *Figure 3*, the vitals' design will have a red, yellow, and green color depending on the state of urgency, and the background will fill in the higher the level. There will also be notifications that appear when a vital drops to the red or critical state. This ensures the design will ease cognitive load, since there are multiple ways to detect the urgency of some vitals. Along with the HUD design, there is also the capability to send EVA system state information to other astronauts and receive it.

The group is iterating on the previous years' work of voice commands for the user interface and design. First, the team is still designing the user interface and controls utilizing the capabilities of the HoloLens 2, such as eye-tracking. Then, the team rewrote some voice command prompts based on the research on "natural-sounding" or more fitting words. Finally, the team will implement gesture-based navigation to complement the voice commands, as seen in *Figure 4*. The goal of these gestures will be to find specific movements, such as blinking three times in succession, that feel natural but would not be accidentally triggered through regular use. Finding the medium between intention and accidental activation is challenging, so the team will only add a small number of gestures to ensure that this issue does not occur. Based on some of the human-in-the-loop testing, the team will evaluate the effectiveness of gesture-based navigation and make adjustments as necessary.

Figure 4 • Geology

Lastly, the geology solution uses the navigation waypoint system to guide science sampling and a gesture to take photographs. As seen in *Figure 4*, there are multiple ways to provide instructions to the science sampling site, such as navigation arrows and estimated arrival time. As well, the team added the gesture of blinking three times in rapid succession to take a photo. This feature will take field notes and capture photographs of excavation sites and geology samples. In conjunction with the design, the team will also implement some 3D models to replace design elements, like the navigation arrows and the crater contour in *Figure 1*. In addition, the team will create a 3D model of a geology sample for testing purposes, as seen in *Appendix B: Figure 2*.

3D Modeling

To enhance the visual experience of navigating using the HMD, the team will fill out the AR environment with 3D digital assets. Digital content creation tools used for building the 3D assets will be Maya, Blender, Cinema 4D, Quixel Mixer, and Substance Painter.

The team will implement 3D modeling for terrain mapping in alignment with the obstacle avoidance capabilities in the design. Dangerous terrain features such as craters, boulders, and crevices will be designed as part of the obstacle course. As previously mentioned in the Design Description, 3D Path segments and arrows will be displayed in the UI for guidance across the terrain.

Tele-Robotics

The robot will use a modular design, allowing it to be applied in various situations, including search and rescue, surveillance, and geology sampling assistance.

A sample prototype of the proposed robot is similar to the one shown in *Figure 5*. The robot's proposed design utilizes the rocker-bogie suspension system, used widely in rovers intended for the moon and mars. This suspension system is often used for its versatility when traversing rugged terrain, being the ideal system for the robot.

Figure 5 • Bogie Runt Rover™

The base of this robot will be a simple cargo robot, the Bradley University Cargo Keeping Escort Tele-robot (BUCKET), which will hold all the tools necessary for various EVAs. Equipped with a 360° vision system, the BUCKET will relay its camera feed to both the user's HUD and locally for later backup to mission control if necessary. The robot will work autonomously for some tasks while allowing the user to control it through gesture and voice navigation within the HoloLens 2. A WiFi communication system will be established between the onboard robotics computer and the HoloLens 2, allowing for the bidirectional transfer of instruction data and sensory/video data.

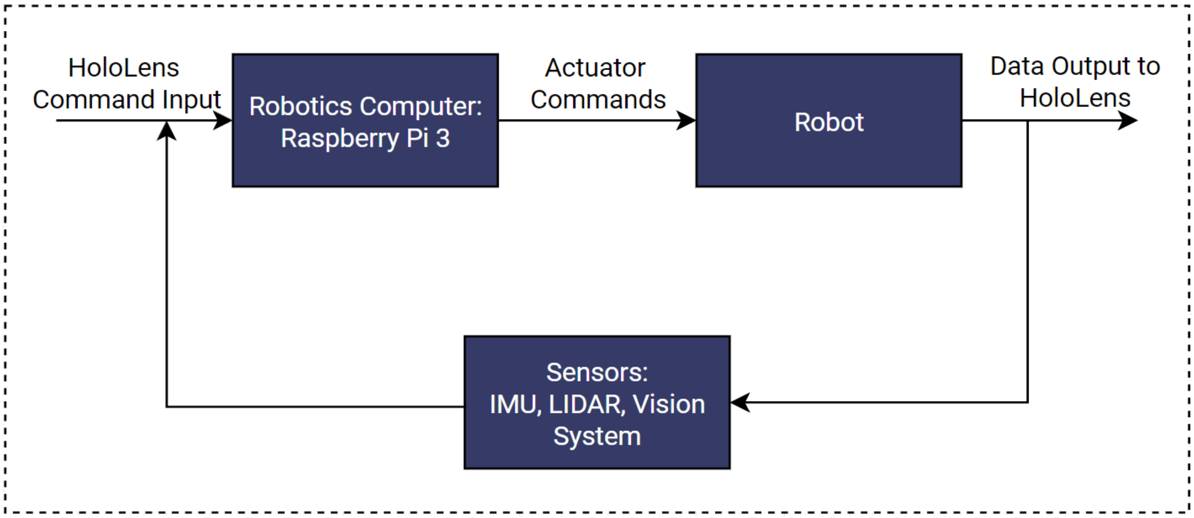


Figure 6 • Robotics System Block Diagram

Figure 7 shows a high-level block diagram of the robotics and HoloLens 2 systems in addition to sensors. The onboard robotics computer will accept commands from the HoloLens 2 for robot control. After these commands are executed, the robot will be capable of transmitting its sensory data back to the HoloLens 2 for real-time viewing.

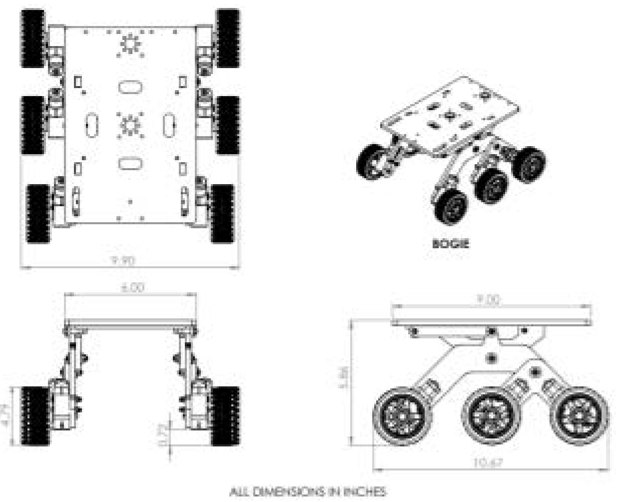


Figure 7 • Bogie Runt Rover™ Schematic

The team will design from a template rather than a pre-built robot as it would give the team more granular control over the robotics design in addition to reducing costs. The goal is to design a robot similar to the ROS Bulldog, a durable multipurpose robot that would allow us to attach augments for different use cases. *Appendix C* shows a manipulator use case that could be used to hold, transfer, and store samples for astronauts. As designing something of this nature will be challenging, reconnaissance and mapping will be the highest priority, with a physical sampling manipulator or sampling assistance being secondary.

Concept of Operations (CONOPS)

While on a Lunar Mission, astronauts have many different goals that demand their attention. The design takes a minimalistic approach, so astronauts are not overstimulated when using the interface.

The display is organized such that the astronaut has access to the most critical information, such as vitals data, from a single command. More detailed information such as step-by-step instructions for tasks and navigation can be shown by navigating through intuitive HUD menus. Also, any panel can be pinned to the astronaut's environment or field-of-view. The interface can be navigated using a combination of voice controls and gestures, allowing both smooth communication with Mission Control and the ability to operate the interface when the user's hands are busy.

The Unity game engine will be utilized for the development platform. Unity is chosen because it offers native integration with the HoloLens 2, a wide variety of libraries, extensive AR support, and the team's experience with the engine.

Navigation between sites will start with a voice command or gesture. If the astronaut knows where they are going, they can immediately begin to navigate. If not, the astronaut will choose their destination from a list of points of interest. Navigation will be done via dead reckoning, using Unity and MRTK's built-in AR anchor system. After navigation has started, the astronaut will be shown a combination of heading, approximate distance, and the estimated time of arrival to their destination. Navigation can be exited at any time and reentered later without losing information.

The astronaut can start the terrain sensing at any time. This will highlight potentially hazardous areas, and allow the user to navigate more freely across the environment. The algorithm used to process the images will be trained using Microsoft Azure. The training set will be pulled from MIT's Indoor Scene Recognition data set. Terrain sensing is togglable at any point so as to avoid astronauts experiencing cognitive overload.

Once at their destination, the astronaut can pull up an instruction screen for their task. The task screens can be navigated step-by-step using voice commands or hand gestures. A table of contents will be available if the astronauts need to skip to a specific stage in the process. The instructions panel can be closed at any time and reopened later without the current step being lost.

Astronauts can view their suit's vitals at any point. A voice command or gesture will pull up a screen displaying the current status of their suit, or individual vitals can be viewed alone. If a vital passes a configurable threshold, an alert displaying the vital in question will be shown. The astronaut may close the alerts, but they will remain present until the issue is resolved. The astronaut may view all alerts, including closed ones, at any time.

Configuration options such as the vitals poll rate and IP address are accessible via a MongoDB database. The information is pulled upon application startup, so an internet connection is only needed momentarily. Should connection fail, the application uses its locally stored fallback configuration. This approach allows for configuration options to be changed without needing to recompile the entire application.

Human-in-the-loop testing (HITL)

Human-in-the-loop testing (HITL) is an essential part of the design process. The team plans to do HITL testing two times during the design process to iterate on the user interface and software. The testing designs will be conducted mainly in an in-person setting within the university's restrictions. If restrictions due to COVID-19 are changed, the team also has a plan to resume with virtual usability testing. Testing and outreach events will allow us to iterate the development of the software using feedback and provide the audience with STEM and NASA Exposure.

The team will gather both qualitative and quantitative metrics by using a proctor. The team will focus on the time it takes for the users to successfully complete various tasks and their ability to run through the process without the aid of the proctor. The team will also gather information about the user's overall experience via a survey after testing is completed.

To gather these metrics, the HITL test will follow a general protocol described below:

1. Inform the user that data will be recorded and that they will be asked questions regarding their experience after the test is done.
2. The proctor will help immediately if the user is having trouble with the hardware (e.g., keeping the HoloLens 2 on or if the app accidentally closed).
3. The proctor will offer minimal help regarding the design to receive unbiased feedback in order to iterate on the work.
4. The proctor will mark down the time it takes for the user to reach certain checkpoints as well as the number of attempts taken to complete said task, and when the user finishes.

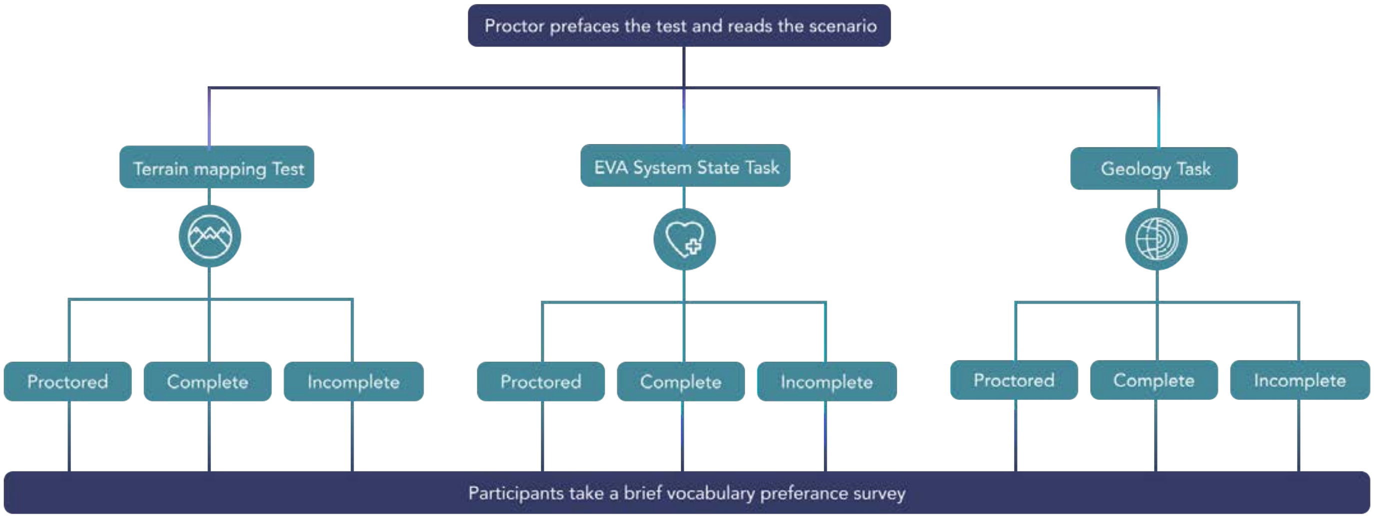


Figure 8 • Study Plan

The subject pools will vary depending on the given outreach events. The team chose to keep the subject pool variable through random sampling as it allows us to reach and gather feedback from multiple demographics. Grade school, high school, and college students will be tested, but the team will employ additional testing for different demographics. For example, the team will have specific tasks for younger audiences, which will show the ease of use of the design because their comprehension skills may not be as developed as older users, such as with the vocabulary test. These users will likely have a high literacy level but a lower or medium understanding of VR software. The team will also plan to use these HITL tests to inspire these users to become more involved in STEAM areas and NASA.

USER PERSONA

Emily Sossa

NASA Astronaut

Biography:
Emily is a 32-year-old NASA Mission Specialist who is currently going through her training. Prior to training, she has never used virtual reality software, but is eager to move to her next section of training involving the HoloLens.

Age: 32

Education: Masters Degree

Personality:

Introvert — Extrovert

Sensing — Intuition

Feeling — Thinking

Judging — Percieving

Goals:

- Clearly understand and interpret the EVA system state information
- Complete search and rescue through terrain sensing
- Complete geological tasks

"Experience all your passions and do what scares you most."

Motivations

- Excited to learn about new technologies and software
- Trying new things and activities is exciting and encouraging
- Completing goals and tasks
- Achieving new limits

Frustrations

- Complexity of technology
- Concerned about confusion
- Does not want to be overloaded with unimportant information

Tech Literate:

Low — High

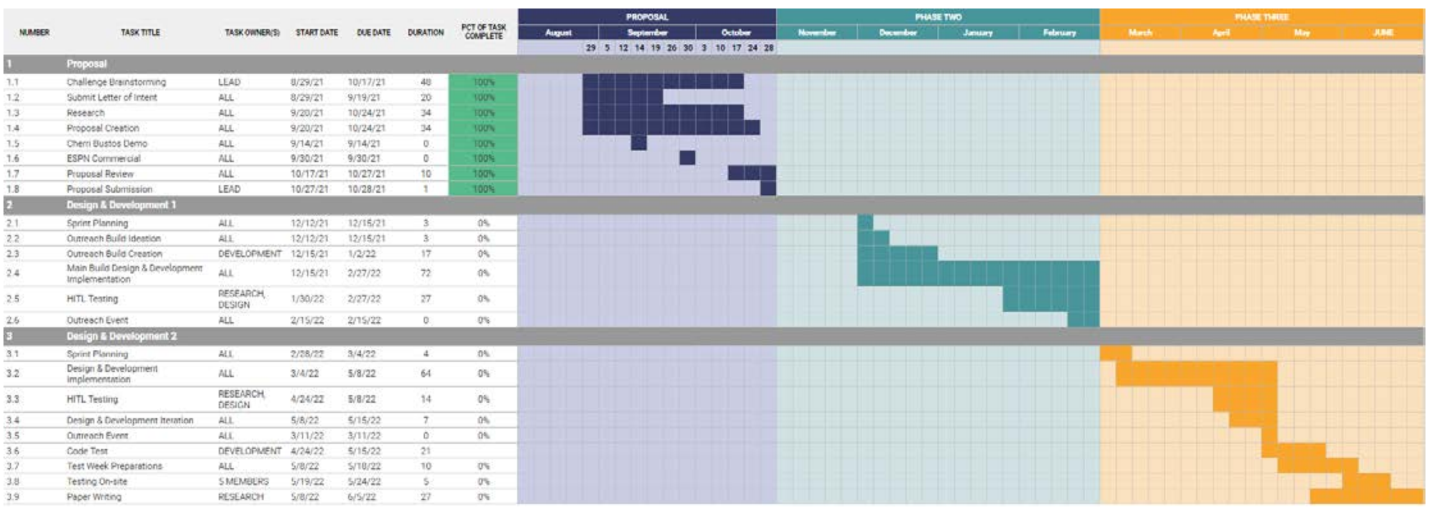
IT and internet

Software

Mobile Devices

Figure 9 • User Persona

Team Project Schedule



NUMBER	TASK TITLE	TASK OWNER(S)	START DATE	DUE DATE	DURATION	PCT OF TASK COMPLETE
1	Proposal					
1.1	Challenge Brainstorming	LEAD	8/29/21	10/17/21	48	100%
1.2	Submit Letter of Intent	ALL	8/29/21	9/19/21	20	100%
1.3	Research	ALL	9/20/21	10/24/21	34	100%
1.4	Proposal Creation	ALL	9/20/21	10/24/21	34	100%
1.5	Cherri Bustos Demo	ALL	9/14/21	9/14/21	0	100%
1.6	ESPN Commercial	ALL	9/30/21	9/30/21	0	100%
1.7	Proposal Review	ALL	10/17/21	10/27/21	10	100%
1.8	Proposal Submission	LEAD	10/27/21	10/28/21	1	100%
2	Design & Development 1					
2.1	Sprint Planning	ALL	12/12/21	12/15/21	3	0%
2.2	Outreach Build Ideation	ALL	12/12/21	12/15/21	3	0%
2.3	Outreach Build Creation	DEVELOPMENT	12/15/21	1/2/22	17	0%
2.4	Main Build Design & Development Implementation	ALL	12/15/21	2/27/22	72	0%
2.5	HITL Testing	RESEARCH, DESIGN	1/30/22	2/27/22	27	0%
2.6	Outreach Event	ALL	2/15/22	2/15/22	0	0%
3	Design & Development 2					
3.1	Sprint Planning	ALL	2/28/22	3/4/22	4	0%
3.2	Design & Development Implementation	ALL	3/4/22	5/8/22	64	0%
3.3	HITL Testing	RESEARCH, DESIGN	4/24/22	5/8/22	14	0%
3.4	Design & Development Iteration	ALL	5/8/22	5/15/22	7	0%
3.5	Outreach Event	ALL	3/11/22	3/11/22	0	0%
3.6	Code Test	DEVELOPMENT	4/24/22	5/15/22	21	
3.7	Test Week Preparations	ALL	5/8/22	5/18/22	10	0%
3.8	Testing On-site	5 MEMBERS	5/19/22	5/24/22	5	0%
3.9	Paper Writing	RESEARCH	5/8/22	6/5/22	27	0%

Figure 10 • Team Project Schedule: Our team will implement agile development and work based on sprints

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Outreach

Public Relations

Bradley University has a dedicated public relations team that has agreed to arrange and execute a marketing plan to release this project on all University platforms. Also, the department and the university have various social media outlets (i.e., blogs, newsletters, Twitter, Facebook, etc.), which they will use to update the public on the progress and status on this project.

Social Media Plan

BU EARTH will be utilizing social media to showcase accomplishments, team members, and experiences through the NASA SUITS Challenge.

The team plans to post/repost content pertaining to the project at opportune times. The social media plan *(Figure 11)* focuses on Twitter (@SuitsBUEarth) and Instagram (@buearth) as those platforms are two of the most popular. Creating a space for the team on TikTok or Facebook may come in the future. As it exists now, the social media plan consists of routine-based posts for both accounts. Typically, Tuesdays are planned for engagement posts via Instagram story content and tweets to encourage user interaction. Every other Friday is planned for team member features to highlight a specific individual and their role on the team.

Figure 11 • Social Media Plan

The weekends will be utilized to catalog the project's activities (ie. photoshoot material, PR outreach events) and plan accordingly for the following week.

Event Plan

Adapting to the Ongoing COVID-19 Pandemic

The team is committed to having a fluid and adaptable approach to the events this year, planning easily adaptable events for a virtual or in-person environment. In cases where the team holds in-person events, the team will follow strict CDC guidelines to ensure the team and the community's safety.

Local Public Schools (VIRTUAL)

During the development cycle, the team plans on periodically reaching out to K-12 local schools for outreach opportunities. For these events, the team will present information about the development process, the project's goal, and how the team is implementing the ideas into reality to their students. After the presentation, the team will have an interactive virtual activity that engages the community in STEM. This activity will be adaptable to meet the technology available to the students. Example activities are Kahoot games based on the presentation and run-throughs of augmented reality activities.

Objective: Inform students about NASA, STEM, and Augmented Reality
Demographic: Grades 6-12

Projected Participants: 50

Local Public Schools (IN-PERSON)
In the case of an in-person event, the activity portion will be hands-on, and the team will employ the Outreach build and present the NASA procedures build. Students will be able to try out the builds themselves and provide feedback or ask questions about the experience.

Objective: Collect Feedback, Inform students about NASA, STEM, and Augmented Reality
Demographic: Grades 6-12
Projected Participants: 100

Horizon (VIRTUAL)
The team plans to present to Peoria public schools through Horizon— a local STEM program in the greater Peoria area. The structure for this form of outreach will be similar to the local school outreach. However, the team will focus on providing students with a more rounded understanding of STEM careers. Given that these students are already STEM inclined, the activities through the Horizon will be more complicated. The team hopes to inspire students to get involved in STEM extracurriculars at their schools and eventually pursue a STEM career.

Objective: Inform students about NASA, STEM Careers, and Augmented Reality
Demographic: Grades 8-12
Projected Participants: 200

Horizon (IN-PERSON)
An in-person variation of this would consist of the same structure alongside hands-on activities for a more engaging outreach form. The team will follow CDC guidelines to ensure that students and the team are socially distanced.

Objective: Collect Feedback, Inform students about NASA, STEM, and Augmented Reality
Demographic: Grades 8-12
Projected Participants: 200

Bradley Admissions (VIRTUAL)
In the fourth quarter of 2022, the team plans to host an outreach event collaborating with Bradley University Admissions. This event will promote STEM and careers to prospective students and current Bradley students while also giving us crucial feedback from these students on the design and development.

Objective: Inform potential university students about NASA, STEM, and Augmented Reality

Demographic: Grades 10-12
Projected Participants: 300

ESPN COMMERCIAL (IN PERSON)
Students participated in a new commercial for Bradley that ran on ESPN and on the University's YouTube channel showcasing the BU Earth NASA Suits Project.

Objective: Share the NASA SUITS project nationally
Demographic: National

BU Earth Booth (IN PERSON)
During February, the team plans to set up a booth in Bradley University's Michel student center on campus and allow Bradley students to test out the build. This will give us a presence on campus and receive valuable feedback from peers.

Objective: Collect Feedback, Inform students about NASA, STEM, and Augmented Reality
Demographic: Local
Projected Participants: 100

Cheri Bustos Campus Visit (IN PERSON)
Students conducted a presentation to Illinois Senator Cheri Bustos on Sept 14th 2021 in-person at Bradley University. The students demonstrated the NASA SUITS design project and provided an overview of the project's challenge and goals. Cheri was able to try the design and provide feedback on the overall experience. The news reel is located here:
https://week.com/2021/09/14/rep-bustos-touts-new-bradley-air-force-partnership-on-vr-tech/

Objective: Share the NASA SUITS project nationally
Demographic: National

Fuse 2022 (IN-PERSON)
In April, the team plans to bring the project to the Peoria Riverfront Museum to be demonstrated to the public. While there, the team will be watching and noting how people interact with the design. Team members will be at the event to answer any questions the testers have.

Objective: Collect Feedback, Inform students about NASA, STEM, and Augmented Reality
Demographic: Regional
Projected Participants: 500

Outreach Materials

Outreach Build *(IN-PERSON*)

When In-Person events are possible, students will be able to wear the HoloLens 2 and use voice commands to go through the outreach build. In this hands-on activity, students are provided with scissors, aluminum foil, and coins to make their own tin moon *(Figure 13)*. Students see the instructions through the HoloLens 2 *(Figure 12)* as they create their moon on a table with their hands. The team will maintain CDC guidelines and ensure that students and the team are socially distanced. The HoloLens 2 will be thoroughly cleaned before and after each student.

Outreach Build (VIRTUAL)

When virtual events are required, the team will collaborate with the teacher on obtaining materials and show the instructions through an online presentation. The team will also discuss augmented reality and show videos of how it would be used in-person.

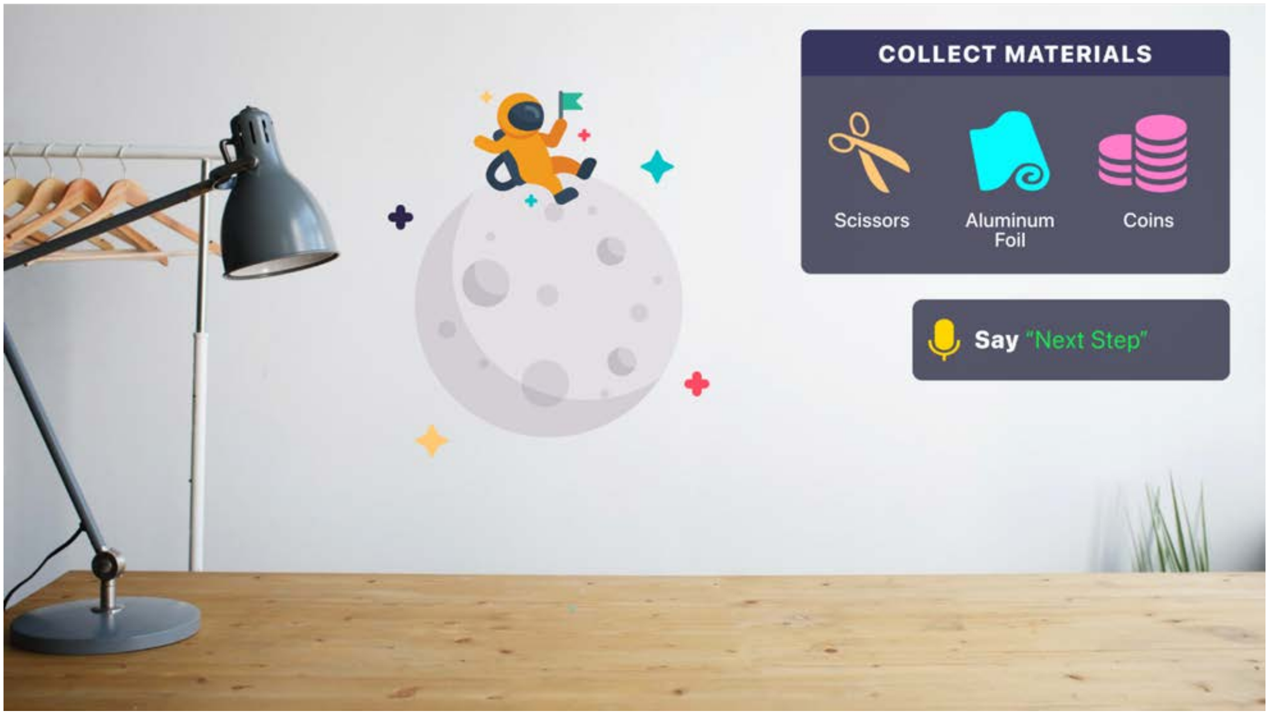

Figure 12 • Outreach Build - First Step

Figure 13 • Outreach Build - Final Result

Outreach Presentations (IN-PERSON & VIRTUAL)
Presentations will be created for each outreach event. The team will discuss the experience working with NASA, the current build, the majors and backgrounds, and augmented reality and its uses in the presentations. The software/tools used to create the build will be discussed and how the team designed for the HoloLens 2, how the NASA SUITS project has helped us in the career/internship search, and other information about STEM careers.

Administrative

Institutional Letter of Endorsement

BRADLEY University

1501 West Bradley Avenue | Peoria, IL 61625 | bradley.edu

Oct 2021

NASA S.U.I.T.S.

To Whom It May Concern:

Bradley University's Slane College of Communications and Fine Arts Department of Interactive Media would like to express our interest in participating once again in the NASA S.U.I.T.S Design Challenge (Spacesuit User Interface Technologies for Students) project. Our students at Bradley University participated in previous year challenges and we feel that Bradley University's Interactive Media department has an excellent perspective on user experience design, graphic design, engineering, and development. Additionally, Bradley University has been involved in three NASA USIP projects, including a sponsor and host for NASA's 3D-Printed Habitat Challenge. We are an ideal candidate to continue working with you again on a design solution for NASA S.U.I.T.S.

The projects we have been doing for NASA have been extremely exciting for our faculty and students, and we have been seeing amazing project outcomes. We long to continue to extend this experience.

Please feel free to reach out and let me know if I can provide you with any additional information.

Sincerely,

Ethan Ham
Chairperson, Department of Interactive Media
eham@fsmail.bradley.edu

Statement of Supervising Faculty

BRADLEY University

1501 West Bradley Avenue | Peoria, IL 61625 | bradley.edu

Oct 2021

NASA S.U.I.T.S.

To Whom It May Concern:

As the faculty advisor for an experiment entitled NASA S.U.I.T.S Design Challenge (Spacesuit User Interface Technologies for Students) proposed by a team of higher education students from Bradley University institution, I concur with the concepts and methods by which the students plan to conduct this project. I will ensure the student team members complete all project requirements and meet deadlines in a timely manner. I understand any default by this team concerning any project requirements (including submission of final report materials) could adversely affect selection opportunities of future teams from their institution.

Sincerely,

Heather Ford
UI/UX UCD Instructor and Coordinator
Department of Interactive Media Bradley University
hford@bradley.edu

Statement of Rights of Use

BRADLEY University

1501 West Bradley Avenue | Peoria, IL 61625 | bradley.edu

October 3rd, 2021

As a team member for a proposal entitled "NASA SUITS Improving Reality Through Augmentation" proposed by a team of higher education students from Bradley University institution, I will and hereby do grant the U.S. Government a royalty-free, nonexclusive and irrevocable license to use, reproduce, distribute (including distribution by transmission) to the public, perform publicly, prepare derivative works, and display publicly, any technical data contained in this proposal in whole or in part and in any manner for federal purposes and to have or permit others to do so for federal purposes only. Further, with respect to all computer software designated by NASA to be released as open source which is first produced or delivered under this proposal and subsequent collaboration, if selected, shall be delivered with unlimited and unrestricted rights so as to permit further distribution as open source. For purposes of defining the rights in such computer software, "computer software" shall include source codes, object codes, executables, ancillary files, and any and all documentation related to any computer program or similar set of instructions delivered in association with this collaboration. As a team member for a proposal entitled "NASA SUITS Improving Reality Through Augmentation" proposed by a team of higher education students from Bradley University institution(s), I will and hereby do grant the U.S. Government a nonexclusive, nontransferable, irrevocable, paid-up license to practice or have practiced for or on behalf of the United States Government any invention described or made part of this proposal throughout the world.

Abigail Irwin

Abigail Irwin '22
Manager and Director
User Experience Design & Psychology
avirwin@mail.bradley.edu

Funding & Budget Statement

Item	Quantity	Price Per	Total
Outreach Materials	N/A	N/A	$500
Robotics Kit	1	$80	$80
Embedded Computer/Robotics Computer	1	$150	$150
Lidar Sensors	1	$80	$80
IMU	1	$40	$40
Vision System	1	$150	$150
Round-Trip Flight from ORD to IAH	5 people	$300	$1500
Hotel in Houston	5 rooms x 6 nights?	$100	$3,000
Food	5 people x 6 nights	$20	$600
			$6,100

Financial Assistance

To fund the project expenses and trip, the team will be creating a Go Fund Me page, applying for assistance through Bradley University's Special Emphasis Student Travel Fund Program, and presenting at Bradley University's Scholarship Expo.

HoloLens 2 Loan Program

C) The team has a device, but would still like to be considered for a loan to aide in the development.

Appendix

Appendix A

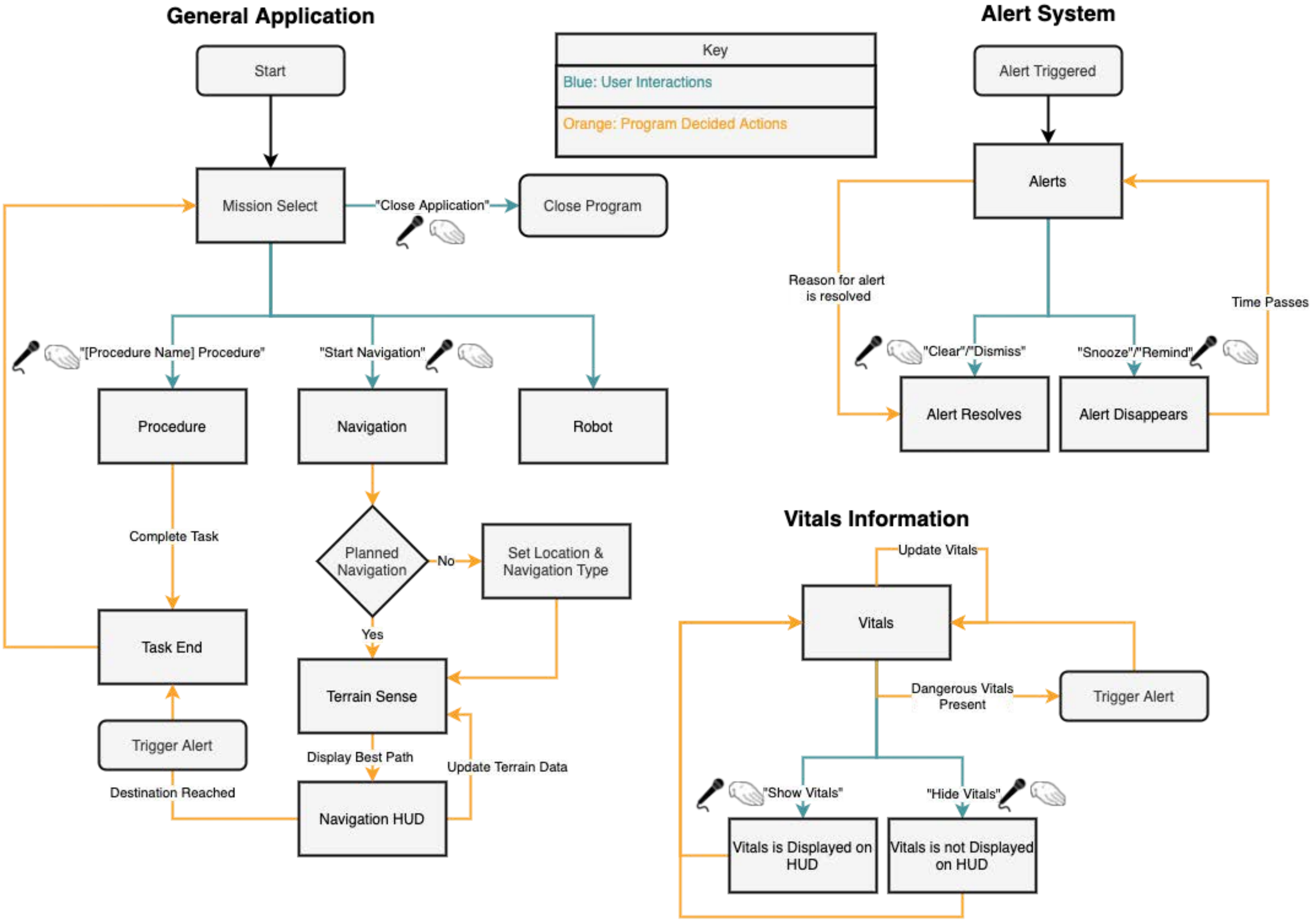

Figure 1• Project Flowchart

Appendix B

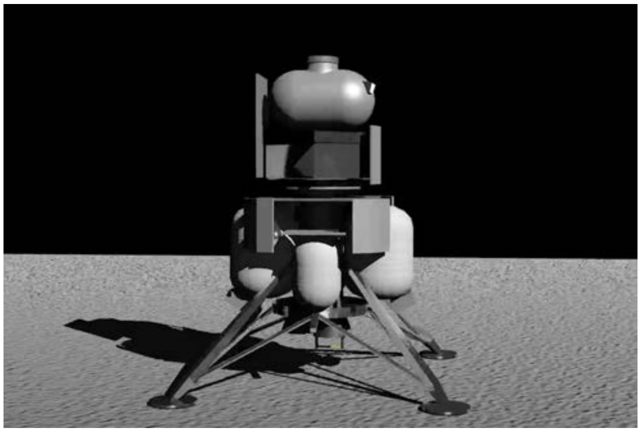

Figure 1 • Lander

Figure 2 • Moon Rock

Appendix C

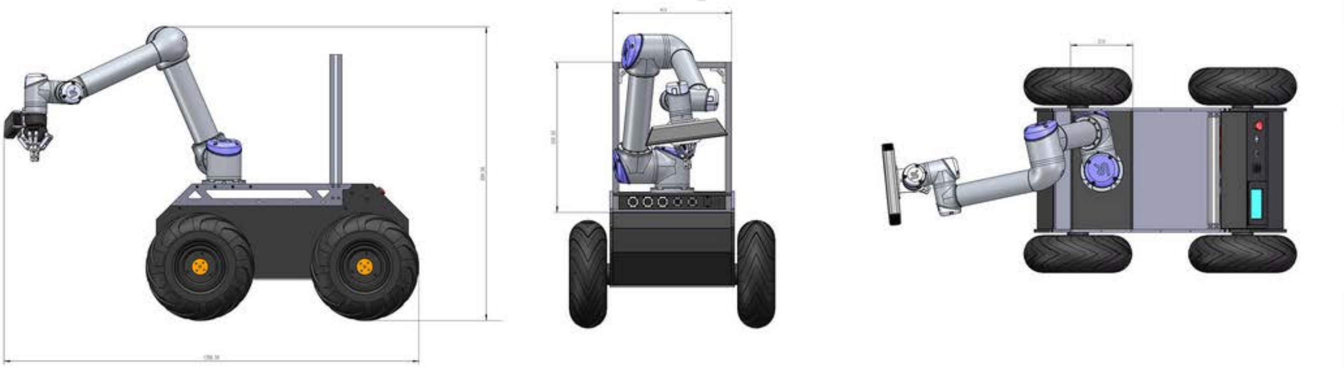

Figure 1 • Bulldog Manipulator