NASA HERA Requirements
Moonscape and Robots Planning Phase v1.01

1. Executive Summary

The NASA HERA Moonscape and Robots project aims to enhance the realism and engagement of the Human Exploration Research Analog (HERA) program by incorporating a remotely operated robotic lunar exploration component. This project will develop an 8ft × 8ft portable lunar landscape model or a VR model with accompanying robotic systems that HERA participants (HERAnauts) can operate during their 45-day isolation missions. The project leverages NASA HUNCH program capabilities for development and implementation, ensuring educational value while meeting mission requirements. This may be an actual model or a VR Model.

This initiative will enhance the psychological fidelity of HERA missions by providing participants with realistic lunar exploration activities while maintaining mission protocols and communication delays.

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3. Planning Stage

The planning stage is crucial as it establishes the foundational requirements for both the lunar landscape and robotic systems. The lunar landscape specifications detail the exact dimensions (8ft × 8ft) and construction requirements, including portability considerations and the need for visual barriers to maintain mission immersion. The robotic system requirements outline the need for four specialized robots with specific capabilities in transportation and manipulation, all controlled via Bluetooth within a 100-meter range. This phase ensures that all technical specifications, from camera systems to power requirements, are thoroughly defined before moving to implementation.

4. Project Overview

The project overview section establishes the fundamental framework for the entire initiative. Its purpose is to enhance HERA missions by providing participants with realistic lunar exploration activities that maintain their psychological immersion in the space environment. The scope encompasses not just the physical construction of the moonscape and robots but also the entire ecosystem of control systems, protocols, and integration requirements necessary for successful implementation.

5. Scope

The project encompasses:

- Development of an 8ft × 8ft portable lunar landscape
- Creation of four specialized robotic units
- Implementation of remote control systems
- Development of mission scenarios and testing procedures

1.3 Planning Timeline

- Planning Phase Start: May 15, 2025
- Requirements Document Completion: July 31, 2025
- Project Presentation Website Launch: August 8, 2025

5. Lunar Landscape Requirements

5.1 Physical Specifications

- Dimensions: 8ft × 8ft (2.44m × 2.44m)
- Height of Side Walls: Minimum 3ft (0.91m)
- Design Concept: Foldable into 4ft × 4ft sections for portability
- Surface Features: If possible, based on actual lunar south pole crater formations
- Lighting: Integrated system for both day and night operations

5.2 Environmental Features

- Crater-within-crater design based on South Pole region topology

- Integration of 3D printed rocks and surface features
- Scaled representation of actual lunar surface materials
- Visual barriers to prevent external world visibility
- Portable design for easy assembly/disassembly

5.3 Robotic System Requirements

5.3.1 General Specifications

- Quantity: 4 specialized robots
- Control System: Bluetooth-enabled remote control
- Operating Range: 100 meters from the HERA module
- Camera Systems: Standard and infrared options with SD card storage
- Power Requirements: TBD during planning phase

5.3.2 Robot Types and Functions

1. Transportation Robot:
    - Payload capacity: 0.5-1.0 lb
    - Ability to carry 10cm³ cube
    - Mobile platform with a stable base
2. Manipulation Robot:
    - Lifting mechanism/arm
    - Precision placement capabilities
    - Cube transfer functionality

3. Support Robots:

- Specialized functions TBD during planning
- Complementary capabilities to primary units

4. Communication and Control Systems

- Bluetooth control interface compatible with HERA systems
- Video feed storage and transmission capabilities
- Mission control monitoring interface
- Data logging and analysis capabilities

6. Goal for requirements of: Student Prototype Development (2025-2026 School Year)

6.1 Scaled Model Development

- 2ft × 2ft prototype landscape
- Scale factor: 1:4 of the final design
- Integration with the NASA HUNCH program guidelines
- Student team collaboration framework

6.2 Robot Prototype Development

- Arduino-based control systems
- Scaled robot designs
- Testing and validation protocols
- Documentation requirements

6.2 Outline Mission Scenario Testing

- Day/night operation verification
- Communication system validation
- Emergency procedure testing
- User interface evaluation

Requirements Checklist

NASA HERA Lunar Landscape Data Collection Checklist

A. Lunar Surface Specifications

1. Crater Topography Documentation

- [ ] Identify a specific South Pole crater to model (e.g., Shackleton Crater)
- [ ] Calculate the scaling factor from the actual 21km crater to 8ft space
- [ ] Document elevation changes and depth requirements
- [ ] Map out crater-within-crater features
- [ ] Identify key surface landmarks for navigation

2. Surface Material Analysis

- [ ] Document lunar regolith composition requirements
- [ ] List acceptable simulant materials for surface texture
- [ ] Record color variations needed for a realistic appearance
- [ ] Identify materials for creating realistic rock formations
- [ ] Document surface reflectivity requirements

B. Physical Structure Requirements

1. Base Structure

- [ ] Measure exact dimensions (8ft × 8ft)
- [ ] Calculate load-bearing requirements for surface materials
- [ ] Document folding/portability requirements (4ft sections)
- [ ] Specify assembly/disassembly procedure requirements
- [ ] List structural support specifications

2. Visual Barrier System

- [ ] Document minimum barrier height (3ft)
- [ ] Select appropriate curtain material specifications
- [ ] List mounting system requirements
- [ ] Specify light-blocking capabilities
- [ ] Document installation/removal procedures

C. Lighting System Requirements

1. General Lighting

- [ ] Document LED specifications for day/night simulation
- [ ] Calculate power requirements for the lighting system
- [ ] Map lighting placement for minimal shadows
- [ ] Specify control system requirements
- [ ] List backup lighting requirements

2. Special Effects

- [ ] Document shadow simulation requirements
- [ ] Specify lunar day/night cycle timing
- [ ] List emergency lighting requirements
- [ ] Document light intensity requirements
- [ ] Specify color temperature requirements

D. Robot Specifications

1. General Requirements for All Robots

- [ ] Document maximum dimensions for each robot
- [ ] Specify minimum separation distances between robots
- [ ] List camera system requirements
- [ ] Document Bluetooth range requirements (100m max)
- [ ] Specify battery life requirements

2. Individual Robot Requirements

Transport Robot #1

- [ ] Document payload capacity (0.5-1.0 lb)

- [ ] Specify ArduSat carrying mechanism
- [ ] List mobility requirements
- [ ] Document camera positioning
- [ ] Specify wheel system requirements

Manipulation Robot #2

- [ ] Document arm reach requirements
- [ ] Specify lifting mechanism capabilities
- [ ] List precision placement requirements
- [ ] Document sensor requirements
- [ ] Specify control system requirements

Support Robots #3 & #4

- [ ] Document specialized function requirements
- [ ] Specify auxiliary equipment needs
- [ ] List backup capability requirements
- [ ] Document communication requirements
- [ ] Specify sensor package requirements

E. CubeSat - ArduSat Integration

1. Physical Requirements

- [ ] Document exact dimensions (10cm cube)
- [ ] Specify weight requirements (0.5-1.0 lb)
- [ ] List handling procedures
- [ ] Document storage requirements
- [ ] Specify safety protocols

2. Operation Requirements

- [ ] Document loading/unloading procedures
- [ ] Specify transfer protocols between robots
- [ ] List emergency handling procedures
- [ ] Document maintenance requirements
- [ ] Specify testing protocols

F. Control Systems

1. Communication Requirements

- [ ] Document Bluetooth specifications
- [ ] List range testing procedures
- [ ] Specify interference prevention measures
- [ ] Document backup communication systems
- [ ] List security requirements

2. Data Collection

- [ ] Specify camera data storage requirements
    - Colour
    - Black and White
    - IR
- [ ] List sensor data collection needs
- [ ] Document data transmission protocols
- [ ] Specify data backup procedures
- [ ] List analysis requirements

G. Safety and Maintenance

1. Safety Requirements

- [ ] Document operational safety procedures
- [ ] List emergency shutdown protocols
- [ ] Specify maintenance schedules
- [ ] Document inspection requirements
- [ ] List safety equipment needs

2. Maintenance Procedures

- [ ] Document cleaning protocols
- [ ] Specify repair procedures
- [ ] List spare parts requirements
- [ ] Document calibration procedures
- [ ] Specify storage requirements

H. Constraints and Critical Requirements

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- [ ] List of Constraints (Physical, Time, Functionality, etc.)
- [ ] Software
- [ ] Reliability
- [ ] Realism

Special Issues

One of the additions would be a lunar landscape that allows the participants to control robots and potentially place ArduSAT Cube or many on a lunar landscape. The HERANAUTS would retrieve the cubes or robots that are exploring on their behalf remotely while they're in their lodging and lab.

The objective of this phase of the project is to gather the requirements and potential requirements, plus scenarios that the Hera facilitators may be interested in setting up for their participants in the simulation. This project will include the following major components.

1. Testing a single Arduino robot with a Bluetooth remote control and a camera.

2. Define the visual scope that the robots would have that ensures that the product will always remain within the scenario. Specifically, when the robots are moving around, they will not see the outside world. Questions we will have to ask include the impact of the Sun on the facility both from a scenario perspective and from a survivability in the human in the human elements or the outside elements of this project additionally are there concerns about lighting that may take them outside of the scenario and do they have to endure both day and night in a lunar landscape.

3. The initial scenario proposed is for all the robots to work inside a crater and that would be the physical limitations the actual size sounds like it could be 8 ft by 8 ft but actual dimensions must be considered also things like when a robot hits a rock or another small divot in within the crater or comes out of another smaller crater will the camera reflect higher and hit the earth's sky with a visual. Hence, this project has to include potentially a backdrop that will hide the Earth from the view of the HERANAUTS another aspect is once the dimensions and the overall scope of the sandbox has been defined then the cad drawings for the outer frame should be defined Any other requirements such as stones and rocks and positioning of pieces the takeoff zones or placement zones of the robot so that we know that it'll stay within that environment.

4. The final deliverable will be a comprehensive report and drawings of the external aspects. That would be given to the requesters and sent to NASA hunt students so they may work on phase two during the school year.

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A. Project Summary

B. PROBLEM STATEMENT

a. The facilitators of the nassahara projects with the mission starting in January 2026 require more activities for the haranots to test challenges that the astronauts will encounter in space this includes a navigating to multiple locations on the moon and to do this they also need to have they also need to have a facility.
b. That they can drive robots on so therefore we have two objectives to solve haha personally I don't know how you survive with just your tablet but keep up the good work and hope things went well for you today, call me anytime, take care, bye.

C. OBJECTIVES

a. Create an 8 ft by 8 ft collapsible environment that will be used to mimic a small segment of the Moon in the south whole area at shackles Shackles Crater. In addition, we would like robots that could carry a CubeSat into this lunar environment. The features for this Terrain must also include appropriate Boulders, Stones, craters, Etc.
b. In addition we have to have a way of managing some sort of regolith facsimile and have the ability to keep track of all this terrain as we move forward up with setting up different locations and different environments the last issue in the subjective is to try and set up a way to isolate the cameras of the different robots so they do not accidentally see ceilings and walls that would represent the simulation being violated
c. We would like to enclose it and in one of the examples that was done this summer students propose the type of tent as a solution obviously with changing the internals of this tent to make it to comply to the 8 foot by 8 ft collapsible environment so that this whole thing can be stored inside a cabinet in the nassahara facility in Johnson Space Center.

D. Constraints

a. some of the key constraints here include number one the ability to collapse the 8 ft by 8 ft Terrain or lunar landscape in addition to keep track of all the pieces and parts that represent the surface can change locations of things like craters or Hills that might be there along with the smaller Boulders and the stones and potentially put in facilities like some sort of mining/water recovery plants at different locations also have spots where light would be managed if we decide to do night options soon the next mission or two.

b. The other unique part of this is that the haranots will be going from a virtual reality environment to an facilities environment where they're controlling the robots by a computer screens optionally if you had some sort of smart facility in the robots they might be able to do some scanning or other fun AI related smart robot related missions that the heronauts would watch the results or maybe have to do a rescue mission if the AI messes up anyways things to think about they will also I have to carry a Cubesat.

E. Deliverables

a. Summary of deliverables include the lunar moon skate and up to four lunar robots that have different functionality but provide the capability to take a cubesat from the Harris facility and drive it over the lunar landscape which would require the cubesat to be put on top of the robot and also to be removed and placed at the end of their trip all robots will have to have some sort of visual control system and the ability to drive the robot using a laptop or a computer with multiple display screens one of those display screens potentially have to be used for each robot