LUNABOTICS
AT THE FLORIDA SPACE INSTITUTE

UCF Lunabotics 2026 Guidebook
Version 4
May 4, 2026

2026 UCF LUNABOTICS QUALIFIERS GUIDEBOOK CHANGELOG

(***Updated 3/17/26***)

- [Section 3.1 and 5.7] Updated arena layout to show a more representative Excavation Zone
- [Section 4.3.3] Updated wording to more accurately reflect the two deliberate actions that are required to restart operation after an E-STOP is activated
- [Section 4.6.7] Clarified that beacons and fiducial targets may only be implemented in the Starting Zone
- [Section 5.4.6] Clarified wording about new Excavation Zone location and how the Starting Zone is now eligible to be excavated
- [Section 5.4.10] Changed outdated wording. Excavation may now begin once a run starts since the Starting Zone may be excavated
- [Section 7.1.18] Removed outdated wording about how use of arena cameras will accumulate an extra 200kb/s of data use since data/bandwidth measurements will not be performed at UCF. Use of arena cameras still affects construction score (see 5.2.4).
- [Section 7.1.19] Removed specifics about bandwidth measuring techniques as bandwidth measurements will not be performed at UCF

(***Updated 4/13/26***)

- [Section 3.1 and 5.7] Updated arena layout to include the location of the center of the Berm Zone relative to the inside corner of the Starting Zone (consistent with the NASA KSC layout). Removed dimensions referenced from the walls. The intent of the update is to remove the reliance of exact wall dimensions during autonomy (which is not allowed), and to add a known berm location with respect to the Starting Zone (an area where position tracking beacons may be placed).
- [Section 3.2.6] Corrected inconsistent team personnel limits for the Arena and Mission Control Center. Teams are *limited* to a maximum of 4 team members in the arena, and 4 team members in Mission Control.
- [Section 4.4.1] Corrected a typo that incorrectly stated, "the **robot** shall be schematically located between the battery and kill switch…" New wording specifies, "the **power logger** shall be schematically located between the battery and kill switch…"
- [Section 5.6.3] Updated the rule on the use of the walls for autonomy. Walls may be used for localization when sensed naturally, provided that no a priori information about the walls is used.
- [Section 5.6.4] Updated to clarify that teams must prove that their autonomy program does not **inappropriately** use information about the walls of the regolith bin.
- [Section 6.2, General Rules Bullet #2] Corrected typo that stated "Teams must announce the start and **competition**…" to "Teams must announce the start and **completion**…"
- [Section 6.2.2] The phrase "Full Run" was removed from the Dump Automation header. Only a single dump cycle is required for this activity.
- [Section 6.2.3] Updated incorrect scoring example.

(***Updated 5/4/26***)

- [Section 5.2.5] Corrected the point allocation for "Dust Tolerant Design" features.
- [Section 6.2] Updated the Autonomous Operations section to remove outdated wording and make the section consistent with rules in the NASA Guidebook
- [Section 6.26] Updated the Autonomous Scoresheet: added scoring option for Excavation + Travel; updated incorrectly labeled column to "Full Autonomy (One Cycle)".

Note

This guidebook governs the Lunabotics Qualification Challenge at the University of Central Florida. Please see the NASA Lunabotics Guidebook available at https://www.nasa.gov/learning-resources/lunabotics-challenge/ for information on the Lunabotics Challenge deliverables and the finals competition at the Kennedy Space Center.

TABLE OF CONTENTS

Contents

SECTION 1: APPLICATION AND ADMINISTRATION (Entire Competition – UCF and NASA) 7
1.1 Lunabotics Objective 7
1.2 Lunabotics Events 7
Event 2 – University of Central Florida Lunabotics Qualification Challenge 7
Event 3 – NASA's Lunabotics On-Site Challenge 7
1.3 Lunabotics Regulations and Policies 7
1.4 Roles and Responsibilities 8
1.5 Code of Conduct 8
1.6 Appeals 8
1.7 Participant Waiver 8
1.8 Social Media 8
1.9 Media Advisory 8
1.10 Mentor/Protégé Teams 8
1.11 Why the Moon 9
1.12 The Lunabotics Awards 9
1.13 Eligibility 10
1.14 Alignment with National Standards in Engineering and Space 10
1.15 Minority Serving Institutions Program 11
1.16 Applying on the STEM Gateway Website 11
SECTION 2: UCF TECHNICAL 12
2.1 RoboPits 12
2.2 Check-in and Set-up 12
2.3 Transportation 12
2.4 Team Spirit 12
2.5 Safety (robot) and Communication (comm) Inspection 12
2.6 Preparing for the Competition Attempt 12
2.7 Clean-up and Check-out 12
2.8 Stop Work Order (SWO) 13
2.9 Waste Accumulation Protocol 13
2.10 Safety in the RoboPits and UCF Arena (participants and other carbon-based life forms) 13
2.11 Personal Protective Equipment (PPE) 13
2.12 Regolith Simulant – LHS-2E 13
2.13 Respirators 13
2.14 Eye/Face Protection 14
2.15 Hand Protection 14

2.16 Hearing Protection ... 14
2.17 Foot Protection ... 14
2.18 Clothing Allowed ... 14
2.19 Clothing Not Allowed ... 14
2.20 Spectators ... 15
2.21 Personal Protective Equipment (PPE) DONN / DOFF ... 15
2.22 Donning Protocol ... 15
2.23 Doffing Protocol in the UCF Arena After completion of the Robot Run ... 15
SECTION 3: UCF ARENA SPECIFICATIONS AND PROTOCOL ... 15
3.1 UCF Arena Specifications ... 15
3.2 UCF Arena Protocol ... 17
SECTION 4: UCF ROBOTS AND ROBOTIC OPERATIONS ... 18
4.1 Robots ... 18
4.2 Robot Requirements ... 18
4.3 E-STOP Button ... 19
4.4 Power Meters / Data Loggers ... 19
4.5 Battery Protocol and Allowed Materials/Processes ... 20
4.6 Robotic Operations ... 20
SECTION 5: UCF SCORING, CONSTRUCTION, NAVIGATION ... 21
5.1 Scoring ... 21
5.2 Construction Points: ... 21
5.3 Construction Points Calculator ... 22
5.4 Construction Protocol ... 23
5.5 Navigation Protocol ... 24
5.6 Autonomy Rules: ... 25
5.7 Fiducials ... 26
SECTION 6: UCF MISSION CONTROL CENTER AND AUTONOMOUS OPERATIONS ... 27
6.1 Mission Control Center (MCC) ... 27
6.1.1 General Guidelines ... 27
6.1.2 Mission Setup ... 28
6.1.3 Mission Operations ... 28
6.1.4 Mission Anomalies ... 29
6.1.5 Mission Conclusion ... 29
6.2 Autonomous Operations ... 29
6.2.1 Excavation Automation: 75 pts ... 30
6.2.2 Dump Automation: 50 pts ... 30
6.2.3 Travel Automation: 250 pts ... 30
6.2.4 Full Autonomy (One Cycle): 450 pts ... 31
6.2.5 Full Autonomy: 600 pts ... 31

6.2.6 Autonomous Operations Scoring....32
SECTION 7: UCF COMMUNICATIONS....32
7.1 UCF Qualification General Communication System Requirements....32
7.2 UCF General Radio Frequency and Communications Approval (Comm Check)....33
7.3 UCF Comm Rule Qualifications....33
7.4 UCF RoboPits Comm Rules....33
7.5 The UCF Exolith Arena Comm Rules....34
7.6 UCF Communications [Exolith Arena – Mission Control Center (MCC)]....34
SECTION 8: UCF ON-SITE WEEK INFORMATION....34

SECTION 1: APPLICATION AND ADMINISTRATION (Entire Competition – UCF and NASA)

1.1 Lunabotics Objective

The primary objective of Lunabotics is for teams of college students to apply the NASA systems engineering process to design, develop, build, and test a prototype lunar robot. The goal is to construct berm structures that would be useful for blast and ejecta protection during lunar landings and launches, shading lunar housing, cryogenic propellant tank farms, providing radiation protection around a nuclear power plant, and other mission-critical uses.

Lunabotics is a two-semester event that allows selected teams to earn points by successfully completing the STEM Engagement Report, the Presentation and Demonstration (optional), the Systems Engineering Paper, the Proof of Life Video, and developing robots that meet all the challenge criteria.

NASA directly benefits from this competition by annually assessing student designs and data the same way it does for its own, less frequent, prototypes. Encouraging innovation in student designs increases the potential of identifying clever solutions to the many challenges inherent in the Artemis missions. Advances for off-world construction offer new possibilities for the same activities here on Earth, expanding the benefits beyond NASA alone. The skills developed in Lunabotics apply to other high-technology industries that rely on systems engineering principles. These industries will create a workforce posed to lead a new space-based economy and add to the economic strength of our nation.

1.2 Lunabotics Events

This is the gateway to the overall challenge. Applicants will follow the directions listed in “Applying on the STEM Gateway Website.” You will receive an email letting you know the selection status of your application. Those teams selected will continue with the challenge consisting of the following events:

Event 1 – Project Development Challenge:

1. STEM Engagement Report
2. Presentation and Demonstration Slides
3. Systems Engineering Paper
4. Proof of Life Video

Teams failing to submit any of these items will be removed from the challenge.

Event 2 – University of Central Florida Lunabotics Qualification Challenge

1. This event is held at UCF’s Florida Space Institute’s Exolith Lab® in Orlando, Florida from May 12th-17th.
2. Here, the teams will put their designs to the test. The 10 highest-scoring teams from UCF’s Qualification Challenge will be invited to NASA’s On-Site Challenge at the Kennedy Space Center. Teams that do not reach the top 10 will also be invited to this event, but they will not be given the opportunity to run their robots.

Event 3 – NASA’s Lunabotics On-Site Challenge

The 10 highest-scoring teams from the UCF Lunabotics Qualification Challenge will be invited to the Kennedy Space Center (KSC) to compete in the Artemis Arena located in the Astronauts Memorial Foundation’s Center for Space Education Building, from May 19th-21st.

1.3 Lunabotics Regulations and Policies

First, read the NASA Lunabotics Guidebook at (https://www.nasa.gov/learning-resources/lunabotics-challenge/).

Frequently Asked Questions / Ask for Help

1. There will be no response to requests for information already contained in the Guidebook, to change a deadline or a rubric.
2. The team is responsible for monitoring the NASA Lunabotics Website, the UCF Lunabotics Qualifiers Website, and the Lunabotics Slack for notices, updates, feedback requests, and responses to FAQs. The Guidebook and the FAQs shall be read together as one document.

3. The faculty advisor and/or team leads shall submit the FAQs. Email shall use an ".edu" domain address. This applies to the application process and communications with Lunabotics. We can only respond to ".edu" addresses.
4. Provide your school's name, cite the relevant rule/paragraph number, which guidebook you are referencing (NASA or UCF), your inquiry, and send it to lunabotics@ucf.edu. There will be no response to inquiries from any other source.
5. We understand the on-site events may conflict with final exams and /or your commencement ceremony. We can assist with proctoring exams on-site; please don't ask us to change dates or deadlines.

1.4 Roles and Responsibilities

It is the responsibility of the Chief Judge and Project Manager to ensure the integrity of the challenge as to the interpretation and enforcement of the rules and rubrics in the Guidebook. The goal is to apply the content of the Guidebook equally to the participants without passion or prejudice. The Lead Judges are responsible for creating the rules and rubrics and judging the deliverables received from the teams for their events. In matters associated with the overall Lunabotics Challenge, the Chief Judge and Project Manager's decision shall prevail.

1.5 Code of Conduct

Lunabotics is a National Aeronautics and Space Administration (NASA) Artemis Student Challenge and is held in a positive and safe environment. Students and faculty shall conduct themselves with integrity as to the spirit and intent of the rules, rubrics, and regulations. Violation of the intent of a rule is a violation of the rule itself. A team found in violation of the rules and rubrics, exhibiting unprofessional behavior, or not following the directions of the Lunabotics staff may be assessed penalty points or may be disqualified from a competition run or the entire Challenge. The Lunabotics Staff have the authority to act in this manner.

1.6 Appeals

All scoring decisions are final. If an appeal is warranted, the advisor or the student team leader shall submit the appeal in writing for consideration to the Chief Judge / Project Manager within 30 minutes of the posting of score(s) in question. The final decision of the Chief Judge / Project Manager shall prevail.

1.7 Participant Waiver

Each team will receive a waiver packet which must be filled out by all team members and sent to lunabotics@ucf.edu in a single pdf. Separate pdf's from every team member will not be accepted.

1.8 Social Media

Keep up to date on Florida Space Institute activities and announcements on Instagram, Facebook, X, and Linkedin.

1.9 Media Advisory

All participants and visitors to Lunabotics at the Kennedy Space Center or to the Lunabotics Qualification Challenge at the University of Central Florida (UCF) give permission to be photographed /videotaped for potential use in future media products, unconditionally releasing UCF and its representatives from any claims and demands.

1.10 Mentor/Protégé Teams

1. NASA collaborates with space agencies around the globe on many programs, including the International Space Station, Earth observation, and the Artemis missions headed to the Moon and Mars. Building and nurturing an eligible, diverse, and inclusive workforce is imperative to the future success of NASA and to our Nation. Veteran schools are encouraged to mentor and collaborate with first-time schools or schools classified as Minority Serving Institutions (MSIs). This is a means for teams to take advantage of the economies of scale as to costs, resources and overall experience. NASA will make the award to the mentor school. The distribution of work, costs, awards, etc., is an arrangement between the schools. As an example, awards to winning mentor / protégé teams would read as follows: "Grand Lakes University" in collaboration with "Faber College".
2. Decades of research by organizational scientists, psychologists, sociologists, economists, and demographers show that socially diverse groups (that is, those with a diversity of age, race, ethnicity, gender, and sexual orientation) are more innovative than homogeneous groups:

3. MSI Capability Gateway – https://beta.nasa.gov/learning-resources/minority-university-research-educationproject/the-minority-serving-institution-msi-exchange/
4. Scientific American – https://www.scientificamerican.com/article/how-diversity-makes-us-smarter/

1.11 Why the Moon

With NASA's Artemis campaign, we are exploring the Moon for scientific discovery and technological advancement and to learn how to live and work on another world as we prepare for human missions to Mars. We will collaborate with commercial and international partners and establish the first long-term presence on the Moon. NASA will land the first woman and first person of color on the Moon, using innovative technologies to explore more of the lunar surface than ever before. The agency will use what we learn on the Moon to prepare for humanity's next giant leap – sending astronauts to Mars (https://www.nasa.gov/humans-in-space/artemis/#missions).

1.12 The Lunabotics Awards

STEM Engagement Report – (1st - $1,000, 2nd - $500, 3rd - $500) best inspiration to study STEM-related topics in their community to include collaboration with middle school students and present a high number of quality activities to a large and wide range of audiences.

Presentations and Demonstrations – (1st - $2,000, 2nd - $1,000, 3rd - $500) present intent and technical outcome of their design project. Allows the students to develop their public speaking skills.

First Steps Award – Best Presentation by a First-Year Team.

Systems Engineering Paper – (1st - $2,000, 2nd - $1,000, 3rd - $500) best application of the NASA Systems Engineering process used to design, build, test, and evaluate their robot.

Systems Engineering Nova Award for Stellar Systems Engineering by a First Year Team – awarded to the team(s) who perform exceptional systems engineering in their College/University's first year in the Lunabotics Challenge as demonstrated in their systems engineering paper.

Systems Engineering Leaps & Bounds Award - for significant improvement over the previous year(s) in the team's application of systems engineering to develop their robot system.

Lunabotics Innovation Award – ($250) for the best design based on creative construction, innovative technology, and overall architecture.

Lunabotics Efficient Use of Communications Power Award - ($250)

The Caterpillar Autonomy Award – (1st - $2,000, 2nd - $1,250, 3rd - $750, 4th –$500, 5th - $250, 6th - $250) awarded by Caterpillar for successfully completing the activities autonomously.

The Lunabotics Construction Award – (1st - $2,000, 2nd - $1,000, 3rd - $500) awarded to the teams that score the most points during the berm building operations in the Artemis Arena.

The Grand Prize, The Lunabotics Artemis Award – ($5,000) The winning team shall submit the required items, complete all the events, and score the most points, a cumulative of the scores.

The Points:

1. STEM Engagement Report	10 Points
2. Systems Engineering Paper	25 Points
3. Presentations and Demonstrations	25 Points
4. Robotic Construction	25 Points

Note: The awards list is not all-inclusive; some are not awarded every year and are subject to change without notice.

1.13 Eligibility

1. The schools shall:
   Be an accredited Institution.
   Enroll one (1) team per school only.
   Be a post-high school, vocational/technical school, college, university, etc.
   Be in the United States, its Commonwealths, territories, and or possessions.

2. The students shall:
   Be 18 years old at registration.
   Be currently enrolled and in good standing with their school.
   Be from the same school as their team.
   Participate in one team.

3. The Teams shall:
   Have its own working robot(s).
   Have at least two (2) undergraduate students.
   The number of students on the team is at the school's discretion.
   Students who have graduated in the same semester/quarter as this challenge are eligible to be on the team.

4. The Faculty / Advisor (F/A) shall:
   Supervise the team as to the spirit and intent of the Guidebook.
   Cannot be a part of the team
   Be employed by the institution and authorized to represent it.

5. For the on-site event at UCF:
   Each team must be accompanied by an adult advisor age 21 or older who is employed by the registered institution and will remain on-site for the duration of the challenge.

1.14 Alignment with National Standards in Engineering and Space

Lunabotics provides students an opportunity to apply the NASA Systems Engineering process in designing a prototype robot capable of performing the proposed construction operations on a simulated Lunar regolith surface. Encouraging innovation in student designs increases the potential of identifying clever solutions to the many challenges inherent in future Artemis Lunar missions. Students will develop a deeper understanding and enhance their communication, collaboration, inquiry, problem-solving, and flexibility skills, which will benefit them throughout their academic and professional lives.

The skills students develop in Lunabotics apply to other high-technology industries that rely on systems engineering principles. These industries will create a workforce posed to lead a new space-based economy and add to the economic strength of our nation. Lunabotics aligns with the Accreditation Board for Engineering and Technology (ABET) criteria outlined below:

Criteria 3. Student Outcomes: For baccalaureate degree programs, these student outcomes must include, but are not limited to, the following learned capabilities:

1. an ability to select and apply the knowledge, techniques, skills, and modern tools of the discipline to broadly defined engineering technology activities;

2. an ability to select and apply a knowledge of mathematics, science, engineering, and technology to engineering technology problems that require the application of principles and applied procedures or methodologies;

3. an ability to conduct standard tests and measurements; to conduct, analyze, and interpret experiments; and to apply experimental results to improve processes;

4. an ability to design systems, components, or processes for broadly defined engineering technology problems appropriate to program educational objectives;
5. an ability to function effectively as a member or leader on a technical team;
6. an ability to identify, analyze, and solve broadly-defined engineering technology problems;
7. an ability to apply written, oral, and graphical communication in both technical and non-technical environments; and an ability to identify and use appropriate technical literature;
8. an understanding of the need for and an ability to engage in self-directed continuing professional development;
9. an understanding of and a commitment to address professional and ethical responsibilities including a respect for diversity;
10. a knowledge of the impact of engineering technology solutions in a societal and global context; and;
11. a commitment to quality, timeliness, and continuous improvement.

1.15 Minority Serving Institutions Program

For More Information on MSIs, visit the Department of Education Office of Postsecondary Education - Programs.

Veteran schools are encouraged to collaborate with schools classified as Minority Serving Institutions (MSIs). Building and nurturing an eligible, diverse, and inclusive workforce is imperative to the future success of NASA and to our Nation. This is a means for teams to take advantage of the economies of scale as to costs, resources and overall experience. The distribution of work, costs, awards, etc. is an arrangement between the schools. As an example, awards to winning mentor / protégé teams would read as follows: “Grand Lakes University” in collaboration with “Faber College”.

Decades of research by organizational scientists, psychologists, sociologists, economists, and demographers show that socially diverse groups (that is, those with a diversity of age, race, ethnicity, gender, and sexual orientation) are more innovative than homogeneous groups:

Being around people who are different from us makes us more creative, more diligent, and harder working. See Scientific American ”How Diversity Makes Us Smarter” at https://www.scientificamerican.com/article/how-diversitymakes-us-smarter/

1.16 Applying on the STEM Gateway Website

Please see the NASA Lunabotics Guidebook for information on this.

NOTE

The remaining sections of this Guidebook pertain only to the Lunabotics Qualification Challenge at the University of Central Florda. Please see the NASA Lunabotics Guidebook available at https://www.nasa.gov/learning-resources/lunabotics-challenge/ for information on the Lunabotics Challenge deliverables and the finals competition at the Kennedy Space Center.

SECTION 2: UCF TECHNICAL

2.1 RoboPits

The RoboPits this year will be located on the UCF Main Campus, approximately 10 minutes away from the competition arena. Use of the robopits at UCF is limited to assembly and disassembly of rover, and code modifications. Soldering will need to be done in a separate designated location. **Teams may not cut metal, weld, or conduct any other modifications that could create a potentially unsafe environment in the robopit.** Drilling into your rover is permitted. We recommend that your rover is built before you come to the competition! The pit boss has final say on whether an activity is unsafe.

2.2 Check-in and Set-up

1. The Pit Boss will assign your pit, explain the inspection process, signing up for runs, and other protocols. If things get hectic, be professional.
2. Your team will be required to provide two contact phone numbers in case the team needs to be reached at any point during the competition and cannot be found. These numbers will not be shared with anyone and will be deleted at the end of the competition.
3. Your pit measures 8’x10’ with two chairs, one table, and two power outlets. Pits have power strips provided. Do not daisy chain power strips.
4. Each team will keep their team and equipment contained within their assigned pit and keep the walkways/hallways clear and unobstructed.
5. Vacuums are provided and are for shared use by all teams as needed. Return vacuums to the designated area.
6. Notify the Pit Boss about any safety concerns or vacuums that need cleaning.

2.3 Transportation

Teams are responsible for transportation of students and their rover from the Robopit to the Exolith® Lab for their competition run. Further details will come at a later date but expect to move from the pit to the Exolith® Lab at least 90 minutes before your competition run to allow for 10-15 minutes of transportation time and a final inspection.

2.4 Team Spirit

You are responsible for creating your pit identification sign. Be mindful of safety guidelines and keep it fun! Your sign should be under 6 feet tall, and you can use LED light strings. Please note that UCF Fire/Safety may ask you to remove it if it doesn’t comply with their regulations. Get creative with a team cheer or chant and in decorating your team shirts. Use your imagination to make your team stand out

2.5 Safety (robot) and Communication (comm) Inspection

1. The inspection stations will be identified.
2. The robot will have to pass the safety inspection first before moving forward.
3. After the inspection is conducted, no modifications to the rover will be permitted until after the competition attempt.

2.6 Preparing for the Competition Attempt

The teams will be brought to the safety inspection approximately 30-45 minutes before the scheduled transportation time to ensure a smooth flow. Once teams arrive at the Exolith® Lab facility, up to four (4) students will go to the personal protective equipment (PPE) prep area to don the PPE gear they will be wearing in the regolith bin. Following a final inspection, the escort will take the team to the arena, where arena escorts will take over. If the team is not ready or cannot be located, the competition run time will be given to another team that is ready.

2.7 Clean-up and Check-out

The RoboPit is expected to be neat each night, with nothing outside of the pit boundaries. Unplug all items before leaving for the night. Keep the RoboPit and the surrounding area neat and generally clean; use the provided vacuums as necessary. You are encouraged to bring floor coverings/mats to facilitate this cleaning. Each team will leave their RoboPit as they found it. Teams are required to clean their pit and the area around it. Teams will request a RoboPit inspection from the RoboPit Chief prior to departure.

2.8 Stop Work Order (SWO)

Lunabotics staff are authorized to issue an SWO to a team regarding any suspected safety issue. The team will immediately stop all activity. The Faculty Advisor must meet with the Pit Boss to resolve the issue. The SWO will remain in effect until the Pit Boss has ruled on the issue. The Pit Boss decision shall prevail.

2.9 Waste Accumulation Protocol

Teams will comply with Federal and UCF hazardous and controlled waste program requirements. Regulation requires that you coordinate with the RoboPit Chief before disposing of the representative items listed below (specially marked containers will be provided):

Waste Accumulation and Disposal Protocol Batteries (Alkaline, Lithium, Ni-Cd). Spray Paint. Oily wipes/IPA solvent wipes. Spray Foam. Solder Waste. Spray Adhesives. Acetone wipes. WD40. PVC cement – brushes, wipes, and cans. PB Blaster. PVC primer – brushes, wipes, cans. Silicone Spray. Super Glue (cyanoacrylates). Oil Cans. Epoxy Tubes. 3 in 1 oil. Aerosol Cans. Any as required by regulations.

2.10 Safety in the RoboPits and UCF Arena (participants and other carbon-based life forms)

Lunabotics personnel (Pit Boss, Arena Chief, etc.) are authorized to rule on any safety and health issues. You are responsible for using the correct Personal Protective Equipment (PPE) for the situation. Do not wear ties, loose clothing, jewelry, hanging key chains, or similar when near or working on moving or rotating machinery to avoid the potential risk of being drawn into rotating parts. Only break-away lanyards are permitted. Use the right tool for the right job, wear gloves/gauntlets to de-energize robots and equipment as needed, bring jack-stands to support your robot instead of folding chairs, and wire strippers should be utilized instead of knives. etc. Bring your own LED lighting for your pit. Address any safety concerns to the RoboPit Chief immediately.

2.11 Personal Protective Equipment (PPE)

UCF will provide goggles, N-95 masks, bunny suits, rubber gloves and booties for use in the UCF Arena.
The teams are responsible for providing all other OSHA, ANSI, etc., or equivalent required PPE.

2.12 Regolith Simulant – LHS-2E

1. Is a crushed Anorthosite and Basalt aggregate with a natural particle size distribution similar to lunar soil.
2. It is alkaline and may cause skin and eye irritation.
3. If you are allergic to talcum powder, it is a good indication that you may be allergic to the LHS-2E. Participants are required to don Personal Protective Equipment (PPE) before coming into contact with the LHS-2E.
4. LHS-2E contains a small percentage of crystalline silica, which is a respiratory nuisance. Respiratory protection shall be used.
5. All PPE must be ANSI-approved, UL-Listed, CE EN166 rated, AS/NZS certified, or CSA rated, as applicable. The following describes the common PPE that you are required to wear.

2.13 Respirators

1. OSHA1926.1153 – Respirable Crystalline Silica, 29 CFR 1910.1053. Permissible exposure limit (PEL). The employer shall ensure that no employee is exposed to an airborne concentration of respirable crystalline silica in excess of 50 μg/m3, calculated as an 8-hour TWA.
2. The Respiratory Protection standard, paragraph 29 CFR 1910.134(g)(1)(i)(A), states that respirators shall not be worn when facial hair comes between the sealing surface of the facepiece and the face or that interferes with valve function. Facial hair is allowed as long as it does not protrude under the respirator seal or extend far enough to interfere with the device's valve function.
3. OSHA – has not exempted any workers for religious reasons; however, we recognize that if such a situation should arise, there are respiratory protection alternatives, such as loose-fitting hoods or helmets that will accommodate facial hair.
4. OSHA – workers cannot sign a waiver to be exempted from the stated requirements. A release or waiver is not possible for employees. That being said, when a(n) employer is looking to accommodate a religious practice, they may have to explore respiratory protection alternatives like helmets or loose-fitting hoods.

5. Most N95 respirators are manufactured for use in construction and other industrial-type jobs that expose workers to dust and small particles. They are regulated by the National Personal Protective Technology Laboratory (NPPTL) in the National Institute for Occupational Safety and Health (NIOSH), which is part of the Centers for Disease Control and Prevention (CDC). NIOSH-approved N95 Particulate Filtering Facepiece Respirators are required in the UCF Arena.
6. There are very few options, but the best choice would be for the individual to purchase a hooded-powered air purifying respirator (PAPR) – especially if they intend to stay in a career that requires the occasional use of PPE. These items shall be provided by the institutions for their participants if required.

2.14 Eye/Face Protection

1. Protective eyewear must be worn in the individual pits and UCF Arena.
2. It is also a good practice and principle to wear eye protection in the following situations:
   - Any area posted with signs requiring the use of eye protection.
   - When performing any work on the robot.
   - When there is a risk of flying particles or chemical exposure (such as splashes, splatters, and sprays).
   - Several forms of eye/face protection are available to provide protection from related hazards, including safety glasses with side shields, goggles, face shields, and face masks.
   - Safety Glasses and protective eyewear are designed to provide a shield around the entire eye to protect against hazards such as splashes of liquids, burns from steam, compressed air, and flying wood or metal debris. To prevent injury, all individuals in the pit area, the practice field area, and the arena must wear safety glasses or protective eyewear that is ANSI-approved,
   - Reflective lenses are prohibited; your eyes must be clearly visible to others. Accommodations will be made for participants that require tinted safety glasses.
   - Prescription Glasses: If you wear prescription glasses that do not have a marked safety rating, you must wear rated safety goggles over them to achieve adequate protection. If you wear marked safety-rated glasses, you may use ANSI-approved
   - Safety-rated glasses, side shields, and frames can be identified by markings stating the standard that they are rated to (ex. Z87.1).

2.15 Hand Protection

Hand protection protects against heat, electrical, chemical, laceration, and mechanical hazards. Use proper gloves and mechanical tool guards for the application. Selected the correct one to use for each activity.

2.16 Hearing Protection

Provide and use hearing protection devices, such as earplugs, where there are unsafe sound levels.

2.17 Foot Protection

Participants must wear shoes that completely cover the entire foot. Shoes must be substantial and have closed toes and heels to protect against foot injuries, regardless of work location. Flip-flops, sandals, mules, lightweight slippers, etc., are unacceptable when working on or near the robot. Safety shoes or toe guards are appropriate for areas where heavy objects can fall on your foot.

2.18 Clothing Allowed

Shirts/tops that cover the upper torso. Long pants that cover the wearer to the ankle. Completely enclosed shoes that cover the instep of the foot, preferably leather, which can be wiped clean. Baseball caps and other headgear as long as they are kept far enough back on the head so that vision is not impaired and do not interfere with protective eyewear.

2.19 Clothing Not Allowed

Hair must not impede vision or come in contact with the work. Hair must be kept away from the eyes. Long hair must be tied back. Hair longer than 6 inches from the nape of the neck must also be pinned up (use of hair nets or hats is acceptable). Flowing garments and neckwear such as ties and scarves that hang loose. Caps worn low over the eyes so as to impede vision. Cropped shirts, plunging necklines, spaghetti straps, or ripped shirts. Ripped jeans, shorts, capris, or skirts. Loose or flowing tops with wide/bell sleeves, outerwear such as coats or shawls. Sandals, open-toe, open-back, or open weave shoes, and shoes with holes in the top or sides that will expose the skin to regolith or retain regolith.

2.20 Spectators

Should follow the same rules as participants. If substantial close-toed shoes are not available, they may enter the pit area as long as they remain in the pit aisles. Spectators who do not meet the footwear requirement for participants, as described above, are not allowed inside individual team pits or in any locations where robots are being worked on.

2.21 Personal Protective Equipment (PPE) DONN / DOFF

1. Personal protective equipment (PPE) is an important element to help ensure participants are protected from hazards in the work area. The PPE Attendant will ensure that participants are provided with the correct PPE for the task they are performing. The following describes the common PPE that you are required to wear.
2. Participant PPE - includes N-95 Filtering Facepiece, full body protective suits with hood and booties, and nitrile gloves when entering the UCF Arena.
3. Judges/Regolith Assistants PPE - inside the arena during robot operation includes full face Respirator with P100 filters or full-face powered air purifying respirator (PAPR), full body protective suits with hood and booties, rubber boots, and nitrile gloves.

2.22 Donning Protocol

1. Participant

- Select the appropriate size Tyvek coverall suit and put it on over shoes
- Select appropriate gloves and don them, overlapping the Tyvek suit.
- Tape gloves to the Tyvek coveralls overlap to ensure skin is not exposed.
- Tape may also be applied above the ankles and waist to contain excess Tyvek coverall material.
- Place N-95 filtering face piece over nose and mouth. Adjust the nose bridge to obtain a comfortable fit and prevent eye protection fogging.
- NOTE: Without exception, proper use of such masks and/or respirators shall require a clean-shaven face as determined by the Competition Staff.
- Place dust goggles over eyes and cover head with Tyvek suit hood.

2. Judges / Assistants

- Full-face negative pressure respirator with P-100 filters or full-face powered air purifying respirator (PAPR) and cover head with Tyvek suit hood.
- Don rubber boots over Tyvek booties if working in the regolith pit.

2.23 Doffing Protocol in the UCF Arena After completion of the Robot Run

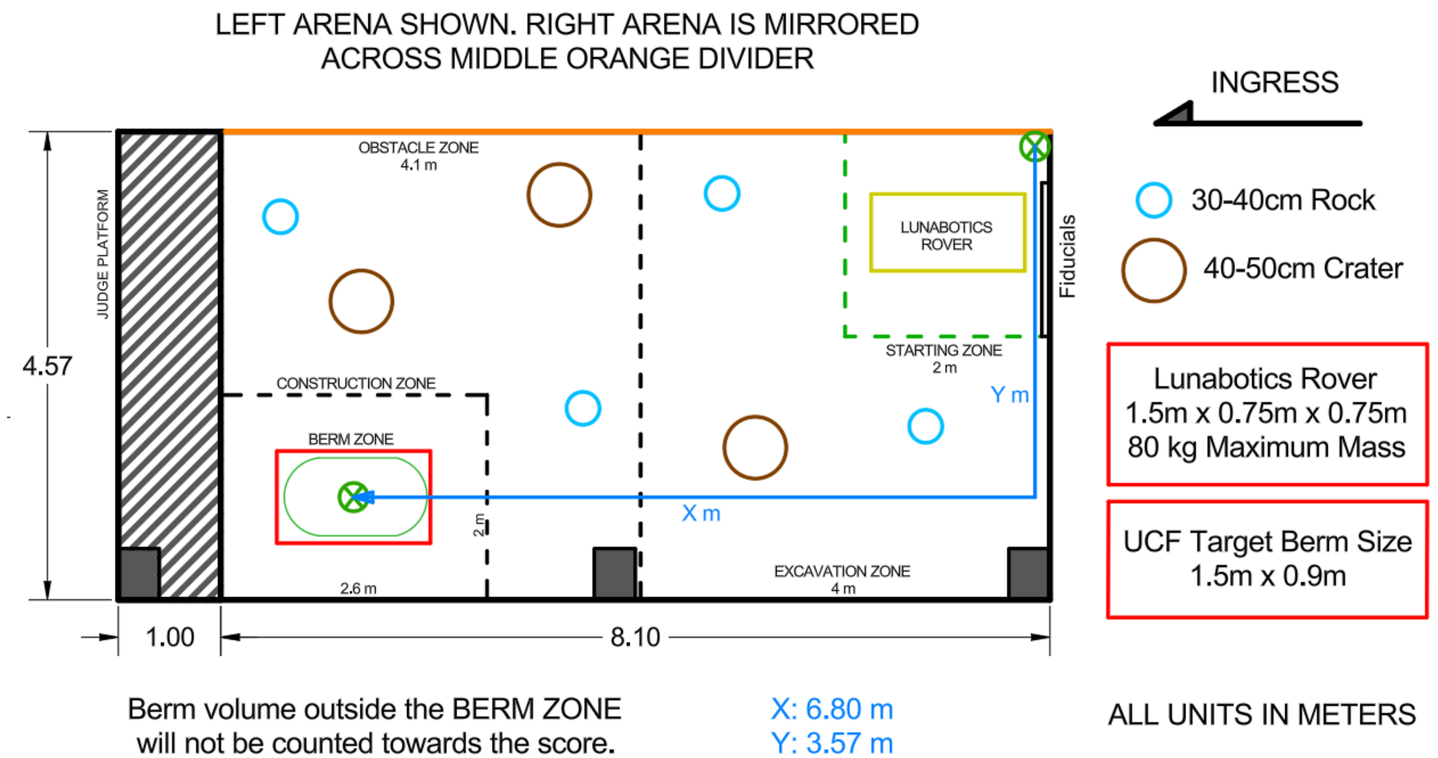
Please keep your Tyvek suit, boot covers, and N95 mask for your 2nd run. We will only be giving out one of each.

SECTION 3: UCF ARENA SPECIFICATIONS AND PROTOCOL

3.1 UCF Arena Specifications

1. The Regolith Bin at UCF is filled with Lunar Highlands Simulant (LHS-2E) from Space Resource Technologies.
2. The arena area measures ~10 m long and ~10m wide.

3. The UCF arena contains ~90 cm depth of LHS-2E.
4. Larger rocks may also be mixed in with the LHS-2E in a random manner.
5. **Obstacle Zone** - the judges will attempt to construct the obstacle field in such a way as to require obstacle detection, mapping, and navigation planning to determine a “slalom” route to reach the excavation zone.
6. **Boulder Obstacles** - there will be at least three (3) obstacles placed on top of the arena surface within the obstacle zone area before each competition attempt is made. The placement of the obstacles will be randomly selected before the start of the competition. Each obstacle may have a diameter of approximately 30 cm to 40 cm and will have random heights. There may be boulders in the excavation zone, these will not exceed the dimensions of any in the obstacle zone.
7. **Crater Obstacles** - there will be at least three (3) craters of varying depth and width, being no wider or deeper than 40 - 50 cm in the obstacle zone.



UCF Arena Layout

Crater and rock locations not representative of final competition placement, which will be random

3.2 UCF Arena Protocol

1. Once competition runs begin, the UCF Arena is considered an operational area with restricted access.
2. Students shall follow the instructions of the Arena Chief and Arena personnel promptly.
3. Faculty / advisors are not permitted in the UCF Arena during the competition.
4. Access is restricted to currently active competing team members only. If the team's robot is not in the arena or arena staging area, team members are not permitted in the UCF Arena.
5. The UCF Arena is defined as all areas surrounding the regolith bin, including the staging area, mission control, and regolith bin deck.
6. For Arena operations, the currently active competing team members are defined as the team members attired in PPE that are tasked with placing the robot in the arena during the setup period and removing the robot from the arena after the run has ended (max of 4 people) and the corresponding Mission Control team members (max of 4 people).
7. Photography and personal electronic devices (smart devices, tablets, cell phones, etc.) will be restricted in the UCF Arena.
8. Team members placing the robot in the Competition Arena will don PPE in the Exolith staging area.
9. When properly attired, they and Mission Control teammates will be escorted to the UCF Arena entrance.
10. The Arena Chief will grant access to UCF Arena staging area when ready.
11. Student cell phones, cameras, tablets, and other restricted electronics devices brought into the UCF Arena shall be placed on the Arena Chief's station to be retrieved later. No exceptions.
12. Team members will be given a Pre-Task Briefing (PTB) containing specific information needed for the run.
13. At the end of the PTB, the Mission Control team members will immediately exit the Arena staging area and proceed directly to the Mission Control staging area.
14. Team members in PPE shall remain with their robot in the designated Arena staging area until directed otherwise by the Arena Chief or designated representative.

15. Approaching the Competition Arena before instructed to do so by the Arena Chief or designated representative is not permitted.
16. The Arena Chief will inform the team members in the staging area when the Competition Arena is ready for the team.
17. At the direction of the Arena personnel, the team members will place their robot in the Arena and perform setup activities necessary to establish communication with Mission Control. The construction robot will be placed in the arena in a randomly selected starting position and direction. Assume there are positive and negative obstacles. Assume you cannot drive over the obstacles.
18. When complete or directed by Arena personnel, the team members will promptly exit the Arena.
19. Only the team members in PPE may observe the competition run from a designated area in the Arena. The team members must remain in the designated area for the duration of the run.
20. Photos may be permitted during this time at the discretion of the Arena Chief. Photos are limited to the construction zone and berm construction. It may be that only the final berm configuration may be photographed. Photos, if permitted, shall be taken by a single designated individual using a single device (i.e. cell phone, tablet, or camera) retrieved from the Arena Chief's station. Any photos taken shall not be shared, posted, or transmitted in any way while the team members are in the UCF Arena. Violation of this rule may result in team disqualification.
21. When the competition run has ended, the team members in PPE shall promptly retrieve their robot and equipment from the Arena and proceed to the HEPA station.
22. At the HEPA station, team members shall:
    1. Vacuum excess LHS-2E from their robot.
    2. Place rover on egress platform to be lowered out of the bin.
23. Remember, the UCF Arena is an operational area during competition days. There are many activities occurring in series and in parallel. It is very important that everyone in the Arena practice situational awareness at all times.

SECTION 4: UCF ROBOTS AND ROBOTIC OPERATIONS

4.1 Robots

1. Lunar bulk regolith construction requires teams to consider several design and operation factors such as high robot dust tolerance and minimizing dust projection, efficient communications, minimizing vehicle mass, minimizing energy/power required, and maximizing autonomy. Each team will have the opportunity to complete two construction competition runs to demonstrate their design.
2. Students on the team shall perform 100% of this project (including design, construction, and task components of their vehicle and deliverables, and including performing or supervising work that is supported by a professional machinist for the purpose of training or safety). Components (i.e. electronic, mechanical, etc.) are not required to be space qualified for atmospheric, electromagnetic, thermal, or Lunar environments.

4.2 Robot Requirements

1. Volumetric dimensions - robot(s) shall be contained within a payload envelope measuring 1.50 m length x 0.75 m width x 0.75 m height. The orientation of these dimensions may be chosen by the team. It may deploy or expand beyond the envelope after the start of each attempt but shall not exceed 1.75 m in additional height (which is 2.5 m above the surface of the regolith). Multiple robot systems are allowed but the starting dimensions of the whole system (all the robots) shall comply with the volumetric dimensions given in this rule.
2. Robots will be inspected for the volumetric dimensions in the stowed configuration during the Safety Inspection. No modifications or team robot interaction is permitted during this verification.
    - Robot Mass - a maximum mass of 80kg. Subsystems/equipment on the robot that are used to transmit commands / data and video to the telerobotic operators are counted toward the mass limit.
    - The mass of the navigational aid system, including any beacons or targets not attached to the robot, is included in the maximum mining robot mass limit and must be self-powered.
3. Equipment not on the robot used to receive data from and send commands to the robot for telerobotic operations is excluded from the mass limit. Multiple robot systems are allowed but the total mass of the whole system shall comply with the mass given in this rule. The commercial cost of delivering payloads to the Moon is about $1.2 Million per kg (estimate). This competition aims to simulate a Lunar mission where a robot is delivered to the Moon. This corresponds to an approximate mission cost of $72 Million. Lower masses will result in lower mission costs so this competition rewards teams that have a lower robot mass.

4. External robot antennas are required to reduce potential interference problems.
5. Robots shall have a minimum of four (4) lifting points, safe for human hands and clearly marked (ISO 7000-1368) for students and staff to use. Teams are responsible for placement and removal of their construction robot onto the regolith surface. There must be one person per 20 kg of mass of the construction robot, requiring a minimum of four people to carry the maximum allowed mass of 80 kg.
6. The robot can separate itself intentionally, if desired, but all parts of the robot must be under the team's control at all times. Unintentional breakage will not be counted against the team. The robot does not have to re-assemble prior to the end of the competition run.
7. The robot can run either by telerobotic (remote control) or in autonomous operations and cannot have any touch sensors to sense and avoid obstacles.
8. Reference Points / Reference Arrows - The launch volume dimensions of the robot may be oriented in any way (length, width, height can be defined along any of the X, Y, Z axes, dimensions correspond to the typical payload volume available on today's Lunar landers).
   - The team must declare the robot orientation by length (arrow 1) and width (arrow 2) to the inspection judge. Reference Point (arrow 3) - must mark the forward direction of the mining robot in the starting position configuration (the reference location and arrow pointing forward can point any direction of the team's choosing, except up or down). The arrow is used only to orientate the robot prior to starting the robot run to face the robot arrow either north, east, south, or west after spinning the direction wheel.
   - The judges will use this reference point and arrow to orient the mining robot in the randomly selected direction and position (you can use a permanent-type marker) indicating the team's choice of forward direction on any location on the robot is acceptable if multiple arrows do not conflict.

4.3 E-STOP Button

1. Also known more formally as an emergency brake, emergency stop (E-stop), emergency off (EMO), kill switch, or emergency power off (EPO), is a safety mechanism used to shut off machinery in an emergency, when it cannot be shut down in the usual manner.
2. OSHA and relevant standards such as IEC 60204-1 state that an e-stop must be readily accessible to the operator. Additionally, it should be unobstructed—no collars or actuation restrictions—and easily accessible without having to reach over, under or around to actuate. Machine-building standards such as ANSI B11, B11-19 and National Fire Protection Agency (NFPA) 79 also address specifics in regard to safety devices such as an e-stop.
3. OSHA and standards such as IEC 60204-1 further state that resetting an E-stop alone shall not resume machine operation. Resetting the E-stop (for example, twisting or pulling the mushroom button) should only restore power and put the machine in a safe state. A second deliberate action, such as pressing a separate start button or sending the robot a start signal, is required to actually resume operation.
4. The robot shall be equipped with an E-STOP button. An unmodified "Commercial Off-The-Shelf" (COTS) red button is required. Use sound engineering practices and principles in placing and securing the E-STOP button on your robot(s), failure to do so may result in a safety disqualification. The E-STOP button shall have a minimum diameter of 40 mm and require no additional steps to access it.
5. The E-STOP button shall be placed on the highest practical location on the robot. There shall be only one E-STOP button per robot and in the case of multiple robots, each robot shall have its own E-STOP button
6. Disabling the E-STOP button without authorization from the Staff shall result in a safety disqualification.
7. The E-STOP button shall stop the construction robot's motion and disable power with one push motion on the button. It shall be reliable and instantaneous. A closed control signal to a mechanical relay is allowed as long as it stays open to disable the robot. This rule exists in order to have the capability to safe the construction robot in the event of a fire or other mishap. The button shall disconnect the batteries from all controllers (high current, forklift type button) and it shall isolate the batteries from the rest of the active sub-systems as well.
8. Only onboard laptop computers may stay powered on if powered by its own, independent, internal computer battery. For example: it is acceptable to have a small battery onboard that only powers a Raspberry Pi control computer, and whose power does not flow through the main robot E-STOP button.

4.4 Power Meters / Data Loggers

1. The robot shall provide its own onboard power. No facility power will be provided to the robot during the attempt. There are no power limitations except that the robot must be self-powered and included in the maximum mass limit.

The power logger shall be schematically located between the battery and kill switch, so the readings are not erased if the E-STOP button is activated. A 30-point reduction to Berm Construction Productivity – Normalized for Energy (BCP Energy) will be accessed if the robot is not wired in accordance with this requirement. This will be checked at Inspection. Also, if a robot is not wired in accordance teams run the risk of scoring zero if the E-STOP has to be triggered.

2. The energy consumed shall be recorded with a “Commercial Off-The-Shelf” (COTS) electronic data logger device. Actual energy consumed during each attempt shall be shown to the judges on the data logger immediately after the attempt (‘immediate’ includes time for the judge climbing into the arena, finding the logger, and recording the power reading). If the logger is independently powered, then the robot can be remotely powered off after the run. Although this is acceptable, it is not recommended in case the robot needs to be commanded to complete an operation so that it can be removed from the arena.

4.5 Battery Protocol and Allowed Materials/Processes

1. Lithium-Ion / Nic-Cad batteries used in robots must be attended while charging. Chargers shall be unplugged overnight.
2. Battery containers must be designed for safely storing, charging, and transporting lithium-ion batteries, or approved equivalent.
3. Batteries must be stored in upright containers; batteries cannot be in contact with each other.
4. Batteries that have been dropped must be inspected for damage and replaced as needed.
5. Do not store batteries that are hot to the touch after charging.
6. If a battery continues to feel hot after charging, if possible, remove from the building and place outside and notify UCF Fire as a non-emergency issue.
7. To ensure the robot is usable for an actual mission, it cannot employ any fundamental physical processes, gases, fluids, or consumables that would not work in an off-world environment. For example, any dust removal from a lens or sensor must employ a physical process that would be suitable for the Lunar surface. Teams may use processes that require an Earth-like environment (e.g., oxygen, water) only if the system using the processes is designed to work in a Lunar environment and if such resources used by the robot are included in the mass of the robot. Closed pneumatic systems are allowed if the gas is supplied by the robot itself. Pneumatic systems are permitted if the gas is supplied by the robot and self-contained.
8. The rules are intended for robots to show an off-world plausible system functionality, but the components do not have to be traceable to an off-world qualified component version. Examples of allowable components are: Sealed Lead-Acid (SLA) or Nickel Metal Hydride (NiMH) batteries; composite materials; rubber or plastic parts; actively fan cooled electronics; motors with brushes; infrared sensors, inertial measurement units, and proximity detectors and/or Hall Effect sensors, but proceed at your own risk since LHS-2E & BP-1 regolith simulant is very dusty and abrasive.
9. Teams may use honeycomb structures as long as they are strong enough to be safe and the edges sealed to prevent dust intrusion, a wheel with a large honeycomb structures that is open on both sides is allowed as long as the edges are not so sharp that they would be a cutting hazard.
10. Teams may not use GPS, rubber pneumatic tires; air/foam filled tires; open or closed cell foam, ultrasonic proximity sensors; or hydraulics because NASA does not anticipate the use of these on an off-world mission. This will not pass inspection.

4.6 Robotic Operations

1. The robot cannot be anchored to the sand prior to the beginning of the proof of life demonstration.
2. At the start of the competition run, the mining robot may not occupy any location outside the defined starting position in the regolith arena.
3. The robot must operate within the regolith arena; it is not permitted to pass beyond the confines of the outside perimeter of the arena or hit the walls during the competition run.
4. The robot may not use any process that causes the physical or chemical properties of the regolith simulant to be changed or otherwise endangers the uniformity between competition attempts. The mining robot may not penetrate the regolith simulant surface with more force than the weight of the mining robot before the start of each competition attempt.

5. No ordnance, projectile, far-reaching mechanism, etc. may be used. The mining robot must move on the regolith simulant surface.
6. Far-reaching mechanism in this context does not include any deployed or extended component as allowed in the dimensions rule above, those will not violate this rule.
7. Beacons or fiducial targets may be implemented only in the starting zone, and for navigational purposes only. They may be attached to the designated 80/20 fiducial bar or anywhere in the regolith within the starting zone and must be completely contained within the starting zone. Tape, clamps, or rods pushed into the regolith may be used, but screws or other fasteners requiring holes may not be used. This navigational aid system must be attached during the setup time and removed afterwards during the removal time.
8. The beacon may send a signal or light beam or use a laser-based detection system which have not been modified (optics or power). Only Class I or Class II laser or low powered lasers (< 5mW) are allowed. Supporting documentation from the laser instrumentation vendor must be provided to the responsible faculty member for “eye-safe” lasers.

SECTION 5: UCF SCORING, CONSTRUCTION, NAVIGATION

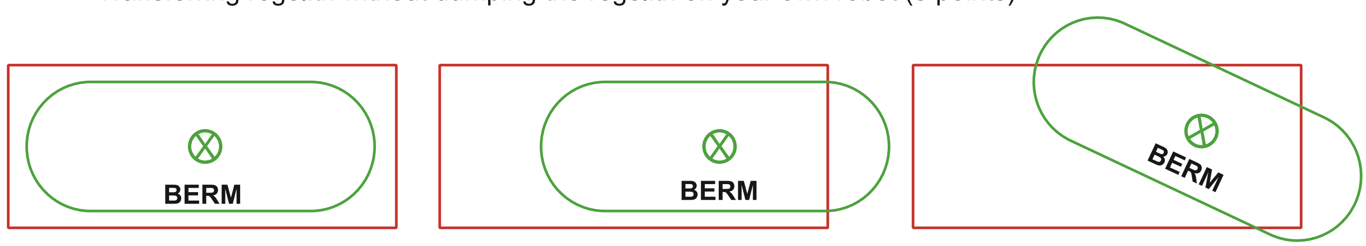
5.1 Scoring

1. UCF & KSC – The berm construction scores from each run will be added together for the final store (final score will be cumulative, not the highest of the two attempts, not an average of the two attempts).
2. KSC Only – The teams with the first, second, and third most construction points will receive up to 25, 20, and 15 points, respectively towards the grand prize. Teams not winning first, second, or third place in the construction category can still earn one bonus point towards the grand prize for every 0.2 cubic meters of berm constructed up to a maximum of ten points.

5.2 Construction Points:

1. **Pass All Inspections (Comm/Vehicle) -** each team is required to perform a mechanical inspection and communications check prior to the first competition run. This should be performed as early as possible after check-in to ensure compliance to all rules and communication functionality. Neither is optional, if one cannot pass, the robot will not be permitted in the Arena.
2. **Construction Berm Productivity – Normalized for Robot Mass (BP Mass) –**
A volumetric scan before and after the run will be performed. Only the berm volume within the target berm location will be counted. The team will earn construction points for each cubic cm of berm constructed above grade per minute per each kg of the robot’s mass. Only the portions of the constructed berm within the target area for berm placement will be counted. The target area has perimeter dimensions of 1.5 M x 0.9 M. There is no restriction on the shape, height, or number of berms constructed.
3. **Construction Berm Productivity – Normalized for Energy (BP Energy) -** A volumetric scan before and after the run will be performed. Only the berm volume within the target berm location will be counted. The team will earn construction points for each cubic cm of berm constructed above grade per minute per each w*hr of energy consumed. The electrical energy consumed must be displayed by an (commercial off the shelf or “COTS”) electronic data logger and verified by a judge.
4. **Camera bandwidth Use -** During each competition attempt, the team will be scored on arena camera usage as follows: 0 cameras = 120, 1 camera = 60, 2 cameras = 0 points.
5. **Dust Tolerant Design -** During each competition attempt a team can earn up to 30 points for dust tolerant design features on the construction robot. Teams are encouraged to point out dust tolerant and dust free features to the judges during inspection and setup. The judges will allocate these points based on an inspection and performance during the competition run. The points for dust-tolerant design are as follows:
   - Drive train and components enclosed/protected: 15 points
   - Active dust control (brushing, electrostatics, etc.): 5 points
   - Custom dust sealing features (bellows, seals, etc.): 10 points

6. **Dust Free Operation -** During each competition attempt, a team can earn up to 30 points for dust free operation. The judges will allocate these points based on actual performance during the attempts. If the construction robot has exposed mechanisms where dust could accumulate during a lunar mission and degrade the performance or lifetime of the mechanisms, then fewer Construction points will be earned in this category. If the construction robot raises a substantial amount of airborne dust or projects it due to its operations, fewer construction points will be earned in this category. Ideally, the construction robot will operate in a clean manner without dust projection, and all mechanisms and moving parts will be protected from dust intrusion. All decisions by the judges regarding dust tolerance and dust projection are final. The points for dust-free operation are as follows:
    - Driving without dusting up regolith (5 points)
    - Digging without dusting up regolith (20 points)
    - Transferring regolith without dumping the regolith on your own robot (5 points)



	KSC	UCF
Berm Size	2.0m x 0.7m	1.3m x 0.7m
Target Berm Area	2.2m x 0.9m	1.5m x 0.9m

Artemis/UCF Arena Layout 2 - Berm Positioning

(Note 1: only the green actual berm volume inside the red box will count towards the berm volume measurement)

5.3 Construction Points Calculator

Example actuals based on a 30-minute run at KSC (UCF runs are based on 15-minute runs).

Construction Points Calculator – UCF Arena

Construction Category Elements	Units	Specific Points	Example Actuals	Example Points
1. ***Pass All Inspections (Comm/Vehicle)***.	Pass = Run / 0=Default		1	**Allowed to Run**

2. ***Berm Construction Productivity – Normalized for Robot Mass (BCP Mass)*** – A volumetric scan before and after the run will be performed. Only the berm volume within the target berm location will be counted. The team will earn construction points for each cubic cm of berm constructed above grade per minute per each kg of the robot's mass.	cm^3 berm / min / kg robot mass	4.4	77551 cm^3 / 15 min run / 66 kg **78.33**	**344.6**
3. ***Berm Construction Productivity – Normalized for Energy (BCP Energy)*** - A volumetric scan before and after the run will be performed. Only the berm volume within the target berm location will be counted. The team will earn construction points for each cubic cm of berm constructed above grade per each w*hr of energy consumed. The electrical energy consumed must be displayed by an (commercial off the shelf or "COTS") electronic data logger and verified by a judge. **NOTE: A 30-point penalty will be accessed if your robot energy data logger is not wired in accordance to ROBOTS AND ROBOTIC OPERATIONS section 4**	cm^3 berm / min /watthour	1.5	77551 cm^3 / 15 min run / 36 whr **143.6**	**215.4**
4. ***Camera Bandwidth Use*** – During each competition attempt, the team will be scored on camera usage as follows: 0 cameras = 120, 1 camera = 60, 2 cameras = 0 points.	# cameras	120, 60, 0	1	**60**
5. ***Dust Tolerant Design*** – see description			30	**30**
6. ***Dust Free Operation*** – see description			25	**25**
7. ***Autonomy*** – See Construction Points – Autonomy	task	50, 75, 125, 250, 300, 375, 450, or 600	75	**75**
8. ***Total Points***				**750**

5.4 Construction Protocol

1. The robot will be inspected before each competition attempt. Teams will be permitted to repair or otherwise modify their robots while the RoboPits are open.
2. Teams are responsible for the placement and removal of their robot onto the arena surface. There shall be one person per 20 kg of mass of the robot, requiring a minimum of four people to carry the maximum allowed mass of 80 kg. Assistance will be provided if needed.
3. Each team is allowed **up to** 10 minutes to place the construction robot in its designated starting position within the arena and perform required setups from MCC, and 5 minutes to remove the robot after the attempt has ended as directed by the Construction Judges.
4. The robot's starting direction and location will be randomly selected immediately before the competition attempt.

5. At the start of each competition attempt, the robot shall not occupy any location outside the defined starting position in the arena.

6. The robot shall start in the starting zone, excavate from anywhere within the excavation zone (including the starting zone), move across the obstacle zone, and dump collected material in the construction zone. The robot shall not acquire regolith simulant for the berm from inside the obstacle zone, or construction zone. All regolith simulants for berm construction must be acquired from the excavation or starting zone.

7. The robot shall not push or move any obstacles in the obstacle zone.

8. The obstacles may only be pushed to the side of the arena in the construction zone.

9. The robot shall avoid the craters in the obstacle zone (it shall not fill in any craters).

10. The robot may start excavation operations as soon as a run begins, since the excavation zone includes the starting zone.

11. The robot may start construction operations as soon as any part of it crosses into the construction zone.

12. The robot shall operate within the arena; no part of it is permitted to pass beyond the confines of the outside wall of the arena during each competition attempt.

13. The robot can separate itself intentionally if desired, but all parts of the construction robot must be under the team's control at all times. The robot does not have to re-assemble prior to the end of the competition run.

14. The robot **shall not**:
    - be anchored to the arena surface prior to the beginning of each competition attempt.
    - ram the wall (may result in a safety disqualification for that attempt).
    - use any aspect of the arena (wall, structure, column, etc.) in attempting any operations.
    - use any process that causes the physical or chemical properties of the regolith simulant to be changed or otherwise compromises the uniformity between attempts.

15. Bulldozing (i.e. pushing a pile of dirt/rocks) with a bladed dozer-type of rover is considered an acceptable excavation and regolith simulant transfer technique for the Lunabotics challenge. In this case, the robot would push material from the excavation zone into the berm area to create the berm. All regolith simulant material must be pushed in a pile from the excavation zone into and through the construction zone to the berm. Regolith simulant may be skimmed from the construction zone, but only if it is part of the operation of pushing it from the excavation zone into the berm (it may not be intentionally collected in the construction zone). The bulldozing pushing operation shall not start inside the construction zone – each bulldozing attempt shall start in the excavation zone.

16. Obstacles that are moved from the excavation zone into the target area will count towards these dimensions. **NOTE: If a rover drives over or compacts a berm that has been dumped, it is likely that the volume will be negatively affected, thus decreasing a team's score for that run. Additionally, any material placed outside of the target berm zone will not be counted.**

17. The robot shall end operations immediately when the power-off command is sent and/or as instructed by the Construction Judge. After the official competition run ends, the regolith judge will determine if the robot needs to move prior to being removed. The judge will instruct the team members when they can enter to remove the robot after ensuring that the lidar scan of the berm has been completed.

5.5 Navigation Protocol

1. The team must declare the robot orientation by length and width to the inspection judge. An arrow on the reference point (the reference location and arrow pointing forward can be any point and direction of the team's choosing, except up) must mark the forward direction of the construction robot in the starting position configuration. The judges will use this reference point and arrow to orient the construction robot in the randomly selected direction

and position (you can use a permanent-type marker), indicating the team's choice of forward direction on any location on the robot is acceptable as long as multiple arrows do not conflict. The arrow does not have to indicate the robot's preferred forward direction. The arrow is used only to orientate the robot prior to starting the robot run to face the robot arrow either north, east, south, or west after spinning the direction wheel.

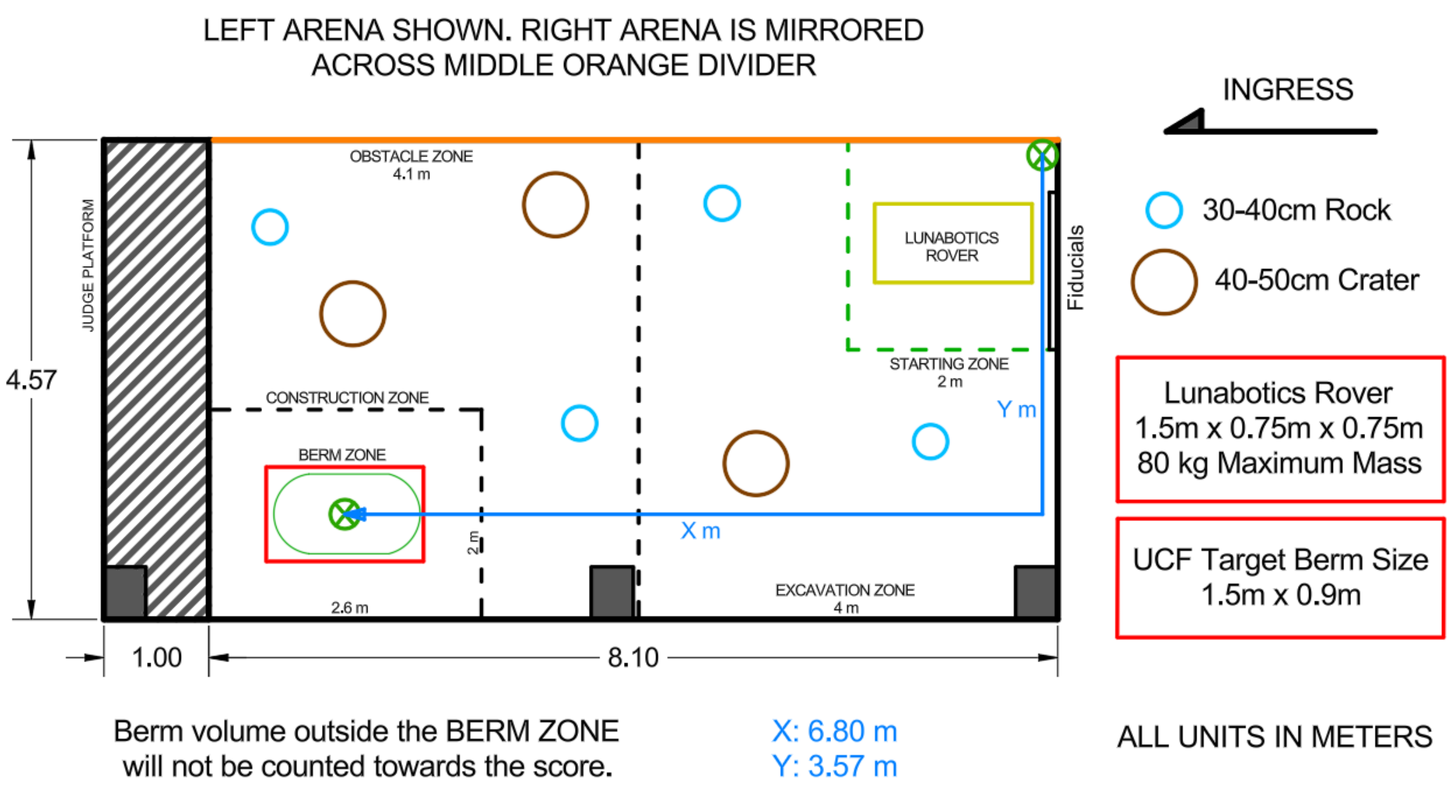
2. Compasses (analog, digital, etc.) are not allowed on the robot.
3. Global Positioning Satellite (GPS) or IMU-enabled GPS devices are not allowed. Teams must explain to the judges how the device will be switched off or the data will be subtracted and ensure the internal calculations do not make use of the GPS or IMU-enabled GPS device.
4. The mass of the navigational aid system is included in the maximum construction robot mass limit of 80.0 kg and must be self-powered.
5. Target Beacons – beacons may be attached to the provided mounting system in the starting area. The beacons may be mounted on rods pushed into the regolith at the starting area for anchoring.
6. The target/beacon may be a passive fiducial, or it may send a signal or light beam or use a laser-based detection system which has not been modified (optics or power). Only Class I or Class II lasers or low-powered lasers (< 5mW) are allowed. Supporting documentation from the laser instrumentation vendor must be provided to the inspection judges for "eye-safe" lasers.
7. Inertial measurement units (IMU) are allowed on the construction robot. Teams have to explain to the judges how the compass feature will be switched off, or the compass data is subtracted to ensure the internal calculations do not make use of the compass (from any magnetic field surrounding the robot).
8. During each competition attempt, the construction robot is limited to autonomous and telerobotic operations only.

5.6 Autonomy Rules:

1. Telemetry to monitor the health of the construction robot is allowed during the autonomous period. Teams will need to remain "hands free" during any attempts at autonomy points. Teams shall explain to the inspection/ attending judge before each competition run how they are interacting with the telemetry system, and the judge will observe to ensure compliance with all competition rules.
2. Teams shall not touch the controls during the autonomous period. Orientation data cannot be transmitted to the construction robot in the autonomous period. See complete details in the Mission Control Center (MCC) and Autonomous Operations.
3. Teams are expected to perceive the arena walls as obstacles and prevent collisions. The walls, when detected, can be used as features for localization as long as no a priori information about the walls (e.g., known dimensions and location relative to the operational area of the arena) is used. In addition, a simple tracking offset cannot be used. For example, following the wall 0.5m away to traverse from one end of the arena to the other would not be allowed. Touching or having a switch sensor spring wire that may brush on a wall or any other surface as a collision avoidance sensor is not allowed (this includes touch sensors).
4. The team must explain to the autonomy review judges how their autonomous systems work and prove that their autonomy program does not inappropriately use information about the walls. Integrity is expected of all team members and their faculty advisors.
5. Teams are allowed to interact with an interface that allows different pieces of telemetry data to be viewed as long as there is no real-time or other interaction to control or influence the robot.
6. Teams are not permitted to update or alter the autonomy program to account/detect or upload information about obstacle locations.
7. Failure to divulge the method of autonomy sensing shall result in disqualification from the competition.

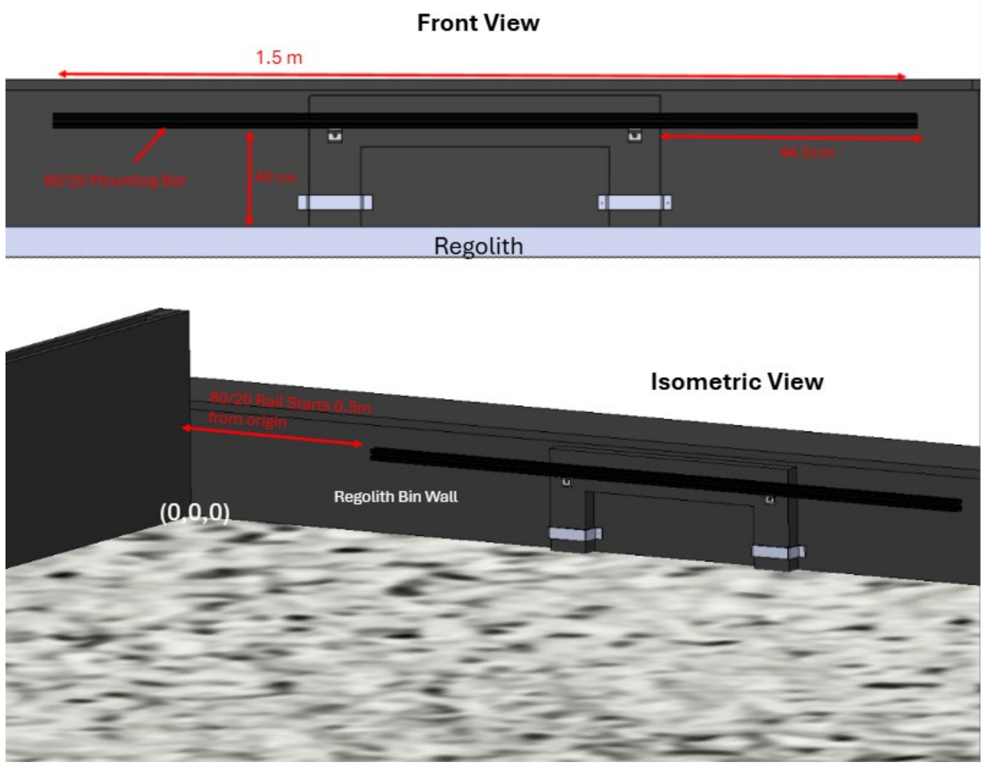
5.7 Fiducials

Navigation beacons can be mounted using the 1.00” x 1.00” 80/20 secured to the front surface of the regolith bin perimeter wall. The 80/20 will be mounted at a height approximately 40 cm (+/- 2.5cm) above the regolith surface. The origin point is the intersection where the barrier separating the two arenas meets the regolith bin perimeter wall (labeled INGRESS). The fiducial mounting rail will be 0.5 meters from the origin and will extend an additional 1.5 meters.



UCF Arena Layout

Crater and rock locations not representative of final competition placement, which will be random



The 80/20 will be matte black to avoid reflections that might impact various navigational systems. The part number is 1010-Black representing the 1.00” X 1.00” T-Slotted profile with 4 open T-slots. The T-slots on the top, front, and bottom of the 80/20 should be available for mounting over the full length of the bar. *The T-slots on the back of the bar are not accessible as there is not enough space to fit anything in between the bar and regolith bin wall.*

SECTION 6: UCF MISSION CONTROL CENTER AND AUTONOMOUS OPERATIONS

6.1 Mission Control Center (MCC)

Teams will control or autonomously operate their robot from the MCC to simulate operations of a Lunar In-Situ Resource Utilization (ISRU) construction mission. Lunabotics Mission Control Judges (MCJs) will supervise team activities in the MCC and assess their performance during each competition run. A Mission Control Director (MCD) will serve as the Lead Judge for the MCC to maintain the integrity of the MCC rules in the Lunabotics guidebook and ensure they are interpreted and enforced equally for all teams.

6.1.1 General Guidelines

1. Each team will be allowed a maximum of 4 team members in the MCC. All members must enter the MCC together when authorized by the MCJ.
2. Faculty/Advisors are not permitted in the MCC at any time.
3. Teams are responsible for ensuring they enter the MCC with all mission-critical components and spares they require that are not explicitly identified in the rules and rubrics as provided by Lunabotics. Once in the MCC, team members will not be permitted to retrieve forgotten items.
4. Teams may only bring electronic devices required for robot operations into the MCC. Extraneous laptops, cell phones, smart devices, etc., are prohibited.

5. Teams that have entered the MCC are not allowed any external communications until the completion of their run. The one exception is communication with their UCF Arena teammates during the setup period, which is only permitted using equipment provided by Lunabotics.
6. Teams must resolve all questions and rule clarifications pertinent to a competition run before entering the MCC for that run. The competition schedule will not be delayed accommodating last-minute requests of this nature.
7. MCJs are observers only and are not allowed to provide “help” during robot operations. Mid-run questions, such as whether the robot is in an acceptable position or if certain points have been attained, will not be answered.
8. The Mission Control and Arena judges have the authority to terminate a setup period or competition run at any time if the team is not using them in accordance with the rules and rubrics.
9. Teams are expected to conduct themselves in a professional manner as if executing a NASA operation.
10. Teams are expected to use sound engineering practices and principles to operate their robot.
11. Team members must comply with all directions from the MCJ.
12. Disputes with MCJ direction or decisions must be elevated through the MCD.
13. Violation of the intent of a rule is a violation of the rule itself. A team found in violation of the rules and rubrics, exhibiting unprofessional behavior or unsportsmanlike conduct, or not following the directions of the Lunabotics staff may be assessed penalty points, disqualified from a competition run, or disqualified from the entire Lunabotics Challenge.

6.1.2 **Mission Setup**

1. Teams may not connect or interact with any equipment in the MCC until the setup period begins.
2. The setup period is for placing the robot in the UCF Arena and bringing it online for the competition run. Teams are allowed up to 10 minutes to connect their laptops and routers, establish communications with their robot, and perform any initial systems checkout required. Teams must indicate competition readiness to the MCJ as soon as their robot is ready.
3. During the setup period, the MCJ will provide the team with a handheld radio to enable communications with team members in the UCF Arena. This radio will be returned to the MCJ at the end of the setup period and may not be used during the competition run.
4. Arena team members are prohibited from pointing out obstacles, craters, and other arena conditions to the MCC team members.
5. Teams may use the arena situational awareness cameras during the setup period without penalty.

6.1.3 **Mission Operations**

1. Teams are allowed 15 minutes per competition run under nominal conditions.
2. Telerobotic operators will have access to two situational awareness cameras in the construction area in the UCF Arena via monitors provided in the MCC. The use of these cameras will result in a point deduction. The MCC monitors provided for situational awareness may not be utilized by the team for any other purpose.
3. Telerobotic operators are only allowed to use data and video originating from the robot and the competition video monitors.
4. It is the sole responsibility of team members in the MCC to communicate effectively with the MCJ to ensure every autonomy attempt is recognized and scored correctly. If the judge Is not notified of the attempt in advance of the team initiating its execution, the score will be zero points. Teams should:
   - Clearly announce and make eye contact with the MCJ when they are going to autonomous operations.
   - Clearly announce when autonomy has begun and has been completed each time they trigger an autonomy cycle.
5. All autonomy attempts must be “Hands-Free”, meaning no team members are permitted to touch any components (e.g., laptops, game controllers) brought into the MCC until the team has declared autonomy completion or autonomy failure.
   - If a team member interacts with any equipment while the robot is still moving or before the team has declared the autonomy attempt complete, the team will receive zero points for the attempt.
   - In the event of an autonomy failure, the team shall announce that the attempt has failed before resuming manual control.
   - Manipulation of the NASA situational awareness cameras, if in use, is permitted during autonomy attempts.

6.1.4 **Mission Anomalies**

1. Once the competition timer has started, the robot has 5 minutes to move on the mission. If the robot has not moved by the 5-minute mark, the robot is considered inoperable, and the run will end.
2. As responsible engineers, the team should notify the MCJ that they are ending the run if their robot experiences an unrecoverable issue that renders it incapable of executing key mission tasks. Such failures include:
   - Loss of Comm: The robot is functional but can no longer communicate properly with the MCC.
   - Loss of Locomotion: The robot ceases movement or experiences infrequent, non-continuous movements for a period of 5 minutes.
   - Loss of Excavation: The robot can no longer acquire regolith per its design.
   - Loss of Deposition: The robot can no longer offload regolith per its design.
   - Loss of Robot: The robot is fully unable to execute the mission. This scenario could be due to technical issues or unfavorable interactions with the competition arena.
3. In the event a robot experiences a mission-ending anomaly and the team does not voluntarily end the run within a reasonable amount of time, Mission Control and UCF Arena judges have the authority to terminate the attempt. “Reasonable” is at the judge’s discretion based on the specific circumstances of the run. Teams “joyriding” or otherwise wasting competition time may be assessed penalty points.
4. It is the team’s responsibility to ensure they are executing corrective actions efficiently and communicating properly with the MCJ about long cycle steps, such as full system resets, that will make the robot appear further inoperable. Failure to do so could result in the termination of the run.

6.1.5 **Mission Conclusion**

1. Teams must cease operations when the competition timer ends. If the robot is in the middle of an autonomous activity, teams must send a command to inhibit their robot from taking any further actions. Regolith offloading is permitted to be completed if the robot was actively dumping material prior to the expiration of the competition timer. If the rover is loaded with regolith and not in the berm zone, it may be necessary to active it once more to unload the regolith prior to egress.
2. Teams may not disconnect communications with their robot or begin dismantling their MCC equipment until directed to do so by the MCJ. Sustained operability is necessary in the event the robot must relocate or unload regolith prior to its removal from the UCF arena.
3. Teams should remain in the MCC until dismissed by the MCJ.
4. Teams are responsible for ensuring they leave the MCC with all equipment they brought into it. Once the next team has entered the MCC, forgotten items cannot be retrieved until that team’s run is complete.

6.2 Autonomous Operations

During each competition attempt, the team will earn up to 600 Construction points for autonomous operation. As Mission Control Judges (MCJ) are not intimately familiar with each robot’s concept of operations (ConOps) procedures, it is the sole responsibility of the team members in the control room to coordinate with and inform the MCJ of each attempt for autonomy points to make sure their autonomous attempts are recognized and therefore scored correctly. The Caterpillar Autonomy Award will be based on the sum of autonomy scores from both UCF runs and runs at KSC. This means that teams that do not make the top 10 and move to KSC may still be eligible for the Caterpillar Autonomy Awards. A tie in autonomy points relative to the Caterpillar Autonomy Award will be broken based on the total berm construction from UCF and KSC.

General Rules:

- For clarity, hands-free means that all team members in mission control must be hands-free and not engage any components (e.g. laptops, game controllers, etc.). The team may control the arena camera/s during this time.
- Teams must announce the start and completion of every autonomy point attempt.
- If your autonomy attempt has failed, you must announce your failure before you begin manual control.

Construction points will be awarded for successfully completing the following activities autonomously:

6.2.1 **Excavation Automation:** 75 pts

1. The Excavation Zone now overlaps with the Starting Zone. Teams may excavate material anywhere in the Excavation or Starting Zone.
2. Within the Excavation zone, the team must indicate to the MCJ that they are going hands-free for the excavation attempt.
3. The robot must execute machine control commands itself during the excavation task.
4. The robot must demonstrate the ability to excavate and collect for regolith for transport. A discernable amount of regolith must be collected for transport as determined by the MCJ. The MCJ may engage the arena judges for confirmation if camera angle/performance does not allow confirmation in Mission Control. Collection can be in an internal hopper, a bucket, a blade, a bucket drum, etc – based on the robot design. Hands-free operation must begin before the robot engages the regolith to begin the excavation process.
5. Excavation mechanisms must be completely removed from contact with the regolith before returning to remote control operation.
6. Once excavation is complete the team must indicate they are going to remote control before taking control of their robot.
7. This level of automation will require teams to master the lower-level machine control of their robot platform associated with excavation. It is noted that past teams have proven this capability to be helpful in achieving better excavation results, as the coordination of human commands for the robot for excavation can be difficult to master

6.2.2 Dump Automation: 50 pts

1. Teams are allowed to traverse the Obstacle Zone via remote control.
2. Prior to crossing into the Construction zone, they must indicate to the MCJ that they are going hands-free for the dump attempt.
3. The robot must execute machine control commands itself during the dump task.
4. The robot must place the regolith at the berm construction location. A discernable amount of regolith must be placed at the berm location as determined by the MCJ. The MCJ may engage the arena judges for confirmation if camera angle/performance does not allow confirmation in Mission Control.
5. Once dumping is complete the team must indicate they are going to remote control before taking control of their robot.
6. This level of automation will require teams to master the lower-level machine control of their robot platform associated with dumping. In addition, teams will need to master localization in the construction zone as well as path planning to align and place regolith at the designated berm construction location.

6.2.3 Travel Automation: 250 pts

Teams must indicate to the MCJ that they are going into hands-free mode while still in the excavation zone. The robot must remain in hands-free mode while crossing the obstacle field into the construction zone. This level of automation will require the team to master the following:

1. Localization across the entire competition arena.
2. Object detection and location relative to the robot.
3. Navigational planning based on location and obstacles/traversable area.
4. The competition judges will attempt to construct the obstacle field in such a way as to require obstacle detection, mapping, and navigation planning to determine a “slalom” route to reach the construction zone. The teams shall not architect a “Point and traverse” approach for this automation step.
5. If the robot contacts a rock or drives across a crater in the obstacle zone, as determined by the MCJ/Arena judges, a 30-point reduction will be applied. This is a one-time penalty.
6. For maximum points, the attempt must be made at the start of the run on the first time leaving the excavation zone. In order to discourage the approach of “breadcrumbs”, a penalty of 50 points will be

applied to any attempt that occurs after traversing the obstacle zone in remote control. If multiple attempts are made, this penalty will only be assessed one time to the successful attempt.

- Example: Robot crosses the obstacle course in remote control before the attempt, hits an obstacle, and drives across a crater during the attempt. 250 points – 50 – 30= 170 points.

6.2.4 <u>Full Autonomy (One Cycle):</u> 450 pts

1. The robot must be in hands free control for one entire cycle.
2. Attempt must be made at the beginning of the competition run.
3. Teams may begin in remote control and move the robot within the starting zone only to localize. Teams must begin with hands free control from the starting area and remain in hands free mode while excavating, crossing the obstacle field, crossing into the construction zone, dumping the regolith for the berm, and crossing the obstacle field and returning to the excavation zone. Once successfully crossing into the excavation zone the team may return to remote control. A discernable amount of regolith must be placed at the berm location as determined by the MCJ.
4. If the robot comes in contact with a rock or drives across a crater, as determined by the MCJ/Arena judges, a 30-point reduction will be applied up to a maximum of 90 points. This is only true in the obstacle zone. The robot is allowed to move rocks and fill in craters in the excavation zone.
5. This level requires mastery of all aspects of autonomy associated with this competition.
   - Example: Robot hits an obstacle and drives across a crater during the attempt. 450 points – 30-30 = 390 points.

6.2.5 <u>Full Autonomy:</u> 600 pts

1. The attempt must be made from the beginning of the competition run.

2. The robot must be in hands free control for the entire competition run.

3. Teams may begin in remote control and move the robot within the starting zone only to localize. Teams must begin with hands free control from the starting area and remain in hands free mode for the entire competition run. At least two cycles of excavating, crossing the obstacle field, crossing into the construction zone, dumping the regolith for the berm, and crossing the obstacle field and returning to the excavation zone must be completed during the competition run. Berm construction points, as determined by the volumetric scan, must be achieved for this level of autonomy.

4. If the robot comes in contact with a rock or drives across a crater, as determined by the MCJ/Arena judges, a 30-point reduction for each occurrence will be applied up to a maximum of 90 points. This is only true in the obstacle zone. The robot is allowed to move rocks and fill in craters in the excavation zone.

5. This level requires mastery of all aspects of autonomy associated with this competition and demonstrates a level of robustness to complete at least two full cycles. System robustness is essential for terrestrial and extra-terrestrial construction.

Example: Robot crossing the obstacle zone hits a rock traveling to construction zone in cycle 1, drives across a crater returning to the excavation zone in cycle 2, and hits a rock returning to the excavation zone in cycle 3 during the attempt. 600 – 30 -30 -30 = 510 points

6.2.6 Autonomous Operations Scoring

Allowable Combinations	Excavation	Dump	Travel	Full Autonomy (One Cycle)	Full Autonomy	Total
Ex: 1	75	-	-	-	-	75
Ex: 2	-	50		-	-	50
Ex: 3	-	-	250	-	-	250
Ex: 4	75	50	-	-	-	125
Ex: 5	-	50	250	-	-	300
Ex: 6	75	-	250	-	-	325
Ex: 7	75	50	250	-	-	375
Ex: 8	-	-	-	450	-	450
Ex: 9	-	-	-	-	600	600

Autonomous Score Sheet

Any successful completion of the Excavation, Dump, and Travel attempts will be combined for scoring. These could occur over separate passes within the run. Excavation, Dump, Travel automation points will not be combined with Full Autonomy (One Cycle) or Full Autonomy.

SECTION 7: UCF COMMUNICATIONS

7.1 UCF Qualification General Communication System Requirements

Note: The rules in this section apply to both the UCF qualification and KSC Final events.

1. All teams shall use IEEE 802.11 wireless protocol standards for their wireless connection (Wireless Access Point (WAP) router and rover client).
2. Routers are required to support both the 2.4 and 5 GHz bands.
3. Routers are required to have the ability to turn off the 2.4 GHz band.
4. Each team will be assigned an SSID upon checking in for the competition that must be used for their wireless equipment. The team's SSID will be written as "Team_##."
5. Teams are required to broadcast their SSID.
6. Robots and access points are ONLY allowed to transmit using their designated SSID.
7. Hidden networks are not allowed.
8. Wireless encryption is required.
9. Teams cannot use channel bonding for 2.4 GHz data transmission. Meeting this rule will require a spectral mask or "maximum spectral bandwidth setting" of 20MHz for all wireless transmission equipment.
10. All team-provided wireless equipment shall operate legally within the power requirements set by the Federal Communications Commission (FCC) for unlicensed wireless equipment operating in the Industrial, Scientific, and Medical (ISM) radio frequency band. The FCC Federal Regulations are specified in the Electronic Code of Federal Regulations, Title 47, Telecommunication, Part 15, and must be followed if any commercial equipment is modified. All unmodified commercial off-the-shelf access point equipment and computers already meet this requirement.
11. If a team inserts any type of power amplification device into the wireless transmission system, this will likely create a violation of FCC rules and is NOT allowed in the competition.
12. The radio frequency power requirements apply to all wireless transmission devices at any ISM frequency.

13. Bluetooth transmission equipment in the 2.4 GHz range is allowed for sensors and other robot communications. Bluetooth is allowed only at power levels of Classes 2 and 3 and is limited to a maximum transmit power of 2.5 mW EIRP. Class 1 Bluetooth devices are not allowed.
14. The use of 2.4 GHz Zigbee/IEEE 802.15.4 technology is prohibited because of the possibility of interference with the competition wireless transmissions.
15. Technology that uses other ISM non-licensed radio frequencies outside of the 2.4 GHz band, such as 900 MHz or 5 GHz frequency bands, is allowed for robot or sensor systems, but these frequencies will not be monitored during the competition. Interference avoidance will be the responsibility of the team and will not be grounds for protest by any team.
16. Teams can elect to use 5 GHz WiFi during competition for WAP to robot communications, however, this frequency will not be monitored for wireless interference and will not be grounds for a protest or rematch by any team.
17. All robots should have an external WiFi antenna for the rover wireless client or show that the rover antennas are not obstructed by conductive or metal structure on the robot.

7.2 UCF General Radio Frequency and Communications Approval (Comm Check)

Note: The rules in this section apply to both the UCF qualification and KSC Final events.

1. All teams are required to successfully pass a Comm Check prior to entering the competition in the UCF qualification or the KSC final competition.
2. Compliance with all rules specified in Section 1 General Communication System Requirements listed previously will be verified during the Comm Check.
3. Each team must demonstrate to the communication judges that their robot and access point are operating only on the assigned channel. Each team will have a maximum of 15 minutes at the communication judges' station.
4. Comm checks are to be performed on Channel 1.
5. Teams in the queue for a comm check are allowed to quickly configure to Channel 1, then turn their wireless off until they are at the comm test station for checkout.
6. The teams must identify and show the judges all the wireless emission equipment on the robot.
7. If the team robot is transmitting low-power Bluetooth or any non-2.4 or 5 GHz frequency equipment, printed documentation from the manufacturer with part numbers of all wireless transmission equipment must be provided to the judges. This printout must be from the manufacturer's data sheet or manual, and will designate the technology, frequency, and power levels in use by this type of equipment.
8. If teams use Bluetooth on their robot, printed documentation of the hardware in use must be provided to the judges. Teams must show that the equipment in use is not using Bluetooth Class 1 and can be verified within the provided documentation.
9. The team must also verify that they are connected to the robot by remote wireless control and are able to control the robot.
10. The team must show that they can turn off 2.4 GHz after demonstrating control of the robot.
11. If a team cannot demonstrate the above tasks in the allotted time, the team will be disqualified from the competition.

7.3 UCF Comm Rule Qualifications

Each team is required to command and monitor their robot over the EXOLITH provided network infrastructure. This configuration must be used for teams to communicate with their robot.

7.4 UCF RoboPits Comm Rules

1. All routers in the RoboPits shall turn off 2.4 GHz by default or power down their wireless equipment.
2. The RoboPits will have full access to the 5 GHz band and is the required WiFi frequency band for use in the RoboPits if wireless connectivity is required (the alternative is to connect an ethernet cable between the devices).
3. If needed, teams in the RoboPits can test their robot using 2.4 GHz with prior authorization from the PitBoss. These tests are to be conducted only on Channel 6 and will only be allowed for a short period.

4. Teams in the queue for a comm check are allowed to quickly configure to Channel 1, then turn their wireless router off until they are at the comm test station for checkout.

The RoboPits communication environment will be monitored. If your team is found to be transmitting on Channel 1 or 11 while in the RoboPits, the following will occur:
1st time, a warning and announcement to all teams in the RoboPits that your team was in violation.
2nd time, a 500-point deduction from your final score (sum of the two runs) will be assessed.
3rd time will result in disqualification from the competition.

7.5 The UCF Exolith Arena Comm Rules

1. Robot operations will be performed on WiFi Channels 1 and 11.
2. Teams must be able to use and switch between Channel 1 and Channel 11 for the competition within 15 minutes of being notified to accommodate real-time scheduling changes.
3. If a team is on the wrong channel during their competition attempts, it will be disqualified and required to power down.
4. WiFi channels 1 and 11 will be monitored during the competition to ensure there are no other teams transmitting on the assigned frequencies.
5. Situational cameras are staged in the Exolith Arena. The camera joystick and display will be located with the team in the MCC.

7.6 UCF Communications [Exolith Arena – Mission Control Center (MCC)]

1. Handheld radios will be provided to each team in the Exolith Arena to link with their Mission Control Center team during the setup period.
2. Each team will provide the wireless link (access point, bridge, or wireless device) to their robot, which means that each team will bring their own WiFi equipment/router and any required power conversion devices.
3. Teams must set their own network IP addresses to enable communication between their robot and their MCC control computers through their own wireless link hosted in the Exolith Arena.
4. A shelf will be set up next to the network drop at a height of 0 to .5 meters above the walls of the arena and will be placed in a corner area. This shelf is where you will place the Wireless Access Point (WAP) to communicate with your robot. During robot system operations during the competition there will be dust accumulation in this area.
5. In the arena, EXOLITH will provide an elevated network drop (male RJ-45 Ethernet plug) that extends to the Mission Control Center, where EXOLITH will provide a network switch for the teams to plug in their laptops. The network drop in the Exolith Arena will be elevated high enough above the edge of the regolith bed wall to provide adequate radio frequency visibility of the entire arena and will be located next to the shelf for the WAP.
6. Network connections to the robot are ONLY allowed via the WAP router and the cable going to the MCC. Any backchannel wireless connections via laptop or cellphone to the WAP router or robot during setup or competition are expressly forbidden and will result in disqualification.
7. EXOLITH will provide a standard US National Electrical Manufacturers Association (NEMA) 5-15 type, 110 VAC, 60 Hz electrical jack by the network drop. This power connection will be used for the WAP router used for robot WiFi communications. This will be located no more than 1.5 meters from the shelf. The team must provide any conversion devices needed to interface team access points or Mission Control Center computers or devices with the provided power source.
8. Teams are strongly encouraged to develop a dust protection cover for their wireless access point (WAP) that does not interfere with the radio frequency signal performance.
9. During the setup phase, the teams will set up their access point and verify communication with their robot from the Mission Control Center.

See KSC Guidebook for KSC Communications Rules

SECTION 8: UCF ON-SITE WEEK INFORMATION

Will be released prior to the competition week when information has been finalized