GEORGIA INSTITUTE OF TECHNOLOGY
George W. Woodruff School of Mechanical Engineering
ME 2110 - Creative Decisions and Design
Summer 2017

The Design Project:
Mission to Mars 2

Design Review and Contest Date: Friday 14 July 2017, 5 PM

In this contest, you are going to Mars to prepare a habitat. Your target objectives are located around a mountain ridge on the planet's surface. During the competition, you must: 1) clear the habitat area of boulders, 2) collect supply crates, 3) land your spacecraft in a marked safe zone, 4) retrieve injured astronauts, 5) retrieve their rovers and 6) move your machine to safety.

All of these tasks will be executed in the competition arena and will be executed during a 45 second time period. The arena is a square having 4 sides of length 7 feet and constructed by 2-inch x 4-inch lumber over ½-inch plywood, as shown in Figure 1. These 2-inch x 4-inch boards are oriented such that their height is 2 inches (actually 1.5 inches) around the perimeter of the competition arena. They are stacked on top of the ½-inch plywood zone base. The arena has 4 home zones as shown in Figure 1 with habitat areas marked along the middle. Each home zone has a starting zone, one of which is shown in Figure 2. At the center of the arena is the mountain ridge, which is a stacked cylindrical body having a diameter of approximately 2 feet as depicted in Figure 3. The dimensions of the ridge are given in Figure 3 and Figure 4. The tasks for your missions are described in Section A.

A. Competition Tasks

1. Land Spacecraft in Marked Safe Zones

The mountain ridge is located at the center of the competition arena and is a stacked cylindrical body approximately 2 feet in diameter as shown in Figure 3 and Figure 4. It rotates clockwise in the center of the arena at a rate of 5 to 7 revolutions per minute. To land on the mountain ridge, you must drop spacecraft into the safe landing zones. The spacecraft are shown in Figure 8 and you will be supplied with 4 spacecraft just before your systems take the track. As shown in

Figure 3 and Figure 4, the mountain ridge has 4 landing zones, which include 2 unsafe zones and 2 safe zones. The astronauts have marked the safe zones and unsafe zones on the mountain ridge with distinct physical beacons as shown in Figure 4. Detection of the beacons will enable identification of the safe landing zones for mission control. The landing zones are approximately 9.5 inches above the arena and are approximately 3 inches high. The zones have a slight lip (approximately 0.5 inches) to prevent the spacecraft from rolling out. Your landing score is dependent on the number of landings in the safe zones. Because landing in unsafe zones will lead to certain disaster, you will be penalized for any spacecraft landing in the unsafe zones. If no spacecraft are landed in the mountain ridge, a score of zero will be given to your team's landing run. **Landing scoring information is provided in Table 1.**

Table 1: Spacecraft Landing Run Scoring Information.

Number of landings	**Competition Point Value (safe/unsafe)**
0	0 / 0
1	15 / -20
2	30 / -40
3	45 / -60
4	60 / -80

2. Retrieve Astronauts and Rovers

Astronauts and rovers, depicted in Figure 9 and Figure 10 are located atop the mountain ridges at equally spaced angular positions as marked in Figure 1. **You receive 28 competition points for retrieving each astronaut and each rover and placing them completely in your home zone. You will receive 14 competition points for partial retrieval of each astronaut and each rover if they are on the boundary with an opponent's home zone, the landslide zone or the competition arena.**

3. Egress Rescue Equipment

After rescuing the astronauts, you must egress your machine a safe distance (3 in) from the mountain ridge so that your equipment is safe from landslides. The safe distance is indicated on in Figure 1 and Figure 2 as a red rim around the mountain ridge. To successfully egress a safe distance from the mountain ridge, your system needs to be completely outside of the landslide

zone at the end of the 45 second competition time. **Any team who successfully egresses from the landslide zone will have their astronaut and rover points doubled.** A successful egress is defined as all parts of your device, with the exception of the spacecraft, being completely outside of the landslide zone. Contact with the landslide zone boundary is not safe.

4. Clear Boulders

You have also been asked to relocate large boulders in order to clear the habitat site. To clear the habitat site, the boulders must be fully outside of the habitat area. A typical boulder is shown in Figure 7 and 3 boulder-s will be initially positioned in your home zone as shown in Figure 6. **Each boulder that is in the habitat area at the end of the run is -6 points from your score. Boulders that are removed from the habitat area are worth zero points each. Note that boulders in other teams' zones could end up in your habitat area, which may further reduce your score beyond the 3 in your habitat initially.**

5. Collect Supply Crates

Supply crates mark the edges of your home zone. These supply crates must be collected to facilitate habitat construction. Figure 5 shows representative images of the supply crates, which are cube-shaped objects of approximately 2 inches. Figure 6 shows the positions of these supply crates. You must clear the supply crates by pulling them into your home zone. **For each supply crate fully in your home zone, 10 points will be added to your team's score.** Note that each home zone is lined by 8 crates. Thus, there is the possibility of having this many items in your home zone after the competition ends.

B. Final Competition Details

Your objective is to build a machine that scores more points than other teams. You are permitted to use energy only from the electricity supplied from your controllers, 5 mousetraps, the compressed air from the charged pneumatic cylinder, and gravity. Your team will be provided with a set of actuators. Your controllers may only power the actuators supplied to you. The controller also powers the sensors supplied to you. You may also purchase additional sensors as long as your budget remains under $100. Please see the rules at the end of this document for details on the budget specifications. Three other teams will be competing at the same time. Table 2 summarizes point values for the various objects and tasks.

Table 2: Scoring Summary.

Task	Competition Point Value
Boulders	-6 per boulder (full or partial)
Supply Crates	10 per crate (full)
Spacecraft	15 per safe landing -20 per unsafe landing
Rover	28 per rover (full) 14 per rover (partial)
Astronaut	28 per astronaut (full) 14 per astronaut (partial)
Egress	Doubles astronaut and rover scores

The head-to-head contest will be Friday, 14 July at 6:15 PM in the GTMI/MARC Building Atrium. From 5 PM to 6 PM, your devices will be on display in the GTMI Auditorium for the design review, which is 5% of your overall ME 2110 grade. The design review score incorporates the device's ingenuity and aesthetics as judged by a group of independent observers. The design score also incorporates the quality of the team's presentation. All team members will need to be in attendance during the design review to discuss the features of the system. This will operate in a typical science fair type mode.

C. Competition Scoring

The competition score for your device will consist solely of its performance in the competition. On 14 July, every machine will be run in head-to-head competitions. The two highest scoring teams out of the four teams competing on a track will be named the winners. All machines will run in rounds 1 and 2. To compete in round 3, a machine must have been named a winner at least once during round 1 or 2. From the third round onwards, the score for each team will be tallied and the lowest scoring team out of four teams competing on a track will be eliminated. Third-place teams may only be advanced to the next round as a "wild-card" to ensure the number of teams remaining is divisible by 4. Chosen teams will be those with the highest total scores among non-winners in the round. Any ties will be broken by the following rating priorities:

1. Egress.
2. Highest number of spacecraft safe landings.
3. Highest number of astronauts and rovers in home zone (full/partial).
4. Highest number of crates in home zone (full).

5. Lowest number of boulders in habitat area.
6. Coin Toss.

The first, second and third place finishers in the head-to-head competition will receive prizes.

D. Performance Grade for Final Competition

Your performance grade for the final competition day has a maximum value of 6 points and is based on the total number of head-to-head rounds in which your machine competes (win or lose). The maximum number of performance points for competing machines and teams is limited to 6 points and the minimum is 1 point. Teams will receive one point for each of the first two rounds competed in. Additionally points will be award for additional rounds. These additional points will be linearly interpolated with the teams competing in the most rounds receiving 4 additional points and teams that don't pass round 2 will receive 0 additional points.

E. Subsystem Competition and Grading

You will have a chance to test several subsystems before the major competition. The subsystem competitions will be held in studio on dates shown in Table 3. Each studio will hold its own subsystem events during its regularly scheduled studio time. In the subsystem events, you will have a fixed amount of time to run your machine on a track, but facing no opponent.

Table 3: All System and Subsystem Competitions

Competition (type)	Week	Date	Maximum Grade Points (% of Final Grade)
Boulder clearing[*] (subsystem)	5	12-15 June 2017	1 (1%)
Supply Crates collection (subsystem)	6	19-22 June 2017	2 (2%)
Mountain ridge (subsystem)	7	26-29 June 2017	2 (2%)
Qualifying (system)	8	5-11 July 2017	4 (4%)
The big competition (system)	9	14 July 2017	6 (6%)

[*] Individual Competition. *You must bring a machine.* ***Your instructor may reduce your letter grade by one letter for not participating in the individual competition.***

Competition 1: Boulder Clearing Competition (INDIVIDUAL)

During week 5, **every student** in the class will build a subsystem and compete individually in the Boulder Clearing Competition. The subsystems produced during week 5 should clear as many boulders as possible. You will be given 5 minutes in which you can run your machine a maximum of 3 times. At the start of the time, you will have to successfully box the machine once within the starting volume (see Rules 9 & 10), then proceed to run the machine up to three times within the remainder of the time limit. The cumulative number of points your machine scores will be compared to the scores of all the machines in the entire class. For this event, you will only be allowed to use energy from 2 mousetraps and gravity. The controller will not be used. The boulder clearing subsystem must be triggered/activated using a manual motion that does not add significant energy to the system. For example, you cannot push a weight off of a height (i.e. input significant human energy), but you can use a stick to trigger a mousetrap (i.e. input nominal human energy). If a machine fails to trigger or your machine disqualifies (DQ's) in any of the runs, it will receive -28 competition points for that run (10 points less than lowest possible for the competition). Other home zones on the track will be left empty. Each individual will be ranked against the entire class and scored from 0.2 to 1 grade points, via linear interpolation. The other tasks will not be set up during this competition, and the mountain ridge will not be rotating during this competition.

Competition 2: Supply Crate Collection Competition (TEAM)

During week 6, your team's subsystems should successfully collect supply crates. As in week 5, you will be given 7 minutes in which you can run your machine a maximum of 3 times. This time, you must clear the go-no-go box before the start of each run. The system must be activated by the track, communicated to your controller using the banana plugs provided in your kit. If a machine fails to trigger or your team otherwise DQs in a run, you will receive -10 competition points for that run (10 points less than lowest possible for the competition). For this event, you will be allowed to use energy from all acceptable sources as defined in the rules. The score your machine delivers in its 3 runs will be compared to those of all the machines in all studio sections. Each team will be ranked against the entire class and scored from 0.6 to 2 grade points, via linear interpolation. The highest scoring team will receive 2 grade points. The lowest scoring team will receive 0.6 grade points. Only one subsystem should be fabricated per team for this competition.

The boulders will not be set-up for this competition. The mountain ridge will not be rotating during this competition.

Competition 3: Mountain Ridge Competition (TEAM)

During week 7, your team's subsystems should successfully deposit spacecraft and collect the astronauts and rovers. The mountain ridge will be rotating during this competition. As in previous weeks, you will be given 7 minutes in which you can run your machine a maximum of 3 times. You must clear the go-no-go box before the start of each run. The system must be activated via the triggering of the track (*i.e.*, using your banana plugs). If a machine fails to trigger or your team DQ's in any of the runs, it will receive -90 competition points for that run (10 points less than lowest possible for the competition). For this event, you will be allowed to use energy from all acceptable sources as defined in the rules. The cumulative number of points your machine scores will be compared to the scores of all the machines in all studio sections. Each team will be ranked against the entire class and scored from 0.6 to 2 grade points, via linear interpolation. The highest scoring team will receive 2 grade points. The lowest scoring team will receive 0.6 grade points. Only one subsystem should be fabricated per team for this competition. The supply crates and the boulders will not be set-up in your home zone for this competition. For this event, you do not have to egress from the mountain ridge.

Competition 4: Qualifying Competition (TEAM)

The qualifying round will be held during your studios in week 8 (the week of 5 July). These will be run as full competitions with all competition items and tasks in play, each team competing on one of 4 home zones, and will be used for the seeding of the final competition. Every machine will be guaranteed at least 3 head-to-head matches during a section's qualifying round. More head-to-head matches may be run depending on the sections size and at the instructor's discretion. You must clear the go-no-go box before the start of each run. If a machine fails to trigger or your team DQ's in any of the matches, for that run, it will receive 10 competition points less than the lowest single match score across all class sections for the qualifying competition. In the big competition, the best performing systems from the various studios will be pitted against those that performed the worst in other studios. So it is to your advantage to have your system perform as best as possible in your studio. The highest scoring team in the qualifying round will receive 4 grade points. The lowest scoring team across all studios will

receive 1 grade points. All other teams will receive a grade that is linearly interpolated between 1 and 4 grade points using their score. Once all matches used for seeding in your studio section are complete, teams from other sections can come to your studio section and participate in the qualifying rounds without affecting their own competition score. This is an excellent opportunity to practice.

Competition 5: The Big Competition (TEAM)

The final competition will be held on 14 July 2017.

F. Design Review Grade

The design review grade will be determined between 5 PM and 6 PM on the competition day before your system competes. **The design review grade is 5% of your overall grade.** The team receiving the top score in the design review will receive the complete 5%, the remaining teams will have their grade scaled by their rank in the class. For example, if your team receives the lowest score, it will receive 0% out of the 5%. Also, if your team is exactly at the middle (50^{th} percentile) of the class, then you will receive 2.5% of the 5%. All design review scores will be determined by averaging of all judges' scores, and linearly interpolating between the highest and lowest design review scores. A copy of the judge's scoring sheet will be available on the web site to calibrate you as to what they will be considering when they are judging you. Note the design review grade does not affect the performance grade.

G. Rules

1. There may be some slight differences between the floor surfaces of the various tracks (*e.g.*, one track may be a bit rougher than another). Your device should be engineered to be robust to these differences.
2. For the head-to-head competition, your device will be assigned an 8-minute time block. All four devices will be automatically activated at the 4-minute mark, and must be removed from the track by the 8:00 minute mark. Your machine must be ready to run at the 3:45 minute mark. Your machine will be disqualified if it is not ready at this time mark. This provides a 15 second buffer between set-up and run. Thus, you will have 3:45 minutes to set-up your device and 45 seconds to have it complete its task. By the end of the 8-minute period you must have removed your device (and any bits and pieces) and cleaned-up the competition track. Your system will be disqualified for taking longer than your allotted time.
3. You will have a minimum of 3 minutes to prepare for the next round. During this time, it is your responsibility notify the track judges of any issues with the track or track items BEFORE the end of the 3 minutes.

4. It is your responsibility to be on time with a working machine. If you are not present during your assigned time, you forfeit the round.
5. The source of power in your device is limited to the five mousetraps provided to you, power provided to your system from a controller box, a charged pneumatic tank, and gravity. Air from the pneumatic tank may only be used to power pneumatic actuators, and may not be vented directly to the environment.
6. No actuators (e.g., valves, solenoids) can be pre-activated prior to the start of a round. Actuators must be in their resting state at the start of a round.
7. The only powered actuators that you are permitted are the ones that are supplied to you by the ME 2110 staff. You may purchase additional sensors as long as your budget remains under $100.
8. You may not use elastic energy (e.g., additional springs beyond the mousetraps, rubber bands, flexed materials) to provide significant power for point-scoring actions or mechanisms. Additionally, no magnets are allowed.
9. The device must fit within a 12-inch x 24-inch x 18-inch (length x width x height) box. Your device will be measured with a go-no-go gage immediately before each attempt. All parts of the device will be measured. The 18-inch dimension is the maximum starting height of your system. All measurements are to be made on the 30-inch x 30-inch starting zone.
10. The device must be launched from within the starting zone as shown in Figure 2. The outside of the lumber perimeter defines one of the sides of the starting zone. You may place your device in any configuration or orientation within the starting zone; however, the go-no-go box must be able to fit over the device immediately prior to its start with it ready to be triggered. You may reposition your device after it has been checked for size, but may not change any aspect of the machine without having to again clear the go-no-go box. If your device triggers errantly (e.g., false start), you must again clear the go-no-go box prior to its start.
11. The tops of the 2-inch x 4-inch lumber boundaries of the home zones are not considered part of the home zones. The ramp is considered part of the home zone.
12. There will be a 3-foot area around the competition arena, marked off by tape on the floor that is off limits during the competition.
13. The device must be safe. It must not damage, stain, or permanently change the competition track or it surroundings and competition items. No adhesives and no Velcro-type materials (e.g., hook and loop binding) may be used to interact with the track or the competition items. The device should not scratch the floor. It must not injure bystanders or you. The faculty will disqualify any device they deem unsafe, resulting in zero points for the competition.
14. Once it has been activated, you may not touch, or even appear to touch, the device until the staff member in charge of the competition arena indicates it is time to clear out the arena. If a team approaches the track before they are cleared to do so (*e.g.*, rushes the track), their system will be disqualified from that round.
15. No device may throw any projectile such as a net or rope over the track centerpiece. Any such action will result in the disqualification of your system.

16. No group may spend more than a total of $100 on the final device. You will be required to document cost of materials by submitting receipts as well as a bill of materials (BoM). Material may be prorated for costs. You may use free material; however, the BoM must show cost of that material as prorated from some verifiable source. The object cost is defined as that which an average citizen must incur in obtaining the object. For donated or scrounged material, an equivalent price must be specified.
17. The cost of the mousetraps, sensor and supplied actuators is NOT included in the $100. The $100 is out of pocket expense; you will not be reimbursed by the School.
18. The costs of any aesthetic materials (*e.g.*, paint) and fasteners (*e.g.*, staples, tape and glue) are not included in the $100.
19. The device shall not be permanently bonded in any manner to the competition track or its surroundings in any way.
20. The device must be activated by using the start plug on the right side of your respective starting zone. The start plug circuits will be closed during the 45 second competition and open otherwise.
21. The device must shut down/stop moving at the end of the 45 second when the start plug circuits are opened. Failure to do so will result in a disqualification.
22. The device must operate autonomously. No remote control is allowed.
23. The device may touch or otherwise utilize any part of the competition track or its surroundings. It may not utilize or interact with any living person or living object during the competition.
24. If your device fails to trigger or has made no perceptible motion after the round has started, this will result in disqualification.
25. Disqualification is defined as forfeiting the particular round in which the disqualification offense occurs.
26. While machines may go outside of the competition zone, there are no guarantees as to what will be located outside of the track (*e.g.*, a wall, pillar, trigger box or person may be located outside of the track area).
27. Wildcard slots for rounds 3 and beyond in the final competition will be set based on scoring in previous rounds and whether a team has held a previous wildcard slot.
28. The faculty will assign the groups. The groups will remain constant for the duration of the project. The faculty has the right to remove or otherwise penalize disruptive members of any group.
29. The faculty's rulings are binding and final.
30. Wanton destruction of opposing devices or competition arena is strictly prohibited.
31. All of ME2110 is to be conducted in a professional manner and, therefore, any inappropriate language or behavior will result in disqualification. The presence of parents, grandparents and young children at the event further strengthens the case for a respectful and professional code of conduct. In general, if you have to ask if an action is rude or inappropriate, or if certain language is unacceptable, you should avoid it.

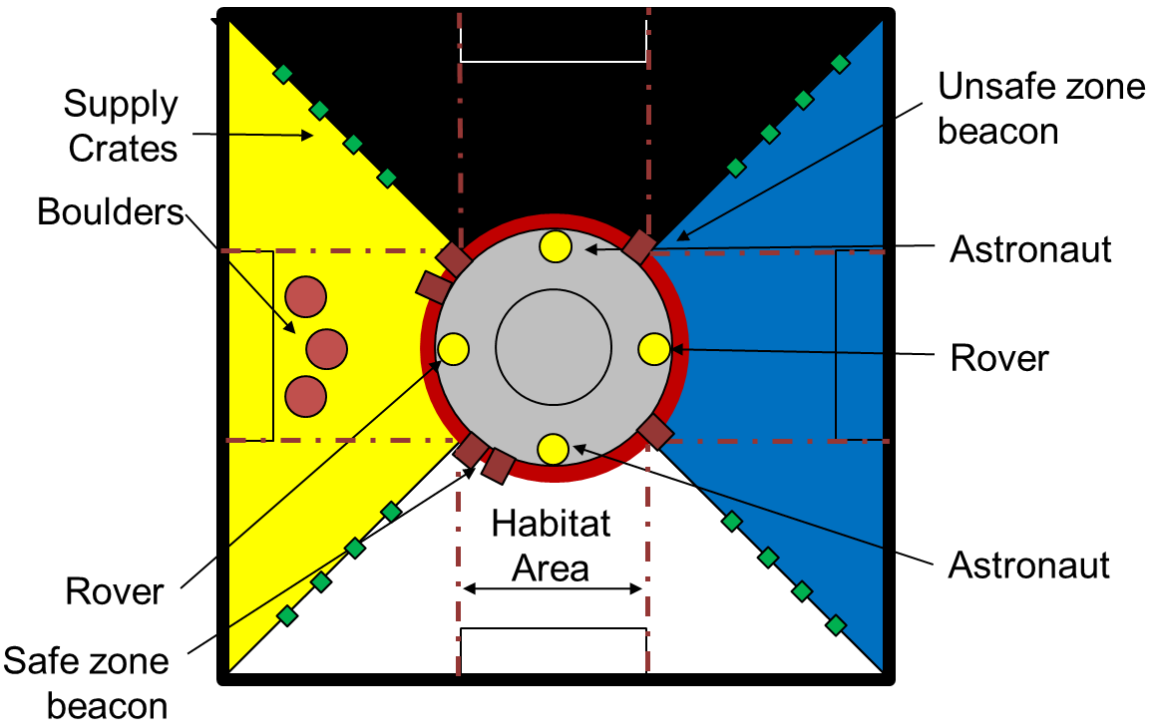

Figure 1. The competition arena.

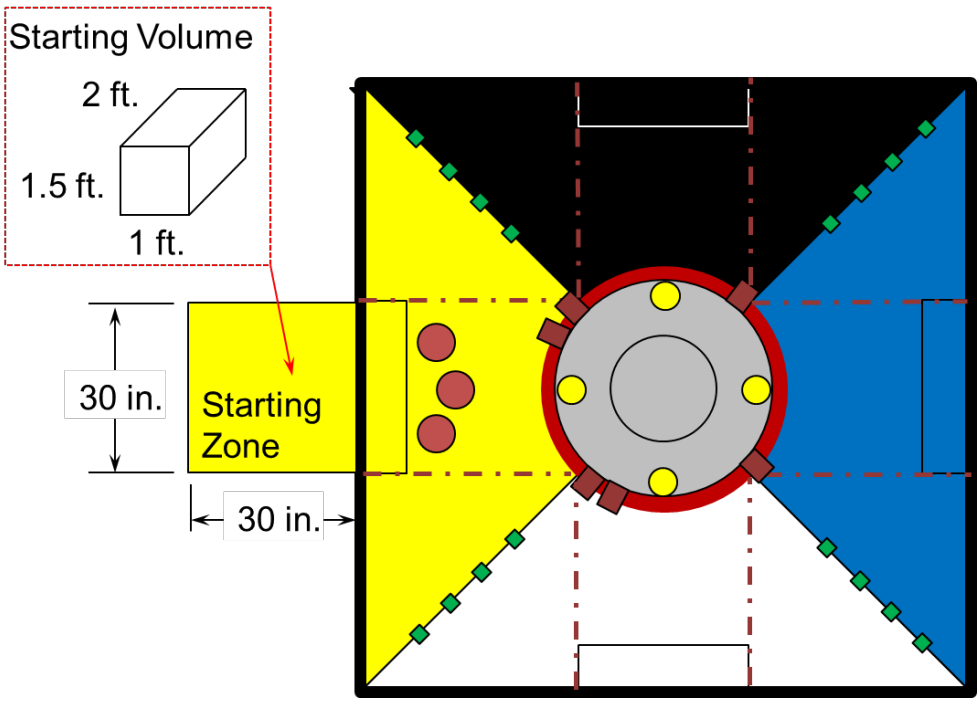

Figure 2. Typical starting zone and go-no-go box.

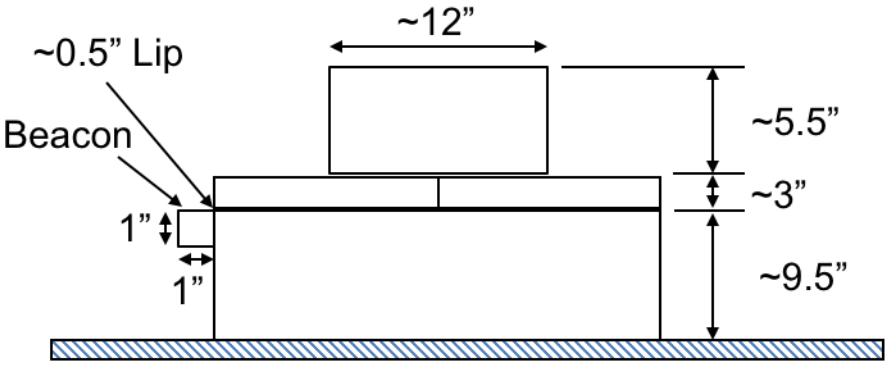

Figure 3. The mountain ridge side view.

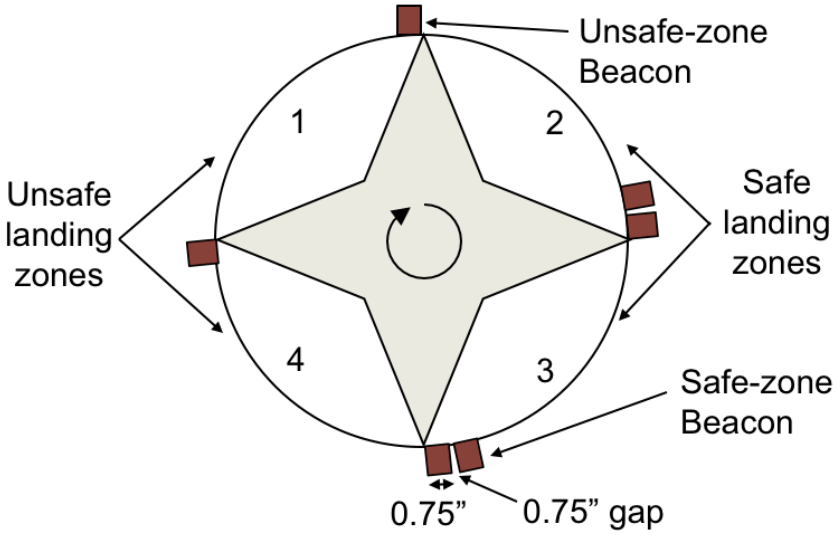

Figure 4. The mountain ridge cross section view.

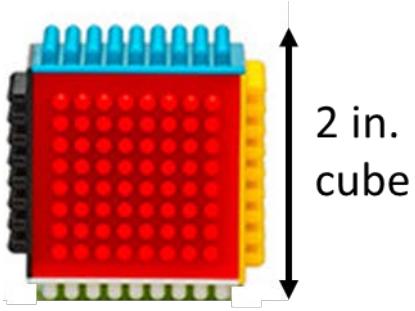

Figure 5. Supply crates as cubes of 2 inches.

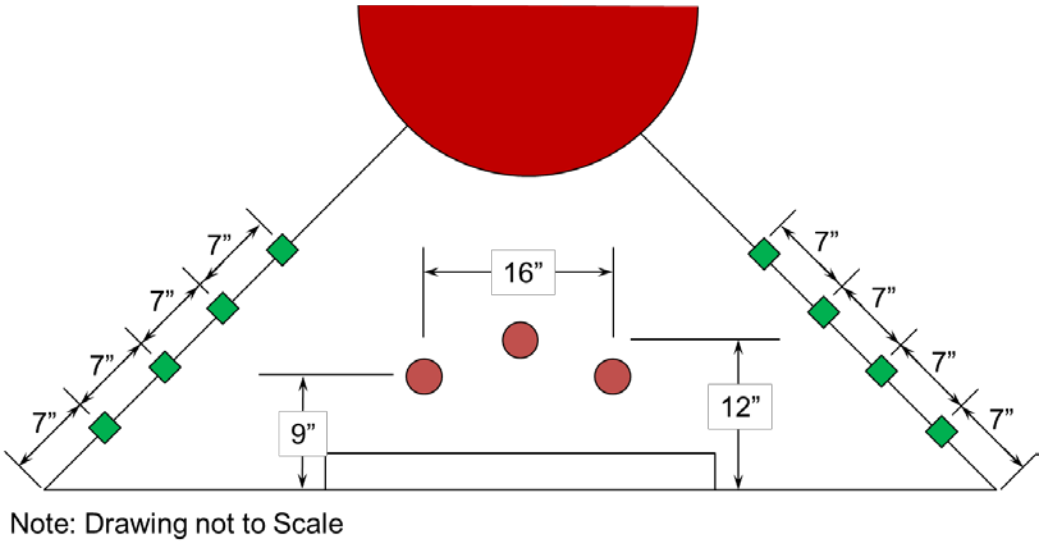

Figure 6. Configuration for supply crates and boulders

Figure 7. Boulders as irregularly shaped foam objects with 3-inch x 4-inch footprint.

Figure 8. Spacecraft in the form of 40 millimeter rubber spheres.

Figure 9. Rovers (3D printed object) approximately 1.5 inches to 2 inches in height.

Figure 10. Astronaut (3D printed object) approximately 4.5 inches in height.