

2021 – A Robot Odyssey

BEST 2007 Design Contest

Game Specific RULES

Version 2.2

July 15, 2007



Boosting Engineering, Science & Technology™

**BEST Game Specific Rules
ACMR00004 Revision 4; July 2007**

1.0 Introduction

After taking a year off to solve the laundry quandary, BEST Robotics, Inc. (BRI) returns to space! In 2007, the Mars Rovers – Opportunity and Spirit – began their fourth year of searching for signs of life on Mars. In 2021, a Martian base has been assembled using construction robots and is now receiving supplies before the arrival of astronauts. Automated Supply Vehicles (ASVs) land at the Martian base and must be unloaded using robots. Because of the harsh environment on the Martian surface (temperatures can reach as low as -155° F), the robots have three minutes to perform the following tasks:

- Exit the base and drive across the Martian surface
- Drive up onto the ASV and load supplies
- Drive off the ASV and store the supplies in a storage bin at the Martian base

The exits on the Martian base dictate that robots must be within certain size and weight constraints.

NASA issued a request for proposals for robots to unload the supply ships. BRI has submitted a proposal and won the contract to provide robots for unloading ASVs.

2.0 Objective

The objective is to design and build a remotely-controlled device to unload supplies from an ASV and place them in a storage bin at the Martian base within a 3-minute time limit.

3.0 Field Description

The field consists of a carpeted area with the outer edge of the field defined by a wooden border constructed from 1 x 4 lumber, as shown in Figure 1. The dimensions of the outer edge of the field are 23' x 23'. The interior of the field consists of the ASV cargo bay, which is represented by a raised platform with a height of 14". The length and width of this platform are 11'10". At the center of the cargo bay is a 2' x 2' cargo container holding food, medical supplies and fuel tanks. The cargo bay has a ¾" high border and has 5 equipment packages located at each of the four corners. Access to the cargo bay is provided by four ramps. Each ramp is 5'6" in length and 27" in width with a 1½" high border. The transition from the ramp to the cargo bay is provided by a 27" x 30" ramp connector with a 1½" border. Starting areas for the robots are located at the corners of the field. The scoring bins are 3' x 2' and are built into the field border. Spotters (S) are located adjacent to scoring bins. Drivers (D) are located on the opposite side of the playing field from their scoring bins and near their robot's starting area. The dimensions of the spotters' and drivers' areas are 3' x 3'.

Detailed dimensions, component specifications, and the locations of the field elements can be found in the separate field drawing document.

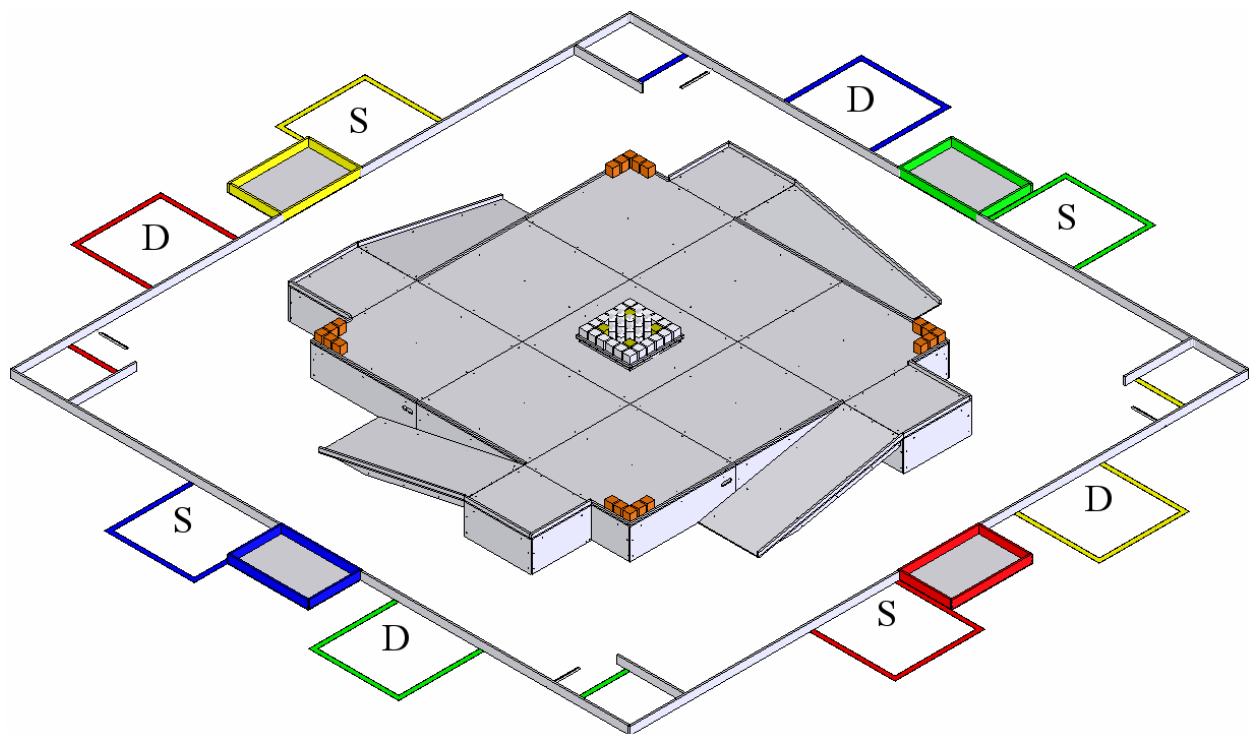


Figure 1 – Field Layout

3.1 Cargo Container

The 2' x 2' cargo container is mounted in the center of the cargo bay, is elevated 1½" above the surface of the cargo bay, and has a ¾" high border. Located around the periphery of the cargo container, just inside the border, are 20 silver boxes containing food. The outside dimensions of the boxes are approximately 3¼" x 3½" x 3¾". Four gold boxes (same dimensions as silver boxes) are located on the inner corners of the cargo container as shown in the diagram and contain medical supplies. The weight of each box is approximately 2 oz. In addition to the boxes, there are 12 bottles with gold caps located in a grid on this panel. The bottles have a capacity of 16 oz., a diameter of 2½", and a height of 7⅞" inches. The weight of an empty bottle and gold cap is approximately 2 oz.; each bottle is loaded with 8±0.5 oz. of pea gravel. The bottles are recessed 1¾" into the cargo container in a hole with a diameter of 2⅝". The bottles are fuel tanks that contain fuel for the electric generators in the Martian base.

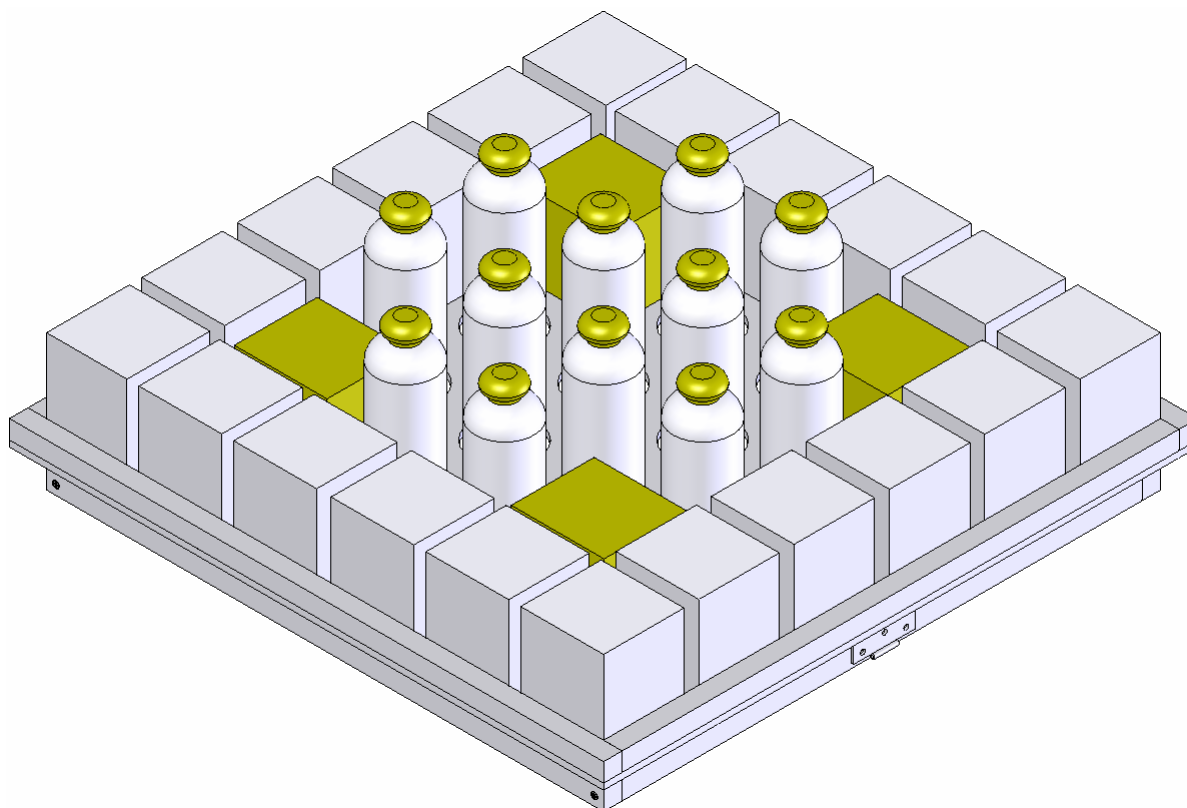


Figure 2 – Cargo Container

3.2 Ramp and Ramp Connector

The ramp and ramp connector are shown in Figure 3. The dimensions of the ramp connector are 27" x 30", and the height of its border is 1½". The height of the ramp connector is 14". The length of the ramp is 5'6", and the border on the ramp is 1½" high. Note that there are 5 orange boxes at the corner of the platform in this figure. The other three corners of the cargo bay also contain orange boxes. These boxes contain equipment such as tools, spacesuits, etc. The outside dimensions of the orange boxes are approximately 3¼" x 3½" x 3¾". The weight of each orange box is approximately 2 oz.

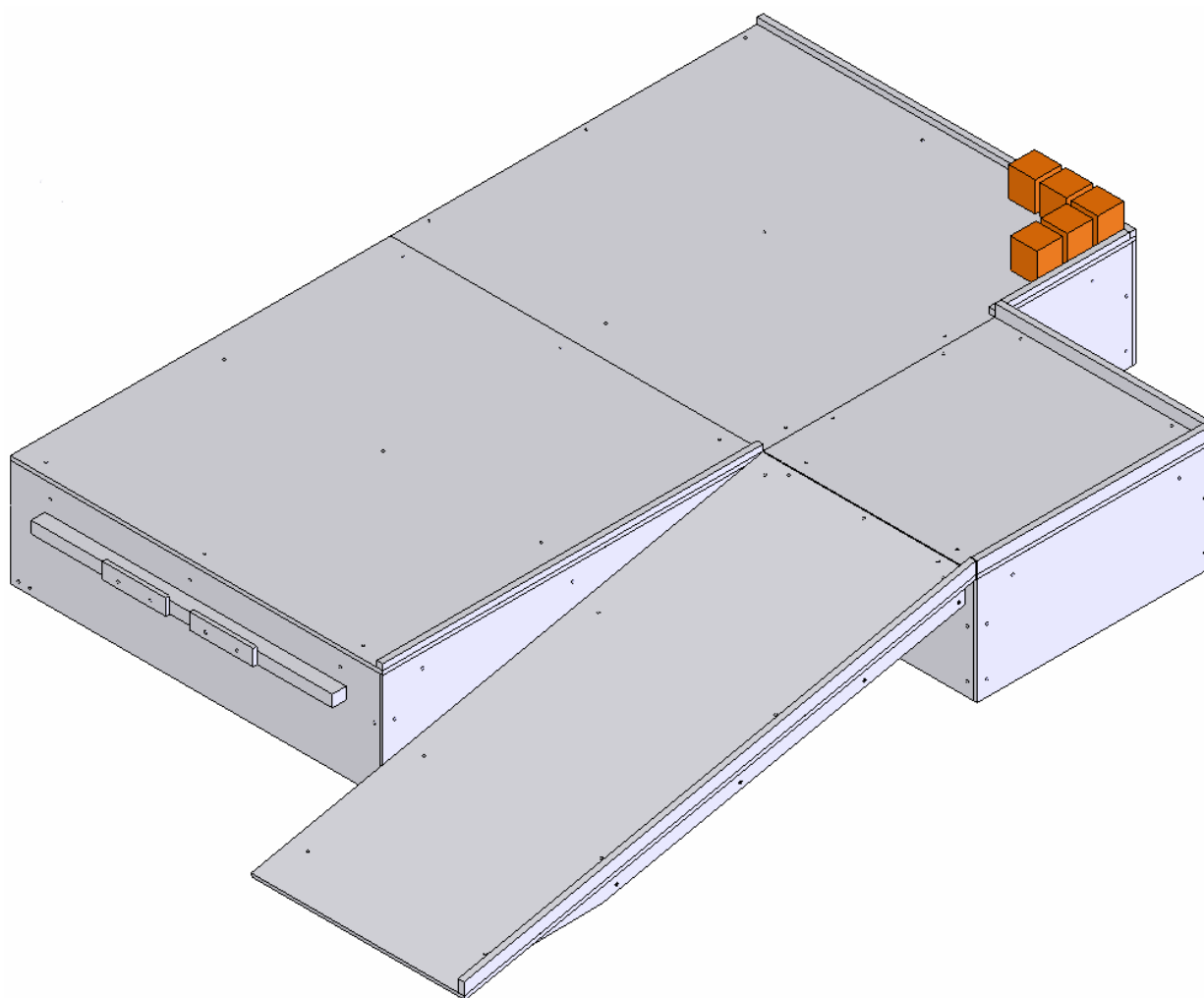


Figure 3 – Ramp and Ramp Connector

3.3 Starting Areas

The starting areas for the robots are at the corners of the field. Two sides of a starting area are formed by the field border itself. A third side of the starting area is made of the same material used to construct the field border. As shown in Figure 4, a 2" wide piece of tape is placed across the open end of the starting area. The inside dimensions of the starting area, measured to the inner edge of the tape, are 24" x 24". A bumper switch is located at the exit of the starting area and functions as the tiebreaker switch. The bumper switch is 12" in length and $\frac{5}{8}$ " high. A force of three to five pounds is required to activate the switch as a robot exits the starting area. The robot must fit within this 24" x 24" starting area at the start of a match.

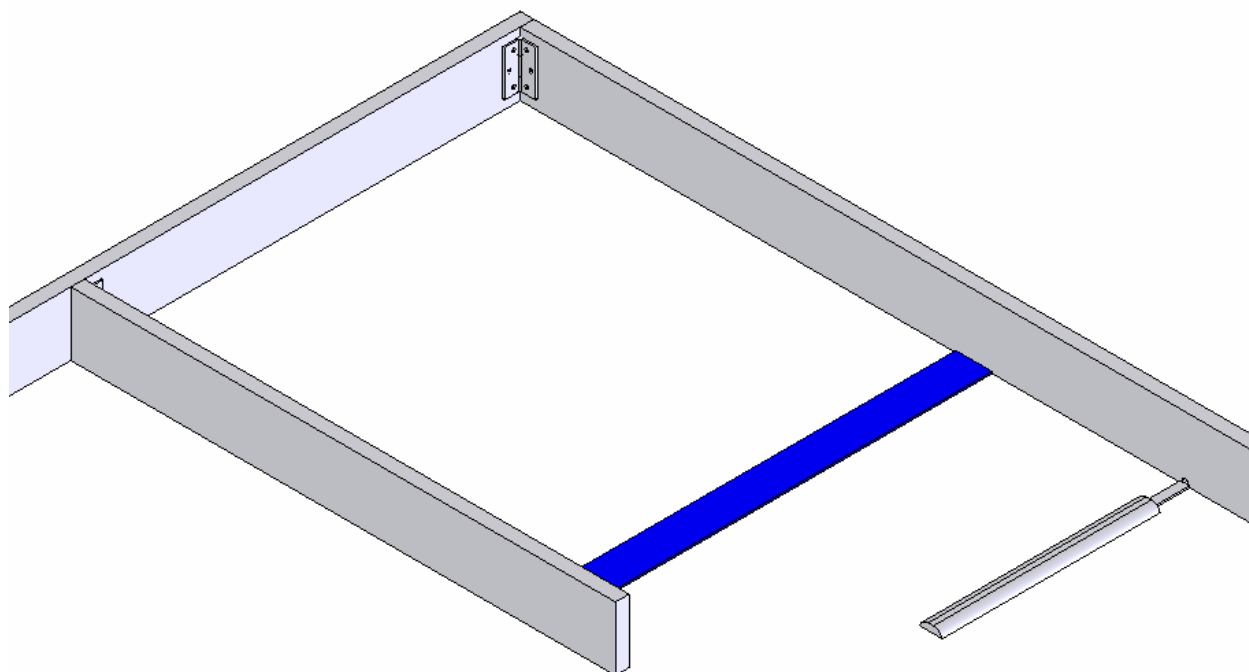


Figure 4 – Starting Area

4.0 Game Pieces

The game pieces are twelve 16 oz. bottles with gold caps (fuel tanks), twenty silver boxes (food), and four gold boxes (medical supplies) located in the cargo container. Twenty orange boxes (equipment) are located at the four corners of the cargo container. The locations of these boxes are as shown in Figure 1.

The orientation of the boxes is shown in Figure 5. The lid of each box is partially open in the photos to indicate the top of the boxes. The boxes will not be in this configuration during competition as the lids will be closed. Text has been added to the photos to indicate the orientation of the boxes for competition. Because the gold boxes contain medical supplies, their top should point upward. For the silver (food) boxes, the top should point inward away from the border on the cargo container. For the orange (equipment) boxes, the top should point inward away from the border on the cargo bay. Corner boxes in Figures 2 and 3 may be oriented such that their top points inward from either portion of the border that forms the corner.

The strong vibrations during takeoff and landing can cause the boxes to shift during their journey from the Earth to Mars. As a result, the spacing between boxes in the cargo bay is not uniform.

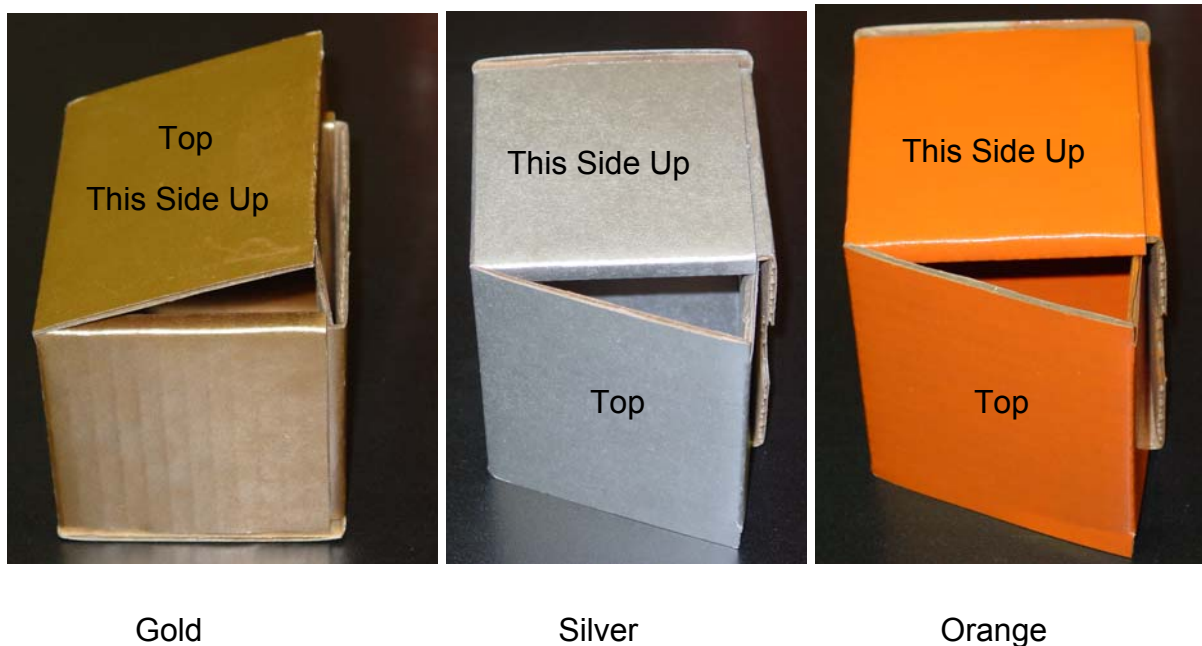


Figure 5 – Box Orientation

5.0 Scoring

Points are scored based on the number and type of game pieces in scoring position in a team's scoring bin at the end of a match.

1. The boxes and tanks are not assigned to a particular team and, as such, may score points for any team.
2. At the end of a match, a game piece in scoring position in a scoring bin does not score if it is in contact with the machine assigned to that scoring bin. Contact between a detached part of a machine (as defined in Section 6.2.5) and a game piece is allowed and does not affect scoring.
3. A game piece is in scoring position if it does not contact or extend over the top surface of the scoring bin, which is highlighted in black in Figure 6. In other words, the entire game piece must be contained within an infinitely-tall vertical box whose sides are defined by the inside walls of the scoring bin. The dashed lines in Figures 7 and 8 represent a side of this vertical box. The bottom three boxes in Figure 7 are in scoring position. The top three boxes in Figure 7 are not in scoring position, because they intersect one side of this vertical box. Likewise, the bottle in Figure 8 is not in scoring position.

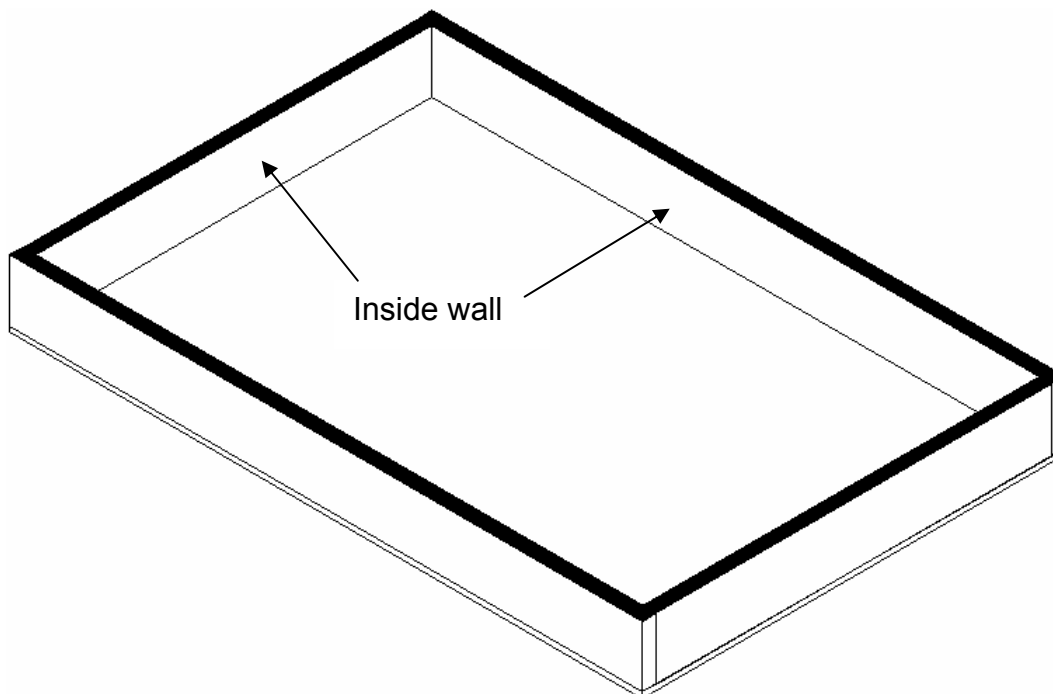


Figure 6 – Scoring Bin Diagram

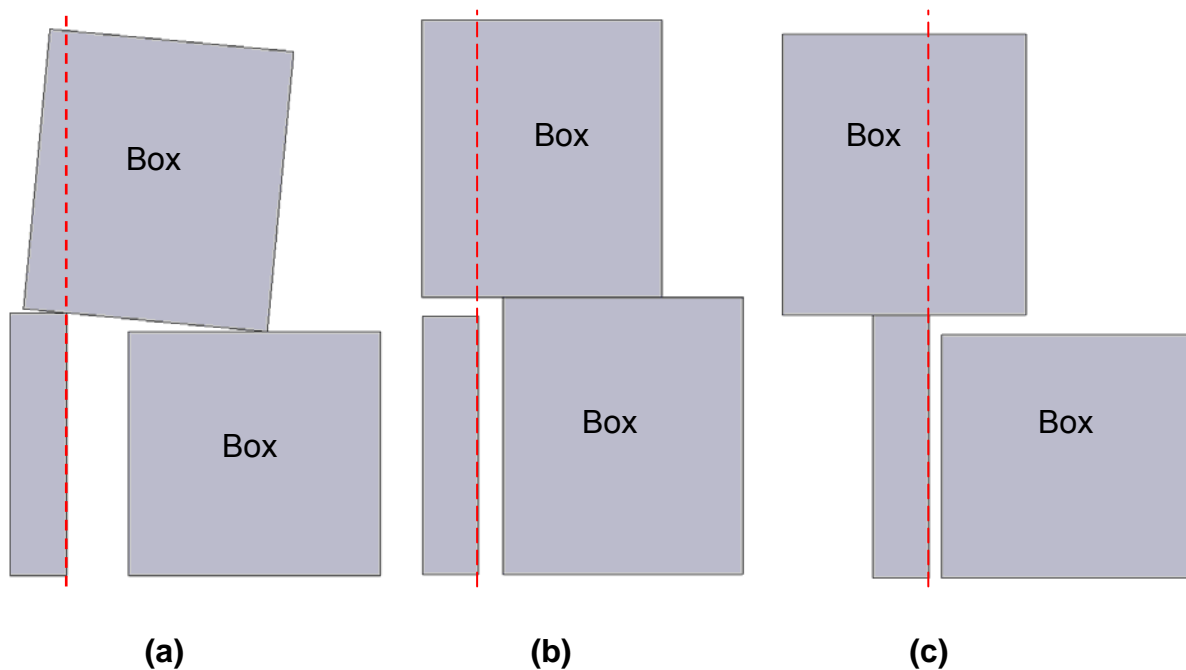


Figure 7 – Scoring Considerations for Boxes

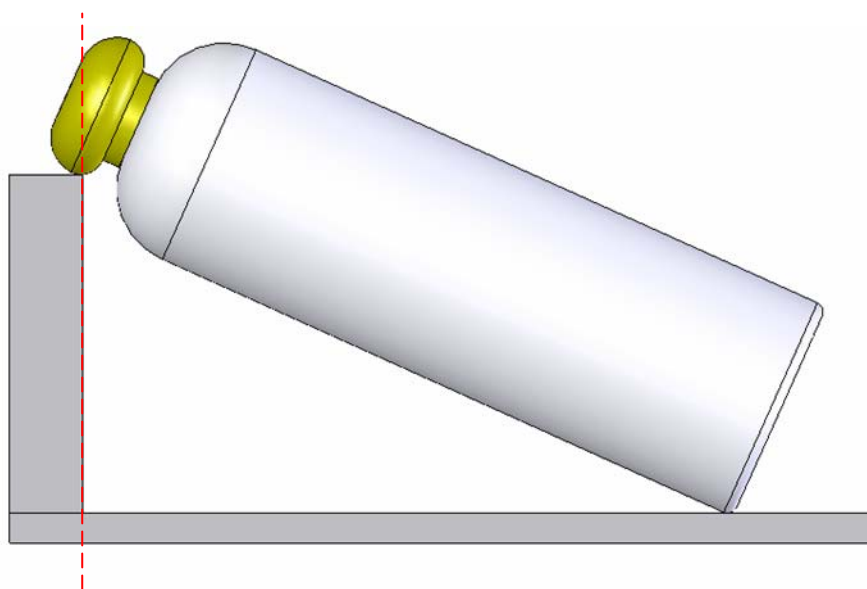


Figure 8 – Scoring Considerations for Bottles

The point values for the different game pieces are shown in Table 1.

Table 1 – Point Values for Game Pieces

Game Piece	Number of Pieces	Points per Piece
Equipment boxes (orange)	20	5
Food boxes (silver)	20	15
Medical supply boxes (gold)	4	25
Fuel tanks	12	40

In addition, a team will receive 1 point for activating its tiebreaker switch.

5.1 Bonus Points

A team may earn bonus points for successfully scoring the following combinations of game pieces:

1. 75 bonus points will be awarded for scoring: a) at least one fuel tank, b) at least one equipment box, and c) at least one food box.
2. 50 additional bonus points will be awarded for scoring at least one medical supply box in addition to the combination listed above.

The maximum number of bonus points that can be scored in a single match is 125.

6.0 Match Protocol

Each match is three minutes long and is played with four teams. If necessary, matches may also be played with fewer than four teams. The scoring software will assign teams to a match and will determine teams' starting locations.

6.1 Starting Locations

At the start of each match, drivers and spotters must be in their respective areas. The machine must be in its starting area and in compliance with section 3.2.1 of the generic rules. The starting area for each robot is described in section 3.3 of this document. Refer to Figure 1 for an overview of these locations. The drivers and spotters must remain in their respective areas for the entire match.

6.2 Additional Considerations

1. Machines may access the cargo bay using any of the four ramps.
2. Machines may retrieve game pieces located on the surface of the cargo bay or the playing field.
3. Game pieces may be retrieved from the cargo bay by a machine located on the surface of the playing field.
4. Game pieces may be moved from the cargo bay to the surface of the playing field through any action or process that does not damage them except as noted in section 6.3.7.
5. Any part of a machine that becomes detached (accidentally or on purpose) ceases to be a part of that machine. A detached part of a machine is defined as the part of a machine that does not include the battery and has no physical connection to, or contact with, the portion of the machine that contains the battery. Machines may retrieve game pieces in contact with or contained within a detached part of a machine, except as described in section 6.3.1.
6. Any game piece not in scoring position may be removed from a scoring bin by another machine.

6.3 Additional Restrictions

1. Machines may not contact a game piece that is in scoring position in another team's scoring bin, even if it is in contact with or contained within a detached part of a machine. In addition, moving the detached part of another machine to remove a game piece from scoring position is not allowed.
2. Machines may not attempt to retrieve or touch game pieces in the grasp of or stored on another machine.
3. Machines may not retrieve any game pieces that have touched any surface outside of the perimeter of the playing field. The perimeter of the playing field is defined by the black line in Figure 9.
4. Machines may not drive into any scoring bin.
5. Machines may not drive onto the cargo container in the center of the cargo bay.
6. It is considered damaging to the game pieces to use a mechanism that penetrates their surface.
7. The fuel tanks (bottles) may not be launched through the air. However, they can be dropped.

8. Drivers and spotters may not touch any game pieces or a detached part of a machine during the match.
9. Violation of any of these restrictions will result in a disqualification from the match.

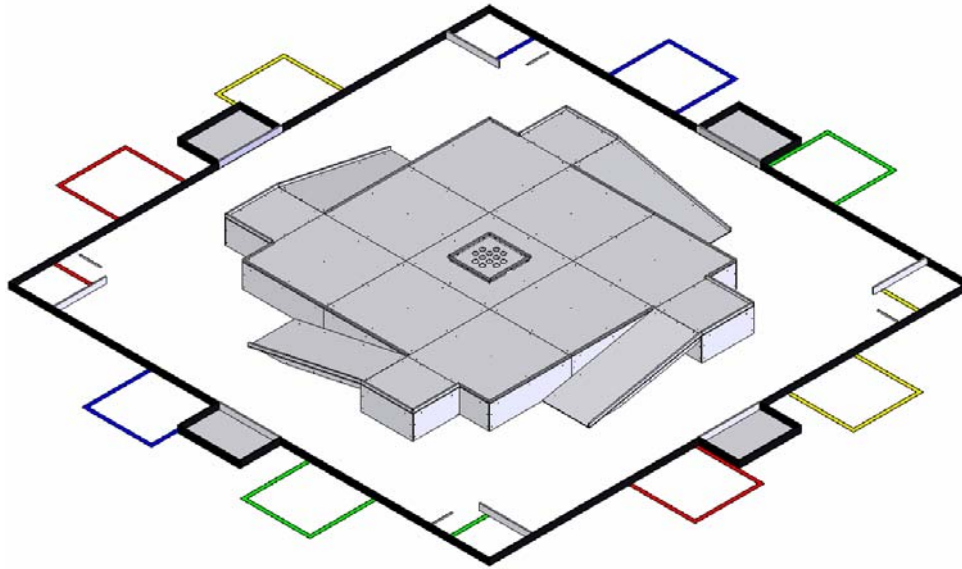


Figure 9 – Perimeter of the Playing Field

7.0 Competition Protocol

There will be three phases to the competition: a seeding competition, a semi-final competition, and a final competition.

During the seeding competition, each team will play up to eight matches against randomly selected opponents. Fewer than eight matches per team may be played when time limitations exist, but all teams must play the same number of matches. The team ranking after the seeding competition will be based on the average of the points scored during the seeding matches, excluding the team's lowest scoring match.

The top seven teams from the seeding competition will advance to the semi-final competition. The eighth team for the semi-final competition will be selected from the other teams by a single "wild card" game between the four teams with the highest BEST notebook scores. Regional competitions will also advance teams to the semi-finals through one or more wild card games.

During the semi-final competition, each team will play a total of three matches based on the rotation shown in Table 2. The team ranking for the semi-finals will be based on the total points the team accumulates during the three semi-final matches (i.e., no scores are dropped, and the results of the seeding matches are not included.)

Table 2 – Semi-final match rotation

Semi-Final Match	Starting Position			
	Yellow	Blue	Red	Green
1	Seed 4	Seed 1	Seed 5	Seed 8
2	Seed 2	Seed 8	Seed 3	Seed 7
3	Seed 6	Seed 4	Seed 7	Seed 1
4	Seed 3	Seed 2	Seed 4	Seed 5
5	Seed 5	Seed 7	Seed 8	Seed 6
6	Seed 1	Seed 3	Seed 6	Seed 2

Competitions with a team count greater than 32 may choose to advance more teams to the semi-final. In this case there will be 16 teams in the semi-final. The top 14 teams from the seeding will advance plus two wild card teams selected from the other teams by a pair of games by the eight teams with the highest BEST notebook scores (each team plays in one of the games). The two teams with the highest scores will get the wild card slots; note that these two teams may come from the same match. Details on the semi-final match rotation for this case will be provided by the hub or regional, but teams will still play a total of three matches each during the semi-final.

The four top ranked teams from the semi-final will advance to the final competition where they will play three additional matches in the field starting positions shown in Table 3. The final team ranking will be based on the total points scored during the three final matches.

Table 3 – Final match rotation

Final Match	Starting Position			
	Yellow	Blue	Red	Green
1	Semi 1	Semi 2	Semi 3	Semi 4
2	Semi 4	Semi 3	Semi 2	Semi 1
3	Semi 3	Semi 1	Semi 4	Semi 2

7.1 Tiebreaker

The average tiebreaker position will be included in the team position calculation for each phase of the competition. The tiebreaker position is determined by the order in which the robots exit the starting areas. The tiebreaker position includes only those matches played during a particular phase of the competition. For the seeding matches, the tiebreaker position of a team's lowest scoring match will be dropped (along with the score). If the average tiebreaker position does not resolve a tie, the tiebreaker positions of the tied teams will be compared, starting with the most recent match and proceeding to earlier matches (within a competition phase) until a difference is found. The team that exits its starting area first will place before the other team(s).