SUBJECT TO CHANGE
31 August 2018, Version 1.2

IEEE SoutheastCon '19
Huntsville, Alabama

Hardware Competition Rules

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"First 50 ... Next 50"

I. Introduction

The year is 2069 and mankind has successfully established colonies on the Moon and Mars and has routine daily flights between Earth and its outposts. The past 50 years have led to great innovations in space travel and colonization. Interplanetary flights have become the norm and commercial Space-based Hotels (Spacetels) are a popular vacation spot for earthlings. Unfortunately, these travels have also caused mankind to create an enormous amount of space debris, creating a hazard for travel to other planets and Spacetels.

You and your friends have taken the latest space flight for spring break aboard the Spacetel orbiting above earth designated S.S. New Orange Beach. During your flight to S.S. New Orange Beach, your astronauts have insisted that you keep your window shutters closed. You couldn't resist the urge to peek; outside your window you see a cloud of debris floating ominously in the distance. A red flyer wagon rockets past your window, barely avoiding collision with the spacecraft.

The repercussions of a collision with even a tiny piece debris traveling at orbital or interplanetary velocities could be devastating; such a collision could destroy a spacecraft. The cleanup process is arduous and expensive, and international regulations only permit unmanned, autonomous bots to assist with the cleanup efforts. To reduce the risk of disaster, debris removal bots have been commissioned by the international community. These autonomous debris removal bots will assist with cleanup of the debris in Earth's orbit. Your mission is to design such an autonomous debris removal bot. In the spirit of cooperation that led to our greatest innovations in space your bot must cooperate with other debris removal bots in orbit and thus making space travel safer for everyone. Good luck in your venture!

II. Objective

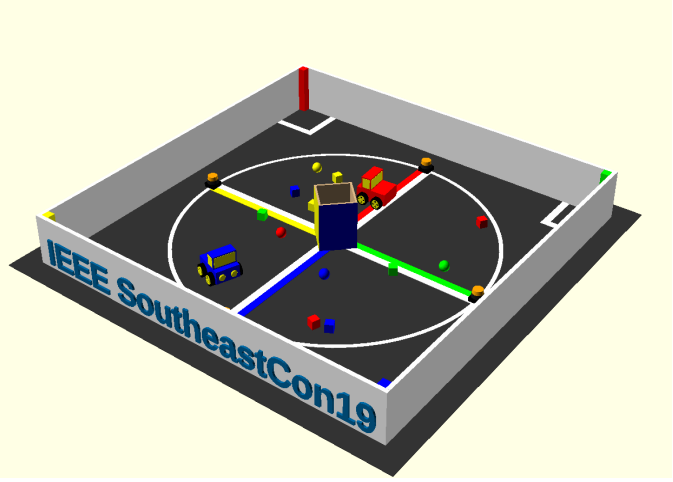
To clear orbital space debris while avoiding Spacetels and return to home base within the time limit of three minutes. The score is determined by a number of factors including: 1) the number of complete playing field orbits, 2) the number and type of space debris cleared, 3) sorting cleared debris, 4) returning to assigned corner square (home base), and 5) avoiding collision with Spacetel.

III. Terminology

Corner Square – Color-coded corner designated as "Home Base" as starting and ending location.
Orbital Line – White circular line surrounding the central column.
Orbit – any Counter-Clockwise (CCW) complete traversal around the central column.
Space Debris – Color-coded blocks or pit balls used for scoring.
Spacetel – Space Hotel, LED obstacles.
Zone 1 – Outer space outside of orbital line.

Zone 2 – Space inside of orbital line.

IV. Playing Field



1. The playing field (see ATTACHMENT A) will be based on a square carpet base with 2.74-m (108”) sides surmounted by walls with internal dimension of 244-cm x 244-cm (96 1/8” x 96 1/8”) that extend 30-cm (11 7/8”) above the playing field surface. The walls will be painted flat white.
2. The playing field will be divided into two zones, Zone 1: an area outside of the orbital line where robot corner squares are located and Zone 2: an area within the orbital line surrounding a central column.
3. The playing field will be further subdivided into four equal quadrants. In order to assist robots in identifying the quadrants, they will be separated with two color-coded lines (see ATTACHMENT A).
4. The division between quadrants consists of a pair of adjacent, color-coded, lines separating the quadrants which includes one WHITE line paired with one each of RED, YELLOW, BLUE, and GREEN (counter-clockwise order). The color of the separating line corresponds to each corner square.
5. The playing field will include four 30-cm square robot home bases located in the playing field corners. The corner squares will be separated from Zone 1 by a 4.78-cm (1.88”) wide WHITE line. Each corner will be marked by a corner color-coded wooden block in RED, YELLOW, BLUE, and GREEN.
6. Zone 1 will be separated from Zone 2 by a 2.54-cm (1”) wide WHITE orbital line as depicted in ATTACHMENT A.
7. The playing field will also include four flashing LED lights that will represent geostationary Spacetels. These items will be placed on the orbital line separating Zone 1 and Zone 2.
8. The playing field environment lighting is not specified nor controlled. The intended location of the hardware competition will be in a high bay/ceiling convention center.
9. No restrictions will be placed on spectators and those present during the competition for use of their cameras and cellphones. As a result, flash photography, infrared range finders on cameras and camcorders will be permitted. Intentional interference with the operation of the robots is not allowed and will result in sanctions.

V. Playing Field Objects

1. The playing field will contain a total of twelve (12) space debris objects. Eight color-coded 5.08-cm (2”) wooden cubes and four 6.35-cm (2 ½“) diameter color-coded pit balls representing space debris. The placement pattern will be **RANDOM** but limited

to only within Zone 2. Spacetels will be represented by flashing lights (ATTACHMENT A).

2. Eight of the debris objects will be 5.08-cm (2") wooden cubes two of each color RED, YELLOW, BLUE, and GREEN.
3. Four of the debris objects will be 6.35-cm (2 ½") diameter pit balls one of each color RED, YELLOW, BLUE, and GREEN.
4. There will be four satellite objects representing Spacetels. These will be placed on the white orbital line circle intersecting the quadrant lines, in a fixed position. The Spacetels will have flashing amber LEDs.

VI. Robot Specifications

1. The robot must operate completely autonomously once started.
2. The robot must be entirely self-contained, including any power source.
3. The maximum size of the robot will be restricted to 22.86-cm (9") x 22.86-cm (9") x 27.94-cm (11"). These dimensions are in order of L x W x H.
4. This maximum size applies when the robot is in the starting square at the start of a round or is in motion on any part of the playing field during the round.
5. When not in motion, the robot may extend a maximum of 7.62-cm (3") by 7.62-cm (3") in length and width direction at a time.
6. The extension must be physically connected to the main robot at all times.
7. The robot may not exceed beyond its maximum allowable dimension and may not include any detachable or remoted extensions.
8. There is no weight limit nor construction material restriction with exception to safety and security rules.
9. Any part of the robot that is deemed by contest officials to be dangerous or injurious to the participants, audience, staff, playing field or surroundings will result in disqualification. If in doubt, ask in advance.
10. Pyrotechnics, compressed gas, hydrocarbons, toxic or corrosive materials are not allowed.
11. The on-board flag must contain the school logo (if affiliated with a university), State, territory or US flag.
12. A robot may not operate in a manner that excessively damages the playing field, causing stoppage of the competition, or require repair of the field for the next competition.
13. Each robot must have a bumper that surrounds 80% of its perimeter in a continuous stretch. This bumper must be the outermost structure at all times when the robot is moving.
14. The bumper must present a vertical surface at least 2.54-cm (1") high and cover, at a minimum, the space from 3.81-cm (1 ½") to 6.35-cm (2 ½") above the playing field.
15. The bumper may be of any shape around the robot and need not be outwardly convex on all surfaces but must not have any radius of curvature less than 1-cm.
16. The bumper must be included in the maximum 22.86-cm (9") x 22.86-cm (9") x 27.94-cm (11") (L x W x H) overall size.
17. In addition to meeting safe operation requirements, a robot will need to pass the size qualification.

18. Robots may be modified physically, reprogrammed, and/or recharged between each match. However, any physical modification will require a re-inspection for safety and overall size compliance.
19. Robots that do not meet these requirements will not qualify and will not be allowed to compete.

VII. Rules

1. Robots must be completely autonomous.
2. Robots must be self-contained and remain a single unit (cannot break apart).
3. Robots may be no larger than 22.86-cm (9") x 22.86-cm (9") x 27.94-cm (11") (L x W x H) at the start or while in motion.
4. A size and safety qualification inspection will be done prior to each round of play.
5. Robots must not damage the playing field, halt competition or require repair of the playing field. Doing so will result in either point deduction or disqualification depending on the severity.
6. There are two qualifying rounds followed by a quarter-final, semi-final, and final round.
7. The scoring for each qualifying round is cumulative.
8. The top 8 scoring teams from the qualifiers will move on to the quarter-final round.
9. The quarter-final round consists of 4 matches.
10. The semi-final round consists of 2 matches.
11. The final round consists of a single match.
12. During the two qualifying rounds, there will be only one robot on the playing field.
13. During the quarter-final, semi-final, and final rounds (see ATTACHMENT B), there will be two robots competing on the playing field at the same time.
14. Prior to the beginning of each round, the next team(s) to play will be announced. They must present their qualifying robots and place them on their designated corner square (home base) within one minute of their announcement. Missing the announcement deadline will result in disqualification of the missing team(s) for that round.
15. For each round, home bases will be randomly selected by the flip of a coin by one of the contest officials. For final rounds, the opponent will be placed on the opposite corner from the first randomly selected home base.
16. A hands-off period will follow the placement of a robot on the playing field. During this time, twelve (12) objects will **RANDOMLY** be placed in Zone 2 on the playing field.
17. After the objects have been placed on the playing field, a contest official will give a verbal start command. A team member will then manually start the robot by pressing a button or flipping a switch on the top of the robot. No further interaction between the robot and a team member is allowed during a round.
18. Team members are not allowed to enter the playing field or touch their robot until the three-minute match ends or a team decides to terminate its participation.
19. Any points scored until early play termination for a team will count towards the final point tally for that round.
20. A round is three minutes from the point that the start command is given until a buzzer sounds the end of a round.
21. Upon start of the match, the robots will depart from the home base and enter Zone 1.

22. Manipulation of the objects are left for each team to decide. The goal of the match will be to de-orbit as many objects from Zone 2 to Zone 1 (which includes home base) as possible.
23. If a robot carrying an object is in any part of the home square at the end of play, all the objects it carries will score.
24. During final rounds, debris objects placed in an opponent's home square will score for the opponent.
25. "In a base" will be interpreted as meaning that any portion of an object is within the boundary of the assigned home base square. If an object is placed wholly or partially on another object within an assigned home base square, it will count as being in the base square.
26. **The contest's judge decision is final regarding whether a block is in scoring position or not**.
27. Destructive Interference: A team may not take any action that purposely interferes with the course of play or causes damage to the playing field or competing robot. Based on Judges' opinion, if the robot is damaging the field of play or interferes with operation of opposing robot, the impeding robot will be subject to disqualification for that match.
28. **Teams should use caution in filing appeals. Unsuccessful appeals will cause a 40 point deduction from the Team filing the appeal if, after review, the Judges determine that the original scoring was correct.**
29. **Judges decisions are final.**
30. **Violations of IEEE code of ethics and code of conduct will not be tolerated and will result in point deduction, disqualification, or ejection from the event based on the severity of the violation.**
31. **When addressing judges with questions teams are expected to act within the IEEE code of conduct. Only one designated team captain can address the judges for written or verbal decision appeals.**

VIII. Judging & Scoring

1. Points may be earned by:
   a. Exiting the starting base and entering Zone 1
   b. Crossing over from Zone 1 and into Zone 2
   c. Orbiting the playing field in a counter-clockwise direction in Zone 2
   d. Removing orbital debris from Zone 2 to Zone 1
   e. Delivering orbital debris to a home base
   f. Finishing in the assigned home base
   g. Raising an on-board flag
2. Points awarded per task are as follows:
   a. Five (5) points are awarded to a robot that completely leaves the starting square and enters Zone 1.
   b. Five (5) points are awarded for the first time a robot enters Zone 2 (the orbital circle).
   c. Five (5) points are awarded for every complete, counter-clockwise orbit of the playing field.

d. Ten (10) points are awarded for each debris removed from Zone 2, and an additional ten (10) points for blocks placed in corner squares (total of 240 points).
e. During preliminary rounds, if a robot places a color matched debris in the associated color corner, ten (10) additional bonus points will be awarded (total of 120 bonus points)
f. Ten (10) points are awarded for a robot residing in its home base at the end of a round.
g. Twenty (25) points are awarded to a robot that raises an on-board teams' school, State, territory or US flag at the end of a round and while in home base.
h. If a robot carrying an object is in any part of the home square at the end of play, all the objects it carries will score.
i. "In a base" will be interpreted as meaning that any portion of an object is within the boundary of the assigned home base square. If an object is placed wholly or partially on another object within an assigned home base square, it will count as being in the base square.
j. A penalty of ten (10) points will be subtracted from a positive score for every separate collision of a Spacetel object.

Table 1 Scoring

Points	**Task**
5 pts	Leave home base and enter Zone 1
5 pts	Cross the orbital line into Zone 2 (first time only)
5 pts	For each complete, counter-clockwise orbit within Zone 2, starting from the quadrant closest to designated corner square
10 pts	Debris removed from Zone 2 (each)
10 pts	Debris placed in home base (additional to removal)
10 pts	Color-matched debris placed in appropriate color corner square (bonus points)
10 pts	Finish in your home base
25 pts	At conclusion of debris removal, raise your onboard flag while in home base
-10 pts	Every collision with a Spacetel

3. During the playoff rounds, debris objects placed in an opponent's home square will score for the opponent.
4. **The contest's judge decision is final regarding whether a block is in scoring position or not**.

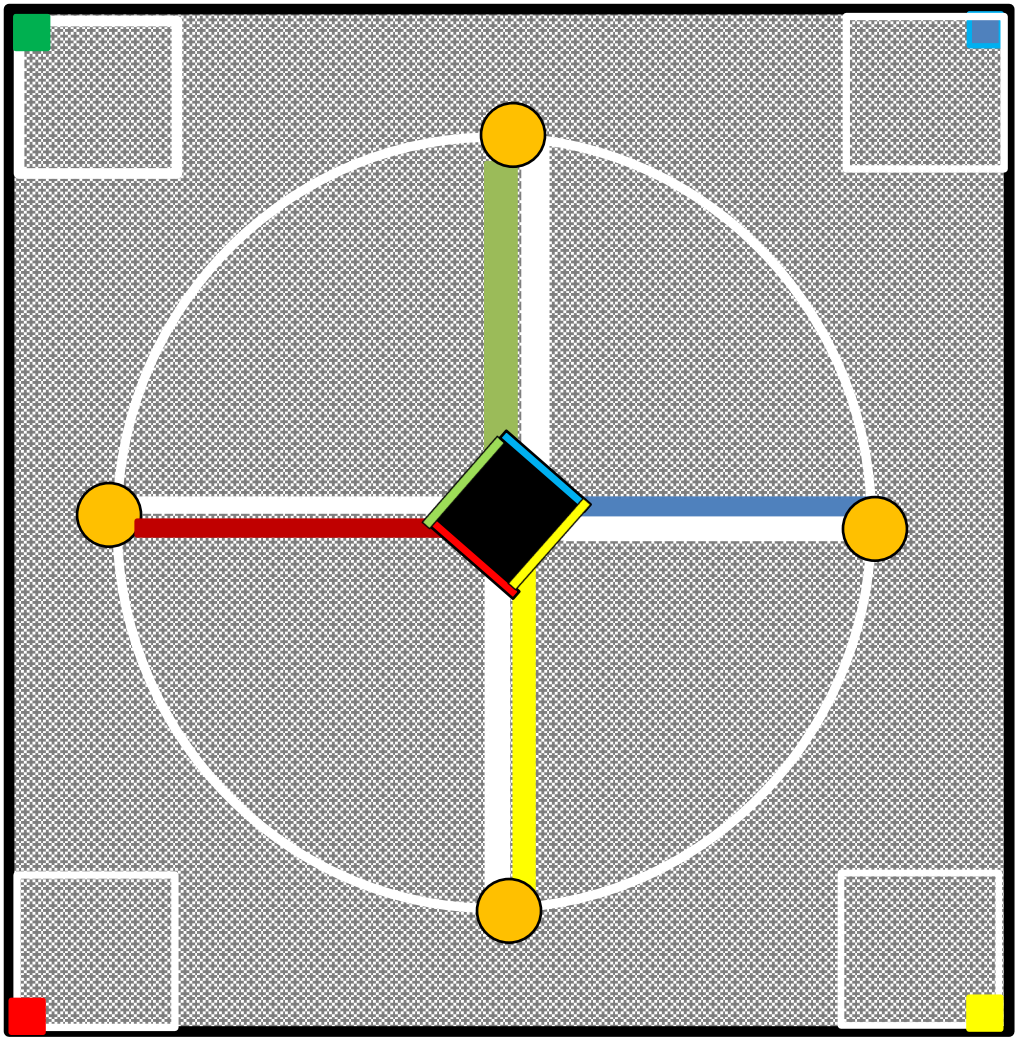
IX. Tournament Format

1. There will be two qualifying rounds of play for all robots, and final rounds for the eight highest scoring robots.
2. Each team will play two preliminary rounds in which only one robot will be on the playing field.
3. The final score for a team will be the sum of points accumulated in the preliminary rounds. A team's qualifying rank will be determined by its final score. The highest scores will determine the top eight teams.
4. In case of ties, i.e. more than eight teams qualify for the Quarterfinals, the number of debris removed from Zone 2, will be used as a tiebreaker. If more than eight teams still qualify, additional, single robot rounds will be held for the tied teams.
5. During the Round of 8 (Quarterfinals), top eight teams will play each other in head-to-head single-elimination competition, with two robots competing for objects on the same playing field.
6. The winning 4 teams in the quarter-finals will advance to the Semi-finals.
7. The losing robots in semi-finals will play each other in the Final round for determination of the third-place team.
8. The winning robots in semifinals will play each other in the Final round for determination first and second place team. The play-off elimination ladder is shown in ATTACHMENT B.
9. The Finals Round will be held during the Saturday evening Banquet.
10. IEEE student membership is required of all team members participating in the competition. Only one entry is allowed per school and the school must be in Region 3 (Southeast) and have registered by March 30, 2019. A team registration form is located on the web site.

X. Tolerances

All materials, sizes, and construction techniques and tolerances are given in ATTACHMENT A.

ATTACHMENT A



Playing Field Materials

1. Carpet Base: Any low pile carpet of a similarly dark color, cut to 9' length. For example: Mohawk Home and Office 12-ft W x Cut-to-Length JETTY Berber/Loop Interior Carpet (Lowe's **Item #** 847612 **Model #** LC51-12-L00). Cut to 9' length.
2. Carpet Tape: Roberts Indoor/Outdoor 3 in. x 15 ft. Double-Sided Carpet Tape Roll (Home Depot Model # 50-605-12 Internet #100645279, Store SKU #950986).
3. Wall Material: 1 in. x 12 in. x 8 ft. Primed Pine Finger-Joint Board (Home Depot **Model #** PFJB1128, *Internet* #203422125, **Store SKU** #352317) will sit on top of the carpeted playing field base.
4. Center Structure: 23-cm (9") x 23-cm (9") x 30-cm (11-13/16") high plywood box placed in the center of the playing field, as indicated in the figure above.
5. Tape Specifications: Five 1.88"-wide duct tape types are used (Yellow, Red, Electric Blue, Neon Green, and White). Walmart part numbers: Red (392874), Yellow (3M

Duct Tape, Yellow, 3920-YL), Neon Green (280839), Electric Blue (CDT-13110), White (280857).

6. Debris Objects:
   a. Eight (8) two-inch wooden cubes (rounded edges) (https://www.amazon.com/Set-15-Large-Wooden-Blocks/dp/B079WNTPQ1/) Two cubes will be painted with the red paint, two with the paint, two with the paint, and two with the green paint.
   b. Four 2 ½" diameter pit balls (for instance https://www.walmart.com/ip/Kiddy-Up-Pit-Balls-100pk/54651159). One each red, yellow, blue and green.
7. Spacetel Lights. A 3.03" diameter by 1.8", amber LED flashing light is placed at the intersection of each colored tape strip and the white orbital circle (Velleman HAA40AN - https://www.jameco.com/z/HAA40AN-Velleman-3-03-12VDC-Amber-LED-Flashing-Light_2247808.html). The lights will be operated at nine volts D.C.
8. Paint Specifications for Wooden Cube Debris Objects and Corner Posts:
   a. White Paint:
      i. Base: Glidden Pre GLN9011N
      ii.

CLRNT	BL	IL	LL
oz	0	0	0
384th	4	4	24

   b. Red Paint:
      i. Base: Glidden Pre int Lt/FLAT, MATTE GLN9013N
      ii.

CLRNT	KXL	EUL	VUL
oz	1	8	5
384th	140	352	272

   c. Yellow Paint:
      i. Base: Glidden Pre int Lt/FLAT, MATTE GLN9013N
      ii.

CLRNT	AXL	KXL	TL
oz	11	0	3
384th	252	260	252

   d. Blue Paint:
      i. Base: Glidden Pre int Lt/FLAT, MATTE GLN9013N
      ii.

CLRNT	DL	EL	KXL
oz	0	3	12
384th	312	68	0

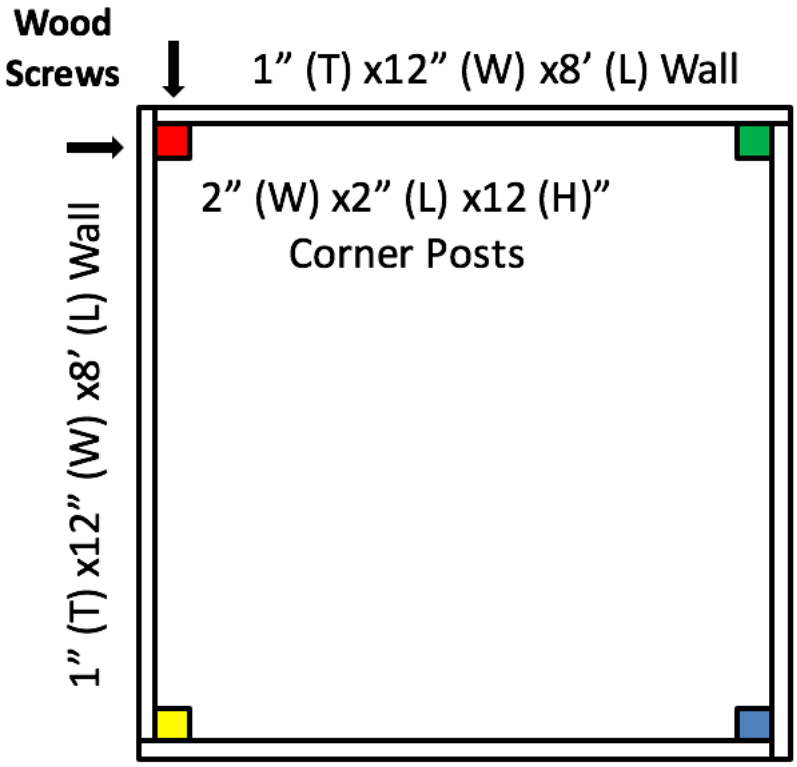
Construction Details

Playing Field - The walls overlap and are held together with 2"x2" lumber that is screwed to the wall elements from the outside. The wall structure sits on top of a 9'x9' carpet. The posts are covered with colored tape as shown in the diagram below.

Double-sided carpet tape will be applied between the carpet and the colored tape to hold the colored tape more securely to the carpet. Using a rolling pin (or a piece of PVC pipe) to roll over the tape aids in the tape adhesion.

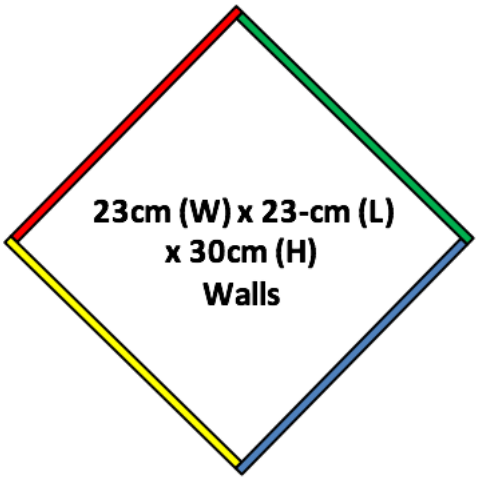
The one meter radius, one (1") inch wide white circle can be constructed by first drawing a one meter radius circle with a piece of chalk onto the carpet. Strips of the 2 inch wide carpet tape and then white tape are placed over the chalk circle to form a

series of overlapping segments. A black marker pen is then used to draw two circles over the white tape, at 1 meter +/- ½ inch radii. An Exacto knife or box cutter is then used the cut away the excess tape.



Center Structure

The center structure box walls are covered with colored tape to match the floor tape. The red box wall faces the red corner post and similarly for the other box walls.



Debris Objects

The wooden cube objects will have all edges sanded round. Then they will be color-coded using paint with the above listed paint specifications.

Corner Posts

The corner posts will be painted to match the debris objects.

Spacetel Lights

Each light will be hot glued to a 1"x3"x3" pine board painted black. The board will be attached to the carpet with Velcro. Power leads will run down through the carpet and out one side of the playing field wall. A 12v wall transformer connected to a 9V regulator will power the lights.

Dimensional Tolerances

The overall playing field size will have a size tolerance of +/- 2-cm. We will strive for 1-cm tolerance, but wood is not a precise medium and the size is also subject to humidity changes.

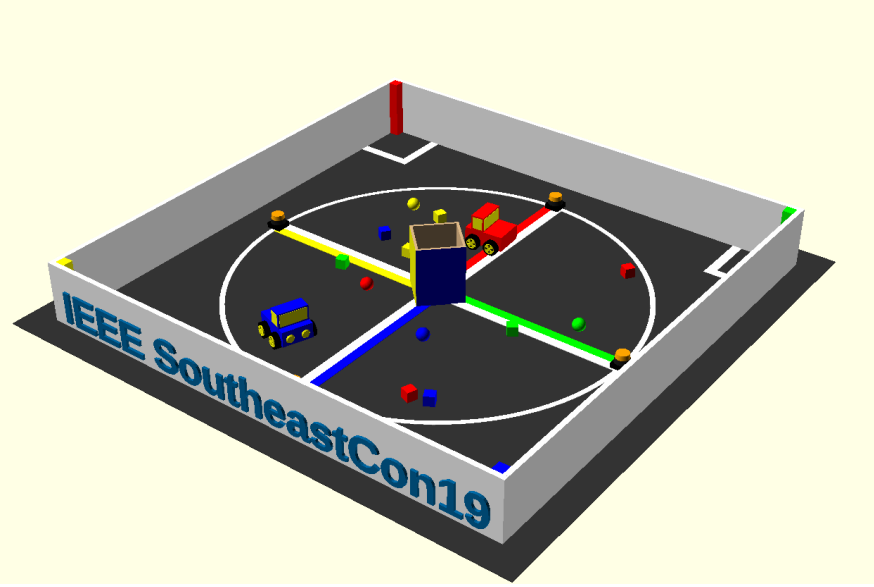


Figure 1 - Field of Play (location and quantity of debris is notional) with notional robots

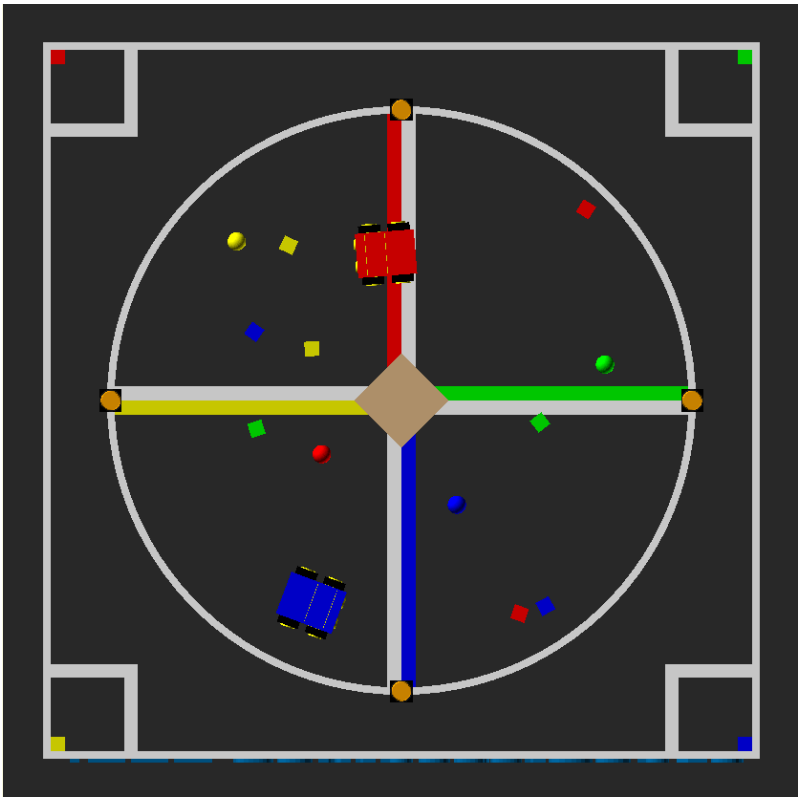


Figure 2 - Top View of Field of Play (location of debris in notional) with notional robots

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ATTACHMENT B

Playoff Round Ladder

1st Rank Team			2nd Rank Team
	Winner A	Winner B	
8th Rank Team			7th Rank Team
3rd Rank Team			4th Rank Team
	Winner C	Winner D	
5th Rank Team			6th Rank Team

Semi-Final Round Ladder

Winner A			Winner B
	Winner A'	**Winner B'**	
Winner D			Winner C

Final Round Ladder

Winner A'	**First Place Winner**	Winner B'

Loser A'	**Third Place Winner**	Loser B'