

2023 IEEE Region 5 Annual
Conference

Rules for a Student Robotics Competition

This document contains the rules of the 2023 Region 5 Robotics Competition. The competition is open to teams of no more than 5 and no less than 2 undergraduate students who are enrolled in a College or University with a student chapter within the IEEE Region 5 boundaries. The competition encourages a multidisciplinary approach to robot development and recognizes the participation of students who may already be members of SAE, ASME, EEGS, etc. Therefore, only one team member will be required to be a current IEEE Student Member.

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Competition Overview

The 2023 student robotics competition will encourage cooperative behaviors between ground robots and small drones. It expands on Denver's 2021 drone-based pandemic competition and Denver's 2017 ground-based tunnel mapping competition. Working together and leveraging the strengths of each platform, the two platforms will communicate to negotiate a series of simple obstacles. Both platforms may only communicate with each other.

Possible real-world applications might be autonomous delivery trucks moving through an urban area with one or more drones landing to gather packages for autonomous delivery. Another application might be an autonomous ship moving through a navigable river with one or more drones monitoring the status of stormwater outflows.

Based on lessons learned in 2017, Denver will strive to lower financial barriers by minimizing the complexity and cost of practice fields. Minimizing the complexity and cost of the competition field generally implies the ground platforms will operate on the carpeting and under the available lighting of the competition venue. It will never be too early in a team's concept design phase to consider uneven surfaces, imperfect carpet seams, wall, and ceiling color variations, and most importantly - the lighting irregularities commonly found in a conference hall.

The competition venue will be the Hyatt Regency Aurora-Denver Conference Center, 13200 E 14th Pl, Aurora, CO 80011

Introduction and General Round Description

The basic objective of the competition is for a ground robot to enter cardboard boxes in the correct order and finish near a designated Done box before time elapses. A drone will assist in guiding the ground robot to the next correct box. Variations on this theme are employed in each competition round.

The ground robot will have a landing pad for the drone. The rounds will begin with the drone on the ground robot's landing pad. At the finish, a successful Team will have landed their drone on a ground robot's landing pad.

Each cardboard box has an ID. The Box ID is represented by a QR Code and printed on the outer top surface. The drone will be required to read and interpret this QR Code.

The next box's ID is represented by a QR Code and printed inside each box on the inner top surface. The ground robot will be required to read and interpret this QR Code.

The round will begin with the drone on the ground robot's landing pad. The pair will be placed in a Start Area near the First Box. The round timing will begin when the Scoring Judge says GO. The ground robot will completely enter the First Box and read the Next Box ID. It will direct the drone to locate the Next Box by searching for the QR Code on top of each box. Once the drone locates the Next Box, it will help the ground robot find the Next Box. The Final Box will have the QR Code for Done. The task is complete when the ground robot exits the Final Box and the drone lands on the ground robot's landing pad. See **Figure 1** for a simple layout. All of the Boxes and Start Area are within the competition field. The Start Area will generally be the same for each Team in each Round.

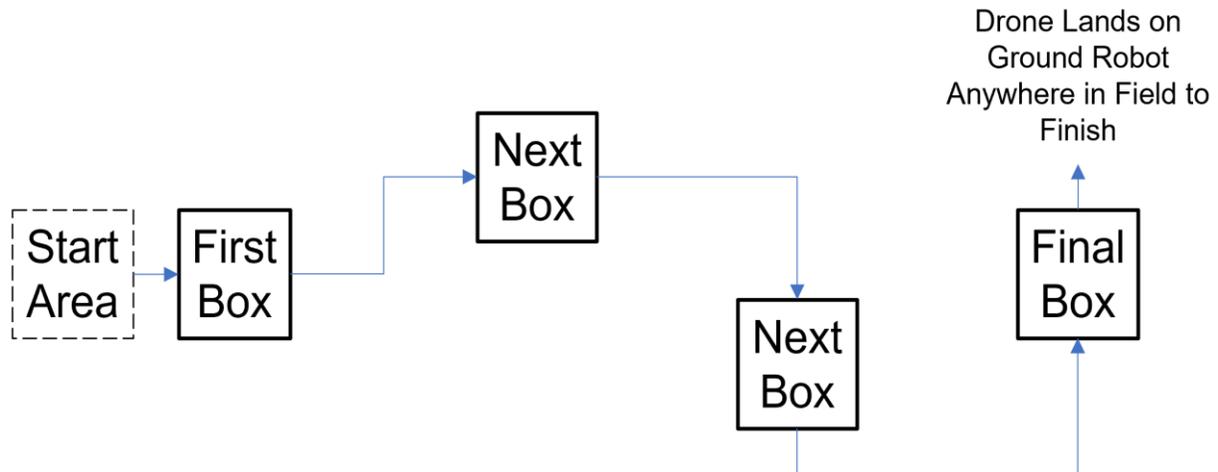


Figure 1 - Simple Field Layout with Possible Path of Drone and Ground Robot

Each Box will have an opening cut into the “front” and “back”. Reflective tape will outline the openings. After being assisted into the vicinity of the Next Box by the drone, the ground robot will locate an opening, enter the box completely to read the QR Code and exit using either opening.

Round 1 – One Player Field

Teams will perform this round as the sole participant.

Points will be awarded for each Box the ground robot enters in the correct order. Points will be awarded for a single “touch & go” landing on the ground robot’s landing pad between Boxes entered in the correct order.

1. Minimum “touch & go” duration - we recommend landing long enough to make it obvious to the Field Judge that a full landing with all gear on the pad was completed.
2. Maximum “touch & go” duration - take off before the ground robot enters a box.

The drone blades may or may not be turning to qualify as a “touch & go” landing.

Round 2 – Multiplayer Field

Two (2) Teams will perform this round. To shorten the round, Teams will have a minimal amount of Boxes to navigate and the Field layout will strive to minimize, but not guarantee robot interactions.

Points will be awarded for each Box the ground robot enters in the correct order. Points will be awarded for a single “touch & go” landing on the ground robot’s landing pad between Boxes entered in the correct order.

1. Minimum “touch & go” duration - we recommend landing long enough to make it obvious to the Field Judge that a full landing with all gear on the pad was completed.
2. Maximum “touch & go” duration - take off before the ground robot enters a box.

The drone blades may or may not be turning to qualify as a “touch & go” landing.

If a ground robot exits the Final Box and the drone lands on its landing pad, the drone may choose to become “Poison”. If it chooses to be Poison, it will take off and search for the opposing Team’s ground robot and land on its EMPTY landing pad. If the Poison drone successfully lands on the opposing team’s EMPTY landing pad, the round is over and the “Poisoned” Team loses all points collected in the round. If the total time allowed for the round expires before a Team is Poisoned, there is no change in points awarded to either Team.

Prior to the round, Team Pairings will be randomly selected by the Head Judge. In the event of an odd number of Teams, any Team wanting a chance to improve their score, will be given an opportunity to be randomly selected for a pairing with the odd Team. Filling the odd Team selection will be made after the Team pairings are completed. If no Team volunteers, a single die will be rolled. The points showing will be the Award place given the odd Team. Sixes will be rolled again.

Robot Requirements

Drone – Only one drone per Team is allowed to compete in each Round. Any commercially available (RYZE) DJI Tello model is acceptable. All modifications and attachments to the drone are permitted EXCEPT the factory propellers, propeller guards, motors, motor drive system and batteries cannot be modified. While on the Competition Field, the drone can only communicate with the ground robot.

Ground Robot – Only one ground robot per Team is allowed to compete in each Round. While on the Competition Field, the ground robot can only communicate with the drone. The ground robot must have a fixed, non-movable horizontal landing pad mounted at the highest point on the robot. There cannot be any part of the robot extending above the landing pad. The landing pad must be flat with no indentations or protrusions greater than 1-millimeter. The horizontal length and width of the landing pad must greater than or equal to 20-centimeters x 20-centimeters. The landing pad must reasonably support the weight of a Tello drone and cannot be equipped with any device that restricts a “Poison” drone from landing. The ground robot must have a Master ON/OFF Switch mounted in a location easily visible to the Field Judge and easily accessible by a Team member. After being directed by the Field Judge to begin the Round, a designated Team member will use the Master switch to enable the ground robot and drone to initiate activities. The overall size and weight of the ground robot is undefined, however we do suggest noting the dimensions of the openings on the Boxes.

Autonomous Operation

The Ground Robot and the Drone must be autonomous. Communication is only allowed between the two systems. No ground station or off-board electronics are permitted.

Wi-Fi

Teams may use a Wi-Fi repeater under these conditions.

1. It must be physically attached to the ground robot or the drone
2. It cannot be operated in the competition hall except during one of your Team’s rounds or during Friday practice.
3. It can only talk to your Team’s ground robot and drone. It must not communicate with any other device during the competition.
4. **IMPORTANT** - Every Team must post a statement to the Google Group on April 1, 2023 or sooner stating that to the best of your Team’s ability their Wi-Fi is configured to not interfere with any other team's devices.

Competition Field

One to four competition fields will be setup in the venue. The field length will be 30 feet. The field width will be 20 feet. Each field will have netting supported on the perimeter to minimize injuries. The netting will be sourced from https://www.tractorsupply.com/tsc/product/tenax-deer-fence-177-in-x-197-in-mesh-100-ft-length-1a100140?cm_vc=-10005 or similar. Two (2) inch wide blue Gaffer's Tape will be placed on the carpet, 12 to 14-inches inside the netting to mark the inside boundary of the fields. The Gaffer's Tape will be sourced from https://www.amazon.com/dp/B01C9AXMSA/ref=redir_mobile_desktop?encoding=UTF8&aaxitk=3cabbc60986ed8a55f18e4de457dad11&content-id=amzn1.sym.552bcbb2-81a1-4e8b-b868-3fba7d5af42a%3Aamzn1.sym.552bcbb2-81a1-4e8b-b868-3fba7d5af42a&hsa_cr_id=5337034270001&pd_rd_plhdr=t&pd_rd_r=47f0eaa7-33e1-4ea4-acda-b0f3762ba475&pd_rd_w=RjLEM&pd_rd_wg=phSaA&qid=1668376737&ref=sbx_be_s_sparkle_lsi4d_asin_0_img&sr=1-1-9e67e56a-6f64-441f-a281-df67fc737124&th=1 or similar. Please note that the drones required for this competition have blade guards and have been used in school competitions around the world without nets.

The Box locations within each Competition Field will not be changed between Teams during Flights 1-4 of Round 1, Flights 5-8 of Round 1 and all of Round 2. The intent is to provide a consistent lighting and terrain to each Team competing on a specific Competition Field. We have no intention of making the lighting and terrain consistent between individual Competition Fields. The Box locations (layout) may not be identical from Competition Field to Competition Field during a Round. If a Box is moved by a robot during a Round, a Judge will return it to its original location to the best of their ability.

The venue carpeting details provided by the venue are shown in **Figure 2**. Please recall the introductory rule comments regarding carpet variability. Additional carpet photos can be found in a Google Group conversation dated November 15, 2022.

Carpet	Ballroom	Tai Ping Axminster Carpet - Custom Pattern #FX01294-166NF; Construction: 80% Wool 20% Nylon Woven Axminster; 10 Row; .250 Pile Height; Width 12' or 4M; Colors 9-12 Color Catching.
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Figure 2 - Venue Carpeting Details

Judges will be encouraged to remain outside the netting, however, please note they may choose to stand between the blue Gaffer's Tape and netting near the field entrance as necessary.

Boxes

The boxes will be modified Extra Large Moving Boxes, Home Depot SKU #1006188676. The dimensions of a box are length 24-inches, width 20-inches, and depth 21-inches. The openings will be a minimum of 15-inches wide by 15-inches tall and cut in the 24-inch sides. The location of the opening on the 24-in sides will be such that sufficient space is available to mount the 2-in wide reflective tape. The edge of the tape will be aligned, to the best of our ability, with the cut edges. The side of the box resting on the venue floor will be cut away between the openings to expose the venue floor. The inner and outer edge of the openings intended for use by the ground robot will be outlined in Red High Visibility DOT-C2 Reflective Tape 2-inches wide manufactured by Qomovo and available on Amazon. Clear packing tape will be used to assemble and modify the box. A Team should not see more than seven (7) boxes including the Done box. See **Figure 3** for a representative sketch.

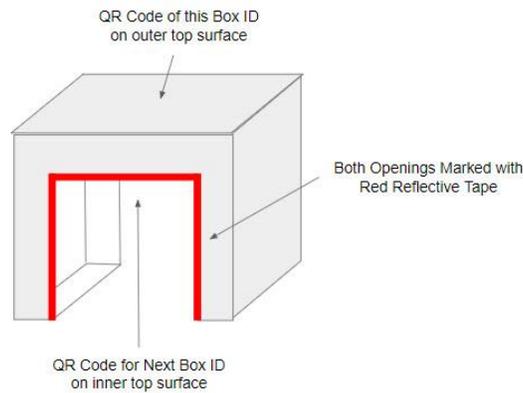


Figure 3 - Simple Box Sketch

QR Code Size, Type and Mounting

The dimensions of the printed QR Code will be square. The sides of the QR Code will 4-inches by 4-inches and centered on a 8.5-in by 11-in paper. The QR Codes will be laser printed on HP Copy&Print20 paper or similar. The HP paper has a brightness of 92 and a whiteness of 155. The Toner cartridge is a Brother TN-730 or TN-760. The QR Code will be centered to the best of the Judge’s ability and attached to the box using any number of adhesive methods. The methods will not cover the QR Code.

The library of QR Codes for the competition are shown in **Table 1**.

A	B	C	D
E	F	Done	

Table 1 – QR Codes

The QR Codes will be static. On the outer top surface and inner top surface of the boxes the QR Codes will be aligned with the 24-inch side of the Boxes as shown in **Figure 4**. Files containing the QR Codes are found in a November 25, 2022 Google Group conversation.



Figure 4 - Alignment of QR Code with Box Sides

In Round 2, Teams will not share boxes A-F. It is possible to have more than one Done Box. We will do our best to place the boxes to minimize the likelihood of interference.

Gameplay / Order of Operations

Rounds will proceed as follows:

1. T-20 minutes - Twenty (20) minutes prior to the start of a Round, teams will have 5 minutes to deliver their robot to the Quarantine Area.
2. T-15 minutes – Fifteen (15) minutes prior to the start of a Round, all robots are required to be in the Quarantine Area. The Quarantine Area will be closed. A Judge will have an opportunity to assess the robot field for rule infractions.
3. T-15 minutes – Configuration of the game fields by Judges and assistants will begin.
4. T-0 minutes – The fields are ready to begin the Round.
5. The Head Judge table will display the order of competition for each game field.
6. The public address system will call the first flight of robots to their respective game fields.
7. Upon entry to the Competition Field Area, the Team Lead will place their robot fully within the START area.
8. Upon hearing the Scoring Judge say GO, the Timing Judge will start the Field Clock and the Team Lead is expected to start their robot. The Team Lead is the only person authorized to touch the robot to complete a Round. See End of Round Conditions.
9. Elapsed Time starts when the Timing Judge says “GO” and starts the Field Clock. Elapsed Time ends when any one of the End of Round Conditions occurs.
10. After any End of Round condition occurs, the Scoring Judge will ask the Team Lead to remove the robot from the Game Field and the remaining team members will leave the Game Field area.

Steps 1-6 will be repeated prior to each competition round.

Steps 7-10 will be repeated within each round until all robots in the Quarantine Area are given an opportunity to compete.

End of Gameplay Conditions

1. A team member touches the ground robot or drone after the Team has started their robot
2. Elapsed Time reaches ten (10) minutes
3. Any robot leaves or touches the Competition Field perimeter (netting)
4. A drone clearly flies above the Competition Field ceiling (8 feet above venue carpet)
5. The Round ends ONLY for the Team who’s ground robot touches a box
6. When opposing team robots touch each other EXCEPT when a POISON Drone has landed. There will be no attempt to assign FAULT and no penalties will be given.
7. The Poison Drone lands on the opposing Team’s landing pad and satisfies the “touch & go” criteria.

Scoring

Round 1 Scoring

- One (1) point for every box entered in the correct order.
- One (1) point for each single “touch & go” landing between Boxes entered in the correct order

Round 2 Scoring

- One (1) point for every box entered in the correct order
- One (1) point for each single “touch & go” landing between Boxes entered in the correct order

Only one “touch & go” point will be awarded between Boxes

Award Determination

- The highest robot point total in each round will be awarded First Place
- The second highest robot point total in each round will be awarded Second Place
- The third highest robot point total in each round will be awarded Third Place
- A tie will be decided by the Tie Breakers below
- If the head judge determines a team has communicated with their robots during the round, they risk forfeiting awards.

Award Distribution

Monetary awards will be given to the top five (5) finishers in each Round. The award amounts and disbursement process will be provided on the Region 5 Student Competition website

Tie Breakers

First Tie Breaker - Team with the highest number of single “touch and go” landings between boxes

Second Tie Breaker – Team with the shortest elapsed time to enter the First Box after the scoring Judge announces GO. If a tie remains, Teams will split the award

Game Restrictions

Flash photography is prohibited during the competition. No light sources external to the robots may be used by teams during the competition

Team Registration

All undergraduate student members of the Team attending the competition must complete a paid registration using the Region 5 Student Competition website. Please contact the IEEE Region 5 Student Activities Chair for all other persons affiliated with the Team.

Glossary of Key Terms

Competition Field Perimeter – the perimeter is defined by the netting

Competition Field Ceiling – the ceiling is 8 feet above the venue carpeting and generally judged in comparison to the height of the perimeter netting

Head Judge – A Denver Section Robot Committee Member who makes all final rule decisions and award determinations

Scoring Judge – Reports all points and penalties to the Timing Judge

Timing Judge – Records all timed tasks and submits judging sheets to Head Judge

Elapsed Time – The time interval between when the Scoring Judge announces “GO” and the moment when any End of Round Condition occurs.

Field Clock – The timing device controlled by the Timing Judge

Change Log

Change #	Description of Change	Page	Date
1	Added "All of the Boxes and Start Area are within the competition field. The Start Area will generally be the same for each Team in each Round"	2	12/30/2022
2	Clarified that to "enter" a Box a ground robot must completely enter the Box	3	12/30/2022
3	Clarified "touch & go" landings	3	12/30/2022
4	Added Wi-Fi Section	4	12/30/2022
5	Added Autonomous Operation	4	12/30/2022
6	Added Location of 15-in x 15-in opening in Boxes	5	12/30/2022
7	Added field Netting and Gaffer's Tape	5	12/30/2022
8	Updated Box Locations within a Round and from Field to Field in the Competition Field Section.	5	12/30/2022
9	Added Venue carpet details	5	12/30/2022
10	Set field dimensions to 20 feet x 30 feet	5	12/30/2022
11	Added "In Round 2, Teams will not share boxes A-F."	6	12/30/2022
12	Added Section "QR Code Size, Type and Mounting"	6	12/30/2022
13	Updated End of Gameplay Conditions	7	12/30/2022
14	Added "touch & go landings" to Glossary	8	12/30/2022
15	Added Competition Field Perimeter to Glossary	8	12/30/2022
16	Added Competition Field Ceiling to Glossary	8	12/30/2022
17	Updated last paragraph to "The round timing will begin when the Scoring Judge says GO"	2	3/31/2023
18	Updated Competition Field. "The Box locations within each Competition Field will not be changed between Teams during Flights 1-4 of Round 1, Flights 5-8 of Round 1 and all of Round 2."	5	3/31/2023
19	Updated Competition Field. "Judges will be encouraged to remain outside the netting, however, please note they may choose to stand between the blue Gaffer's Tape and netting near the field entrance as necessary."	5	3/31/2023
20	Updated Gameplay / Order of Operations step 8 "Upon hearing the Scoring Judge say GO, the Timing Judge will start the Field Clock..."	7	3/31/2023
21	End of Gameplay Conditions. Added "7. The Poison Drone lands on the opposing Team's landing pad and satisfies the "touch & go" criteria.	7	3/31/2023
22	Scoring. "Only one "touch & go" point will be awarded between Boxes"	7	3/31/2023
23	Per the IEEE website, deleted Fourth and Fifth Places	8	3/31/2023
24	Glossary. Updated Scoring and Timing Judge	8	3/31/2023
25	Glossary. Deleted "touch & go" as it is defined on page 3	8	3/31/2023