

# 2020 IEEE Robotics Competition

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# Introduction

## Overview

This section describes the motivation for and overview of the 2020 IEEE R5 robotics competition.

## Theme

Pollution of various forms is an ever-present problem in our modern world. For the last 50 years, considerable attention has been focused on larger institutional sources of pollution, and while there is more to do, significant progress has been made. Many individuals have also learned to make better personal choices, yet the basic problem of litter remains pervasive worldwide. There are still large numbers of people that feel entitled to simply drop or toss waste items they are through with wherever they are. This is particularly evident walking along a roadside, or looking in or underneath the stands after a sporting event. In much of IEEE region 5, high winds and open country allow outdoor litter to be dispersed from its source into other settings. It commonly finds its way into streams and lakes, where it causes additional environmental problems. It also commonly appears on the grounds of people that have personally made efforts to avoid creating litter, insulting them and adding to their burdens.

There are three different approaches required to address this problem. It is important to educate those who do not already know better about the consequences of their behavior. It is also important to create a form of accountability for those that continue polluting behavior. Finally, it is important to responsibly clean up the mess before it creates greater problems. This year's game has elements representing each of these areas. But unlike many former games, we are not merely cleaning up some symbolic representation of trash; we will actually be picking up and properly disposing of four extremely common articles of actual litter. With a modest amount of additional work, we expect a successful robot from this year's competition could actually be used to help clean up areas that have been badly littered, such as grounds after a sporting event.

## The Contest

Competitors will be tasked to pick up items of litter on a 12ft X 12ft standard VEX robotics field. This size field, although larger than has been used for the IEEE R5 robotics competition in the past, was selected to better scale the robots and the game to the sizes of actual articles of litter.

The game will include the following items of litter

- aluminum soft drink cans,
- plastic water bottles,
- snack size chip bags
- paper trays commonly used for serving concession food.

The competing robots will share the field with a robotic adversary that will display the worst habits of a habitual litterbug. This litterbug will disperse litter during the round in a random manner, while chattering in some uniquely robotish dialect.

- By responding appropriately to the litterbug's chatter, the competitor will have the ability to convince the litterbug to stop disbursing additional pieces of litter of a specific type.
- By catching the litterbug in the act of littering the competitor will hold the litterbug accountable. What constitutes 'catching' will be described in future rules updates.
- By successfully removing the litter items from the playing surface and by placing these items in an appropriate bin located to the side of the playing field teams will earn points in a given match.

The contest will be held on Saturday, April 4, 2020 in the One Broadway ballroom of the Sheraton Downtown Oklahoma City. All awards will be based on performance at this event.

Scrimmage events will be held on the campus of Oklahoma Christian University on a Saturday in November 2019 and February 2020. A small fee will be required of each team participating at each scrimmage to cover the costs associated with the event. Lunch will likely be provided. We hope that the scrimmage events will be fun and exciting, and will lead to a higher quality final competition in April.

# The Game

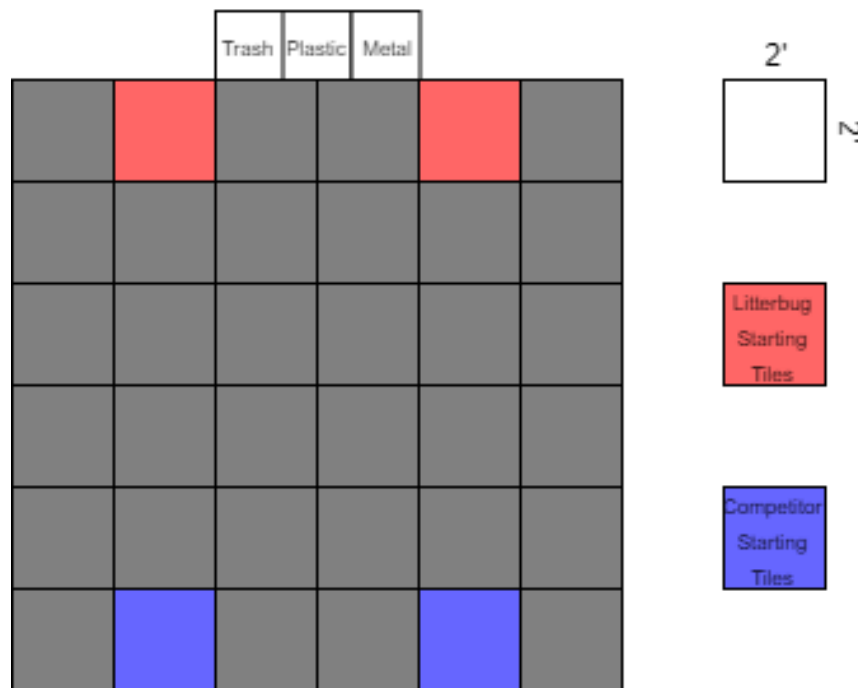
## Overview

This section describes the arena, game pieces, the litterbug, and general rules for the 2020 IEEE robotics competition.

## The Arena

The arena will be a standard 12ft X 12ft VEX robotics field with border walls functionally equivalent to standard VEX borders. The field will be made of 36 2ft X 2ft foam tiles. 32 grey tiles, 2 red tiles, and 2 blue tiles. The border will be approximately 11.5 inches tall and surround the entire field. The red tiles are possible starting locations for the litterbug. The starting location for the litterbug will be chosen at random by the game management system. The blue tiles are the possible starting locations for the competitor's robot. Once the litterbug has been placed, the competitor will place their robot on the blue starting tile farthest from the chosen litterbug starting location.

Judging Tables



More detailed information about the playing field can be found at the VEX competition products website.

The Tiles:

<https://www.vexrobotics.com/278-1502.html>

The Border:

<https://www.vexrobotics.com/278-1501.html>

The Bins:

Bins for metal (soft drink cans), plastic (water bottles), and trash (chip bags and paper trays) will be located on the designated side of the field outside of the border. These bins will have the same approximate height as the border. The exact dimensions will be published with a future update of these rules, but they will all be of equal size and large enough to easily fit all game pieces.

## The Game Pieces

- 1) Aluminum soft drink **cans** will be empty 12 oz aluminum cans. They will be opened, reasonably free of contents, and may or may not still have the opening tab attached. They may be dented, but any that are substantially crushed or torn open other than at the opening tab will be considered damaged. They may have formerly contained any product and brand, and so may be of many different colors.
- 2) Plastic water **bottles** will be empty 500 ml clear plastic water bottles. They are typically made of PETE (recyclable symbol 1). They may or may not still have a label on them. They will start the match inflated to close to their “full” shape and will have the cap on to make them somewhat less prone to crushing. If a bottle is torn, crushed, punctured, or can no longer be restored close to its “full” shape, it will be considered damaged.
- 3) Snack size chip **bags** will be of sizes ranging from 4”x5.25” up to 6”x8”. They will be substantially free of contents, but are not guaranteed to be free of oils, salt, or fine crumbs. They will be torn open, and some portion of the bag may be missing as a result of opening. Dangling fragments that the referee considers likely to come off during handling will be removed before the start of a match. A bag will be considered damaged if it is shredded or missing approximately 25% or more of the bag surface area. They may be of any product and brand that commonly comes in a bag within this size range, and therefore may have essentially any color scheme. While it is unlikely that a real bag would have a color scheme that is uniform and substantially the same as the field tiles, if such a bag is encountered by the referee or field staff, it will not be used in the game.
- 4) Two-pound paper **trays** commonly used for serving concession food (approximately 6”x4”x2”). These may or may not have been used for actual food, and so cannot be guaranteed to be completely clean. They will not be used for

the game if they contain significant deposits of ketchup, mustard, melted cheese, or similar gooey substances, however for real-world use a robot should be designed to be tolerant of such hazards. Ripped trays will be considered damaged.

For example: [www.amazon.com/dp/B07LB72QLS](http://www.amazon.com/dp/B07LB72QLS)

Although the game pieces are litter, competing robots must be designed to not cause the game pieces to become damaged. Not only does this rule facilitate the reuse of game pieces, but it reduces the likelihood of sharp edges that can result on cans and plastic bottles and be a hazard to robots and the field staff. Robots that continue to damage game pieces after a warning will be disqualified, and will have to be modified and inspected prior to resuming competition matches.

## The Litterbug

The litterbug is an autonomous robot that will be operating on the field with each competition robot. It will move around the field and dispense litter.

### Litterbug motion

By design, the litterbug will use ultrasonic sensors located at four “corners” to attempt to detect the field borders and the competition robot when they are within a given distance (to be published in a future update), and will move to try to avoid contact with any of them. In the absence of proximity to field borders or the competition robot it will move randomly, but filtered so that the rate of change of speed and direction are limited. While the intent is for the litterbug to avoid contact, it is possible for the competition robot to move in such a way that it will hit or be hit by the litterbug. Teams are responsible for designing their robot to account for this possibility.

### Litterbug “littering”

The litterbug will start each match with 4 items of each of the four types of litter. For each type of litter, the litterbug will dispense the 4 items at random intervals throughout the match. Littering will not begin until at least 15 seconds into the match, and will be completed (or disabled) before the last 15 seconds of the match. Each type of littering will operate independently, so it is possible for multiple items of different types to be dispensed at the same time.

### Litterbug communication

The litterbug will “chatter” in the form of broadcasting four different types of messages. The key transmission parameters include: the frequency band, modulation type, and message synchronization. These parameters will be different for each

message type. The data payload of each message will have a similar structure including data fields identifying the field number, the type of trash associated, a “name” for the particular litterbug, and a timestamp. If the litterbug receives a correctly formatted request to stop dispensing that type of litter within 10 seconds, it will do so for the duration of that match. The request will need to include the identifying information from the litterbug’s corresponding broadcast, but will be different enough in structure that a simple RF memory echoing technique will not be successful.

The specific properties of all of these messages will be defined in a future update of the rules.

### Litterbug status

Lights on the top of the litterbug will indicate which types of litter it is currently enabled to dispense. At the beginning of each match all four lights will be illuminated. It is still possible to persuade the litterbug to stop dispensing a type of litter and have the light go out even if it has already dispensed all of the items of that type. It will not be possible to do this once the litterbug has received the end-of-match signal.

## General Rules

<G01> All team members must be enrolled undergraduate students and must be IEEE members at the time of registration for the competition.

<G02> No more than 10 members can be registered as members of any one team. No student may be registered as a member of more than one team.

<G03> The design and construction of the robot must be substantially completed by those 10 members, and operation of the robot must be performed by one of those members. This rule is not intended to limit the following positive behaviors:

- a) Cheering on the performance of a team
- b) Offering advice or suggestions to a team
- c) Members of one team offering technical assistance at the event to another team that is encountering difficulty with their robot
- d) Incorporating design elements and best practices from other teams, and from other robots designed in prior years or for other events.

This rule IS intended to prevent a team from competing with a duplicate of another team’s robot that they have not had a substantial role in making.

Scrimmage events will be exempted from this rule.

<G04> All team members will treat fellow competitors and the event staff with courtesy and respect.

It is an important life and professional skill to treat others with courtesy and sensitivity even in a directly competitive environment. Particularly remember that ALL competition staff are volunteers who have offered significant amounts of their time in order to make this event possible, and they are doing their best within the constraints they have to deal with.

<G05> There may be times, especially at scrimmage events, where individuals associated with a team will help in the Referee or Scorekeeper roles. Individuals with emotional investment in the success of particular teams should avoid volunteering to help in this way. In no case should an individual associated with a school serve as referee or scorekeeper for a match of a team associated with that school. This rule does not apply to demonstration matches (for instance by the host team) that are not being counted in any of the event standings.



# The Competition Robot:

## Overview

This section describes constraints on the competition robot for the 2020 IEEE robotics competition.

## Design Constraints

<R01> The robot must be no larger than 24" by 24" by 24" in its configuration at the start of the match. A robot failing a check of these dimensions will not be allowed to compete in a match until the dimensions have been met and confirmed by inspection. Note that this is considerably larger than robots in most recent IEEE R5 competitions. This is intended to allow robots to hold and process multiple pieces of litter at once, while keeping robots to a size that is practical for our venues.

<R02> Once the match has begun, the robot may extend outside its starting volume, but must not at any time extend outside a 36" diameter vertical cylinder. This rule is intended to reduce the frequency of physical contact with the litterbug, and limit strategies based on using overly long arms to sweep large areas of the field at once.

<R03> The robot must be a single entity and remain that way. Strategies based on splitting into multiple independent entities are prohibited this year. Parts must not be detached and left on the field. After all, we are trying to clean up litter, not add to it! Deliberate violation will result in disqualification for the match. Parts inadvertently left on the field (including hardware such as screws, nuts, or zip-ties) will be penalized by -1 point each, like other litter.

<R04> The robot, as it will be placed on the field, must not weigh more than 25 pounds. Heavier robots create more safety issues and are likely to damage the foam tiles of the field.

<R05> The robot must operate autonomously. It must not respond to any external commands except to start match operation and to stop match operation. (See <R08> below)

<R06> The robot must have a prominent stop button that will stop all motion by and within the robot, but not necessarily remove power from the control elements. It must be possible for team members or the referee to access this button easily and rapidly at any time regardless of the position of any other mechanisms of the robot. This could be used to stop the robot at the end of the match or in instances where the referee has determined it to be a hazard.

<R07> The robot must not contain any hazards to people or the litterbug, or cause damage to the field or game pieces. Example hazards could include (but are not limited to) sharp edges, corners, or points that could cut or tear skin or the field tiles, exposed electrical contacts that could deliver a significant shock, mechanisms that could throw litter significantly outside the

playing field, or wedge shaped elements that could tip the litterbug. Under no circumstances may highly flammable liquids or gasses, or explosive materials be used in the robot.

<R08> It is permissible (and even encouraged) to have a paired Bluetooth link to your robot that allows you to start match operation and to stop match operation remotely. You may also use the link to receive telemetry from your robot for diagnostic purposes. Otherwise it must remain within <R05>.

<R09> No spillable or flammable battery technology shall be used on the robot.

<R10> No pneumatic pressures greater than 100 Psi shall be used. At inspection teams using pneumatics should be able to provide documentation that all components are rated for the operating pressure used.

<R11> Robots must not leak or drip any fluids, including lubricants. The only exception would be for residual fluids present in the game piece litter.

# The Matches

## Overview

This section describes how the contest will be carried out and the conduct expectations of the competitors during the rounds of play of the 2020 IEEE robotics competition.

## Progression of Play

1. Setup
  - a. One of the two red tiles will be randomly selected for the litterbug's starting location and the litterbug will be placed on that tile.
  - b. The competitor robot will be placed on the blue starting tile furthest from the litterbug.
  - c. The playing field will be populated with litter according to the rules outlined in <M05>.
2. Startup
  - a. The referee will signal the start of the round which will initiate a 2 minute timer and autonomously trigger the litterbug.
  - b. At the referee's signal the competitors will start their robot.
3. The round
  - a. The litterbug will dispense litter randomly in accordance with "litterbug littering" section above.
  - b. The competitor's robot will perform its function.
4. Ending
  - a. At the moment the 2 minute timer sounds off the competitor's robot must be stopped. It is encouraged for this to happen automatically but the competitor may stop it manually.
  - b. The litterbug will autonomously stop operation.
  - c. Scoring will be conducted as listed in <M11>

## Match Rules

<M01> Matches shall be scheduled in rounds. Within each round, each team will have a chance to compete if they are ready when they are scheduled. Scheduling will be randomized, such that the order in which teams are scheduled and the field they are assigned to compete on will typically be different in each round. There will not generally be a break between rounds; as soon as all matches of a round have been completed play will proceed directly into the matches scheduled for the next round.

<M02> Each team is responsible for being present at the “on-deck” area for their assigned field prior to the completion of the match preceding theirs on that field. If they are not present they will forfeit that opportunity to compete and will score no points in that round. The schedule of matches will be determined and made available to teams prior to the first match.

<M03> Prior to the beginning of each match the litterbug will be stocked with the prescribed quantity of litter and placed on one of the two RED starting tiles.

<M04> Prior to the beginning of each match the competition robot shall be placed on the BLUE starting tile furthest from the starting location of the Litterbug. At this time the robot shall NOT contact the border wall or any other tiles. The referee may use a measuring tool to confirm that the robot is completely within the prescribed starting volume.

<M05> Once the competitor robot has been placed, 12 items of litter will be placed on the field. This will include 3 paper trays, 3 plastic bottles, 3 aluminum cans, and 3 chip bags.

<M06> Each field litter item (see <M05>) will be placed on a different field tile that is not a RED or BLUE tile. The tiles used will be randomly selected by the game software before each match. The exact location of each item of litter on each tile is only guaranteed to be completely within the borders of the tile.

<M07> Each match shall have a duration of 2 minutes.

<M08> The referee or another competition staff member shall trigger the match timer at the end of a verbal countdown. This triggering will also enable operation of the litterbug. A team member will be responsible for initiating operation of their robot as soon as practical after the countdown.

<M09> At the end of the match, the match timer software will make the end-of-match sound and will disable the litterbug. A team member must disable the competition robot as soon as possible after the sound is played.

<M10> Once the competition robot has been disabled, the match shall be scored. Scoring will be based on the position of all litter once all motion of the field has stopped. If a robot appears to continue to operate after the end-of-match sound has been played, the referee may reverse the position of any affected litter before scoring. The judgement

of the referee will be final. Teams are encouraged to design and operate their robots so that there is minimal chance of this happening.

<M11> The scoring for a match is as follows:

- +1 point for each item of litter loaded in the Litterbug or placed on the field at the start of each match.
- -1 point for each item of litter on the field at the end of the match. This includes any parts that have come off the competition robot.
- +2 points for each item of litter in the correct bin (Cans in the can bin, bottles in the plastic bin, snack bags and paper trays in the trash bin)
- +1 point for each can or bottle placed in the trash bin. No points are awarded for putting incorrect items in a particular recycle bin.
- -1 point for each piece of litter from the match that is outside the field perimeter and not in a bin or touching the robot
- +2 points for each type of litter that the litterbug has been persuaded to no longer dispense, as indicated by the litterbug lights going out. An additional +2 point bonus will be awarded if the litterbug has been persuaded to no longer dispense any of the types of litter, as indicated by all four lights going out.

<M12> It is our goal to avoid ever needing to restart a match. However, in the event of a major litterbug malfunction, official game timer or scoring malfunction, or other reason that the referee believes necessary, a reset may be declared. The field and its game pieces must be set to the intended beginning state, the game timer reset to two minutes, the match score reset to zero, and the competitor robot must be prepared to restart the match.

<M13> The number of rounds completed will depend on the efficiency with which teams and the event staff can complete the required matches, and occurrences outside the control of the event staff. The goal will be to complete at least 6 rounds at each event.

\*Note: this goal is liable to change after the scrimmages based on our experiences.

<M14> The final score for each competitor will be the sum of the points received for their 3 highest scoring matches. In the event that a tie in the standings affects any of the first three places, each of the teams that are tied for one of those positions will compete one more time to resolve that specific tie. (For instance, if three teams are tied for 3rd place, they will each have another match to break the tie, but the outcome of those matches will not affect the standing of 1st or 2nd place.) If this fails to break the tie, the following tiebreaker values will be consulted in order until the tie is broken:

- Most points awarded in all scheduled matches for litter placed in the correct bin

- Most points awarded in all scheduled matches for persuading the litterbug to stop littering
- Least points deducted in all scheduled matches for litter remaining on the field or out of the field of play
- Most points awarded in the tiebreaker match for litter placed in the correct bin
- Most points awarded in the tiebreaker match for persuading the litterbug to stop littering
- Least points deducted in the tiebreaker match for litter remaining on the field or out of the field of play

In the highly unlikely event that a tie still remains, the places will be awarded as a tie, and awards will be shared accordingly.

<M15> Actions that appear deliberate that tip or damage the litterbug, or that damage the field will result in disqualification for that match, and no points will be awarded.

Before a team that has been disqualified under this rule will be allowed to compete in a later match, the team will be required to demonstrate to an inspector that actions have been taken to prevent this behavior.