2020 BEST Robotics Competition Rules

15 September 2020

Quick Links

General Rules	OUTBREAK	Judged Activities
Consumable Kit	Game Specific Rules	BEST Award Components
Returnable Kit	Scoring Summary	Awards
Team Custom Parts	Virtual Game	Advancement

Contents

Section 1 General Rules

1.1 Overview

This is a student-oriented contest. The students will gain the most if they do the work. Mentors and coaches are to provide guidance only and not to make parts, detail design, nor force their will on the students.

The rules governing the BEST competition consist of the following:

1. Section 1 BEST General Rules
2. Section 2.1 Returnable Kit List
3. Section 2.2 Consumable Kit List
4. Section 3 Game Specific Rules (may supersede Generic Rules)
5. On-line Question and Answer (Q&A) system

Most questions about the game can be answered by first READING THE RULES THOROUGHLY. All questions concerning these rules (during the 6-week design and construction phase, not during the competition) must be submitted to the Game Committee in writing through the web-based interface at **https://www.bestrobotics.org**. All questions and answers will be distributed to all teams via the web. Responses to the posted questions on the web site are an extension of the rules. In the event of contradiction between the rules and the Q&A responses, the Q&A responses supersede the rules.

1.2 Safety

Safety may not and will not be compromised.

1. Safety is a priority.

2. The referees will disqualify any machine that appears to be a safety hazard.

3. Batteries, chargers, and other components of the BEST Control System Kit may not be tampered with or altered in any way.

4. Except for a power drill/driver and a soldering iron/gun (electrically powered only), no power tools (including battery operated) will be allowed in the pit area during any BEST activity. Common hand tools will be allowed. The power drill/driver may be used for drilling and/or hardware insertion/removal, but not for grinding, sawing, routing, etc. The allowed power tools can be operated only in the pit area or in the hub designated workstation area.

5. All individuals working on the machine in the pit area must wear safety gear appropriate to the activity (e.g., safety glasses should be used when soldering or drilling).

6. Any illegal tools may be confiscated for the day.

1.3 Robot Design Constraints

1.3.1 Material Constraints

Each team receives two kits: a Returnable Kit and a Consumable Kit. Each machine must be constructed using only the materials that appear on the returnable and consumable kit lists (provided in Section 2). Exceptions to this rule are described in Section 1.3.2.3 .

The Returnable Kit List and Consumable Kit List are the official references for parts; therefore, they define the type and quantity of parts that can legally be used on the machine. The team is responsible for confirming that items in the received kits are consistent with the items on the lists and include no excess parts. Excess parts may not be used.

1.3.2 Construction Requirements

1. All robot construction is to occur after the hub Game Kickoff event has been held. There should be no part construction prior to the Game Kickoff event nor reuse of parts from previous competitions. Robot parts may be permanently marked (via scribing, drilling holes, etc.) by BEST personnel to prevent reuse.
2. There are no restrictions on the tools or machines that are used to create parts; however, there is still the expectation that students will be taught how to use these tools/machines and that they will be the ones using and operating them in the fabrication of the parts.
3. The VEX Cortex microcontroller and battery must be secured to the robot. The Cortex microcontroller must be mounted to your robot through the holes provided on its base (suggest using #8 machine screws to avoid damaging the Cortex).

1.3.2.1 Returnable Kit

1. All Returnable Kit items, including boxes and packing, **must be returned** at the conclusion of the contest in the same condition as received except as noted in item 2 below.
2. Returnable Kit equipment cannot be modified in any way, with the following exceptions:
    a. The belt stock supplied in the returnable kit may be modified as needed (e.g., cut, holes punched, etc.); however, the belt that is provided as loop may not be modified.
    b. Servo horns may be modified as desired.
    c. BEST IR Sensor Kit may be assembled.
3. The Returnable Kit List specifies certain items that may not be attached to the machine (e.g., the battery chargers).

4. The motors and servos may not be opened for any reason. For example, it is illegal to change the gearing or to re-wind the armature of any motors.

5. The pulleys, bearings, and shoulder screw included in the return kit may not be modified. You may not use any glue or adhesive tape on these items.

6. Tape/adhesive/glue may not be applied to any returnable item unless specifically allowed (see Section 1.3.2.3). The adhesive portion of the supplied Velcro™ brand hook and loop fastener may not be attached to the battery or to any other returnable item.

7. Paint may not be applied to any Returnable Kit item.

8. The VEXnet Joystick, servos, VEX Cortex microcontroller, VEXnet Keys, batteries, and battery chargers may not be tampered with, modified, or adjusted in any way. The only exception is that the VEX Cortex microcontroller may be programmed as desired.

9. Teams may not put labels or rubber bands on the VEXnet Joystick, nor make internal, reversible modifications to the joysticks.

10. Wires may be soldered to the motor power lugs.

11. Only the motor controllers or the servo power adapter cables may be plugged directly into the VEX Cortex microcontroller motor ports. Motor ports 1 and 10 cannot be used (do not plug the screw terminal motor interface cables into these ports). Only the screw terminal sensor interface cables or the cables from the BEST IR Sensor Kit may be plugged directly into the VEX Cortex microcontroller digital/analog input/output ports. No other connection methods to the Cortex may be used. Soldering to the Cortex microcontroller or to any of the interfacing cables is not allowed.

12. The BEST-supplied 7.2 Volt NiMH 3000maH batteries are the only allowed source of electrical power for the functional components of your entire machine.

13. The 7.2 Volt batteries may **only** be connected to the VEX Cortex microcontroller through the supplied mating connectors. Do not attempt to connect the 7.2 Volt batteries to any other Cortex input other than the battery connector. Do not attempt to connect the 7.2 Volt batteries to any item/circuit other than the Cortex microcontroller.

14. Only one 7.2 Volt battery may be used on the machine during a match. Even if unconnected, the other battery may not be on the machine.

15. On Game Day, replacement batteries will only be provided upon proof of battery failure (e.g., a bad connection) on an exchange basis (you must turn in the faulty battery).

16. You must play all your Game Day matches using the 7.2 Volt batteries supplied by BEST. Team-owned batteries (that power the robot) and team-owned battery chargers for the 7.2V batteries

are not allowed on the field or in the pit area on Game Day; however, team-owned batteries are allowed during other BEST activities.

17. You may use the provided AAA rechargeable batteries or team provided batteries in the VEX Joystick.

1.3.2.2 Consumable Kit

1. Consumable Kit parts may be modified as desired within the constraints of these rules.

2. Limited numbers of replacement parts may be available from your local hub, upon a justified request. Otherwise, lost or damaged kit material may only be replaced with identical components. Replacement parts purchased by the team must have the same:

    a. material as the kit part;

    b. treatment or grade as the kit part; and;

    c. dimensions as the kit part.

    e.g. a 1x4 may **not** be replaced with a 2x4 of the same total volume.

3. The Consumable Kit list identifies optional items that may be provided by the team and used on the machine.

4. Team supplied pennies may not be altered.

5. The only Consumable Kit items that may be used to conduct electricity are the provided wire, the snap-plug terminals or the (optional) quick-disconnect terminals (and also soldering material at the wiring connections). The only exception is that any of the Consumable Kit provided/allowed metallic materials may be used as part of a sensor circuit.

6. No package materials may be used (materials that come with kit items to protect or store them before use). Examples: The plastic film that covers the adhesive portion on the hook and loop strip; cardboard roll at the center of a tape roll.

1.3.2.3 Additional Materials, Constraints and Exceptions

1. Lubricants may be used for lubrication only. A machine may not intentionally contaminate the playing field or an opponent's machine with lubricant.

2. Paint, finish, and/or decals may be used on the robot as described. They cannot be applied to any of the returnable items. Paint or finish cannot be used to change the mechanical properties of what it is applied to. The optical properties (color and reflectivity) of the paint/finish/decals may be used in a functional manner on the robot.

3. Other non-functional decorations are only permitted if they do not aid the machine in performing the game tasks. If you can remove it or cover it up (and you may be asked to) and your machine behaves the same, it is probably non-functional. Lights can be added to the machine, but no strobe lights are allowed.

4. Video capture devices (like a GoPro or a phone) are allowed on the robot subject to the rules for decorations and with the additional rules listed below:

    a. display screen cannot exceed 6” diagonal

    b. display must be turned off or covered up

    c. non-BEST kit mounting brackets/hardware are considered to be a part of the device

    d. recommend that device be protected from possible contact with field or other robots (BEST not responsible for any damage that occurs to the device during game play)

    e. device cannot be transmitting a signal (no streaming)

    f. BEST officials may ask for the device to be removed at any time for any reason

5. Non-functional decorations may use a separate power source (e.g., 9V battery).

6. The use of markers/paint/printouts may be used to provide visual information that does not aid the team in performing the game tasks. Examples of what is allowed would be things such as labeling machine parts with a marker, placing a copy of the Cortex port use schematic on the machine, and so on.

7. You may solder electrical wire connections using your own solder except where electrical connectors are provided. Where connectors have been provided (i.e., on the VEX Cortex microcontroller, servo power adapter cables, servo extension wires, batteries and other returnable items), they must be used without soldering to the connector. Solder may be applied to connectors included in the Consumable Kit (e.g., bullet connectors or quick-disconnect connectors).

8. No welding, brazing or structural soldering is allowed.

9. Metal, rubber, and plastic items may be heated and reformed, but may not be melted and re-cast.

10. Materials may not be changed chemically. The exceptions are that strings and the outer sheath of the shock cord may be singed to prevent loose ends and that kit allowed resin and hardener may be mixed to result in epoxy.

11. Residue-free “painters” tape (supplied in the Consumable Kit) may be used on any Returnable Kit items except the Joystick.

12. Thread locker may be used on Consumable Kit fasteners.

1.3.2.4 Team Custom Parts

Two Team Custom Parts (TCP) are allowed.

1. Each part can be made from any uniform (homogeneous) team supplied material.
2. Each part must be able to fit, unconstrained, into a 2” x 4” x 4” cuboid.
3. Each part must be a single continuous piece of material (when in its operational state).
4. The basic raw stock form of the chosen material must be used for the part. The starting raw stock must be rectangular or cylindrical material if the final part retains any of the original raw stock shape. Material starting shape is irrelevant for parts that are in a liquid state in the forming process or if the final part is completely carved/machined from a solid block of the material.
5. No other kit parts may be embedded in a TCP.
6. No hazardous materials are allowed (rule 1.2 item 2 still applies).
7. No welding is allowed (rule 1.3.2.3 item 8 still applies).
8. Melting is allowed (rule 1.3.2.3 item 9 is waived).
9. Chemical change is allowed (rule 1.3.2.3 item 10 is waived).

1.3.3 Size

1. At the start of each match, the machine must fit, **unconstrained**, within a cubic space that is 24 inches on a side (machine can be powered on during this check). The machine must remain within the maximum size limit, unconstrained, until the beginning of the match.
2. Once the match begins, the machine may unfold and change size through its own power.
3. There is no size requirement at the end of the match (i.e., the machine does not have to return to its initial configuration).

1.3.4 Weight

1. The weight of the machine may not exceed 24 pounds, including the battery and all parts and devices of your machine (e.g., detachable pieces, optional equipment, tethered parts, decorative items, etc.).

1.3.5 Energy Sources

1. The energy used by the machine must come solely from:

    a. electrical energy derived from the single onboard battery pack;

    b. storage achieved by the deformation of the springs provided in the kit or springs created per the Team Custom Part rules;

    c. a change in the altitude of the center of gravity of any part of the machine; and/or;

    d. stretched items (inner tube/rubber bands/shock cord/TCP) are allowed provided that the part is attached to the machine so that it will not fly off if broken

1.3.6 Compliance

1. All machines will be inspected for compliance with the regulations before the competition. Machines must meet these regulations to qualify for the competition. The winning machines may be inspected again following the competition. Failure to comply with the regulations will result in disqualification.

2. No substitute machines are allowed. Machines may be modified between matches but must still meet all the regulations after the modifications are made. The compliance official must approve all modifications prior to the team's next match of competition.

3. Random re-checks of machines will be performed throughout the day at the discretion of the referees. Any machine found to be non-compliant will not be allowed to continue the competition until brought into compliance and may be disqualified from prior matches.

4. The machines may not leave the competition site between the time they are checked for compliance and the start of the competition without approval from the competition officials.

5. Teams that place high enough to advance to a regional/national championship are allowed to make repairs and/or functional improvements to their machine. Machines will be rechecked for compliance prior to the regional/national championship competition.

6. A machine may have multiple configurations, like different arms that can be swapped-out. Each configuration must meet size and weight requirements independently and be approved through a compliance check. The sum total of all parts and materials from all of the configurations cannot exceed the quantities defined by the Returnable and Consumable Kit Lists.

1.3.7 General

1. Machines must be designed to operate by reacting only against the surfaces of the playing field (including the PVC pipes, ramps, etc.), the opponents' machines, and the air. Machines are allowed to clamp to anything in the field except another machine.

2. During a match, the machine may only be controlled through normal operation of the VEXnet system. Touching the robot will result in penalty or disqualification as described in section 1.4.3 and the Game Specific Rules.

3. No external devices may be connected to the joystick during match play unless specifically provided by BEST competition personnel (things such as an auxiliary power supply or a channel shifting dongle).

4. Machines must prominently display their team number.

5. Powered tandem devices are permitted and may use an umbilical to connect the two devices. This umbilical is considered part of the machine and is subject to the same constraints as the rest of the machine.

6. All projectiles must have a frontal area greater than 10 square inches. A projectile is anything launched through the air, whether free flying or tethered. Parts that detach or fall from a machine and remain on the playing surface are not considered projectiles.

7. Gaining traction or gripping game pieces through the use of adhesives, or by abrading or breaking the surface of the field is not allowed. The friction tape (either side) from the Consumable Kit is not considered an adhesive and is allowed (actually intended) for gripping.

8. Spiked wheels are allowed only if the portion of the spike in contact with the field has at least one dimension greater than ¼ inch.

9. Strategies aimed only at destruction, damage (e.g., stabbing, cutting, etc.), over-turning, or entanglement of an opponent's machine are not in the spirit of the competition and are not allowed. Turning over an opponent's machine may or may not result in a penalty depending on the opinion of the referees. Review section 1.4.3 for a description of penalties for overly aggressive actions.

10. Machines may deploy detachable components on the field. A component is considered "detached" if it has no kit parts connecting it, directly or indirectly, to the set of kit parts that includes the battery. Such components may be used to capture, contain, manipulate game pieces, and/or block another machine. Such components may not be launched at, deliberately attached to, or otherwise deliberately used to entangle another machine. Incidental contact between any machine and such detachable components after deployment will not result in a penalty for any team. Detached components will not count as "part of the machine" unless otherwise stated.

11. Following the competition, all items provided in the Returnable Kit must be returned to the hub (local BEST organization). The rest of the machine may be retained by its respective school.

1.4 Head-to-Head Competition Rules

1.4.1 General

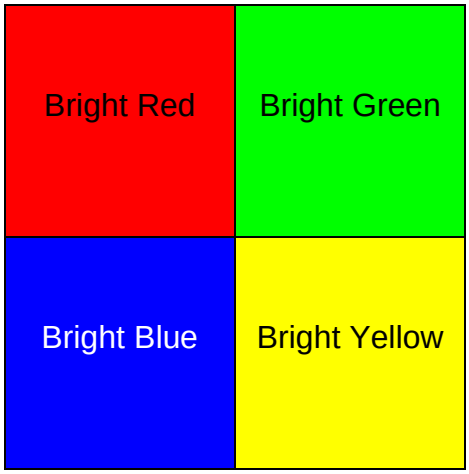
1. Referees have ultimate authority during the competition. No protests will be allowed.

2. On Game Day there will be individuals identified as Team Advocates to answer questions about the game or rules. Do not approach referees, scorekeepers or other officials with questions.

3. A referee, at their discretion, may untangle machines that become entangled with part of the field, or each other, for more than 10 seconds or that may appear to be damaging the field because of the entanglement. A machine that is high-centered on an element of the field or on a game piece is not considered entangled. A machine that has tipped over is not considered entangled. A referee may ask the driver to quit attempting to free their machine if the field is at risk of being damaged.

1.4.2 Field Colors

Specific team locations on the field (e.g., driver/spotter locations, robot starting area, allowed team maneuvering areas, team scoring areas, etc.) are designated through the following four-color scheme.



1.4.3 Drivers and Spotters

1. During a match, only one student member of each team is allowed in the team driver's area and one student member is allowed in the team spotter's area. Adult coaches and teachers are not allowed in either of the areas during matches. Students are not allowed to stand on platforms of their own construction (or each other) to get a better view. A hub may, on a case-by-case basis, make unique provisions for special needs drivers/spotters as deemed appropriate.

2. Only one person per match is allowed to drive the machine (i.e., operate the VEXnet Joystick). Prior to the competition, each team must submit a driver list to the organizers. The minimum number of student team members on the driver list is shown in the following table:

Student team members **present** at competition	**Minimum** number of students on driver roster
2-4	2
5-6	3
7-8	4
9 or more	5

Please note that the previous table reflects the minimum number of drivers required; BEST encourages participation by as many team members as possible. Also note that the number of student team members present at the competition is used to determine the minimum number of drivers on the list.

3. The first person on the driver list is the driver for the first match; the second person on the list is the driver for the second match, etc. This rotation will continue for successive matches until the list is exhausted, at which time the rotation will start again at the top of the list. Rotation in successive phases of the competition (e.g., seeding, semi-finals, and finals) will begin where the previous phase rotation left off. If the organizers eliminate a match for any reason, the driver rotation will continue in accordance with the driver list with the driver scheduled for the eliminated match (or matches) being the first driver for the following match.

4. The spotter may be any student from the team.

5. Spotters and drivers are not allowed to handle the game pieces prior to a match.

6. During a match, spotters and drivers may not communicate with anyone through the use of any electronic devices or other signaling technique that involves a signaling aid that is not part of the human body (e.g., signs, sticks, marked gloves, etc. are not allowed).

1.4.4 Penalties

1. A 20-second suspension may be assessed for a variety of infractions that are detailed below and in a(Game Specific Rules) of this document. This penalty requires the driver to surrender their VEXnet Joystick to a referee for a period of 20 seconds. The referee will return the joystick to the driver upon expiration of the penalty and the machine may continue the match. Penalty decisions of the referees will be final.

2. If a driver touches their own machine before any part of it has left the starting area, a 20-second penalty will be assessed after contact ceases. Machine contact within the starting area is allowed only for the purpose of debugging a defective machine (e.g., turning on the on/off switch). If a spotter or driver otherwise touches their own or another team's machine, the machine of the individual doing the touching will be disqualified.

3. Spotters and drivers are not allowed to enter the field during a match. If a spotter or driver enters the field during a match, their machine will be disqualified.

4. If a spotter or driver leaves the designated spotter or driver area, a 20-second penalty will be assessed as described in item 1 of this section.

5. Machines that touch the ground outside the field boundary will be assessed a 20- second penalty as described in item 1 of this section. Machines that completely leave the field will be stopped for the duration of the match.

6. Damaging any portion of the field or game pieces may result in disqualification. Intentionally moving or tipping over static portions of the field is considered damaging the field and will result in disqualification.

7. Referees may instruct the driver of an aggressive machine to cease an action if the referee feels that another machine or the field may be damaged by that action. Referees will disqualify a team from a match if a major breach of the rules occurs.

8. Disqualification is on a match basis, except for non-complaint machines as noted in Section 1.3.6 . Any team that is disqualified will receive zero points for that match.

1.4.5 Match Protocol

1. There will be at least five referees during each match. The Head Referee will act as timekeeper and the other four referees will monitor each of the teams.

2. Each match will be three minutes long and will be played with four teams, if possible. The scoring software will assign teams to a match and will determine the team's quadrant/color for each match.

3. Teams will be notified of their field and position assignment at least two minutes before the match. Teams must be in the staging area at the end of the preceding match.

4. Prior to the beginning of the match, teams must wait at the designated staging area until the beginning of the setup period. Once signaled, teams have the duration of the setup period to place their robot into a valid starting position.

5. As a guide, a maximum setup time of 30 seconds will be allowed once the team arrives at the field. If a team has not successfully placed their robot by the end of the setup period, the head referee has discretion to allow the team to continue to place their robot and assess a 20-second penalty to be applied at the beginning of the match or whenever the team is ready to begin play.

6. At the start of each match, the machine must be placed at the designated starting area. The spotter or driver may enter the field prior to the start of the match to place the machine in its starting location and prepare it for the match. Temporary alignment marks on the field are not permitted. Additional team members may be allowed to assist in setting up the machine but must leave the field area prior to the start of the match.

7. The machine, driver and spotter must be in the designated location(s) at the start of the match to score any points during the match. The driver and spotter must remain in the designated areas during the match.

8. A maximum of 30 seconds will be allowed at the end of each match for removal of the machines. Additional team members may be allowed to assist in removing the machine.

9. At the end of the match, the driver and spotter must remain in the designated areas until referees have completed scoring of the match and indicated that robots may be removed.

10. Following the match, the referee will review the scored items with the driver; the driver will sign the scorecard indicating agreement.

1.4.6 Competition Protocol

There will be four phases to the head-to-head competition:

- a seeding phase,
- a wildcard phase,
- a semi-final phase, and
- a finals phase.

This protocol will be the same for both hub contests and championships.

Error! Reference source not found. Game Specific Rules define any tiebreakers for determining which team advances from one phase to another in the event of a tie. If no tiebreaker is identified, the default method will be 1) Engineering Notebook scores, 2) head-to-head match results, 3) Coin toss, in that order.

1.4.6.1 Seeding Phase

The Seeding Phase will consist of a round robin competition among all participating teams. Each team will participate in up to eight matches against randomly selected opponents. Fewer than eight matches per team may be played when time limitations exist, but no fewer than five matches. All teams will participate in the same number of matches. Match scheduling will attempt to ensure that each team plays on each quadrant of the field and that back-to-back matches are limited.

The team ranking during this phase will be based on the average of the points scored during the seeding matches excluding the teams' lowest match score. Consult Section 3 Game Specific Rules for any variation to this ranking method.

For competitions with 32 or fewer teams, the top 7 teams from the seeding phase will automatically advance to the semi-finals phase. The final team to advance into the semi-finals phase will be selected from the remaining teams during the "Wildcard Match Phase".

For competitions with greater than 32 teams, the top 14 teams from the seeding phase will automatically advance to the semi-finals phase. The final two teams to advance into the semi-finals phase will be selected from the remaining teams during the "Wildcard Match Phase".

1.4.6.2 Wildcard Match Phase

For competitions with 32 or fewer teams, the wildcard phase will consist of a single match between the four (4) teams with the highest BEST Engineering Notebook scores, who have not automatically advanced to the semi-final phase. The team achieving the highest score during the wildcard phase will advance to the semi-finals.

For competitions with greater than 32 teams, the wildcard phase will consist of two matches between the eight (8) teams with the highest BEST Engineering Notebook scores who have not automatically advanced to the semi-final phase. This phase will consist of 2 matches of 4 teams (as all matches are limited to 4 teams), which may be played in parallel. The two (2) teams achieving the highest scores during the wildcard phase will advance to the semi-finals.

The wildcard phase will be conducted according to the rules for the seeding phase. Each wildcard team will play in only one match during this phase.

1.4.6.3 Semi-Finals Phase

During the semi-finals phase, each team will participate in three (3) matches based on the rotation shown in Table 1 or 2. The team ranking at the end of the semi-finals will be based on the total points each team accumulated during their three matches. No scores will be dropped and the scores from all previous phases will be disregarded. Game play will be the same as previously described for the seeding phase. Only the top four (4) ranked teams from the semi-finals phase will advance to the finals, regardless of the number of teams competing in the semi-finals.

Table 1. Field Position Assignments for 8-team Semi-Finals

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

Table 2. Field Position Assignments for 16-team Semi-Finals

Semi-Final Match	Field Position Assignment			
	Yellow	Blue	Red	Green
1	Seed 4	Seed 13	Seed 1	Seed 16
2	Seed 5	Seed 10	Seed 3	Seed 15
3	Seed 6	Seed 9	Seed 8	Seed 11
4	Seed 16	Seed 4	Seed 2	Seed 14
5	Seed 8	Seed 5	Seed 6	Seed 12
6	Seed 7	Seed 11	Seed 9	Seed 10
7	Seed 3	Seed 14	Seed 13	Seed 2
8	Seed 10	Seed 12	Seed 5	Seed 1
9	Seed 15	Seed 6	Seed 16	Seed 7
10	Seed 14	Seed 8	Seed 11	Seed 13
11	Seed 1	Seed 7	Seed 4	Seed 3
12	Seed 2	Seed 15	Seed 12	Seed 9

1.4.6.4 Finals Phase

The four (4) top ranked teams will participate in three (3) matches during the finals phase. Field assignments per match will rotate as shown in Table 3. The final team ranking will be based on the total points accumulated by the team during these 3 finals matches. No scores will be dropped and the scores from all previous phases will be disregarded. Game play is the same as previously described for the seeding phase. The winner is the team with the most points accumulated during the three final matches.

Table 3. Field Position Assignments for Finals

Final Production Match	Field Position Assignment			
	Yellow	Blue	Red	Green
1	Semi-Final 1	Semi-Final 2	Semi-Final 3	Semi-Final 4

2	Semi-Final 4	Semi-Final 3	Semi-Final 2	Semi-Final 1
3	Semi-Final 3	Semi-Final 1	Semi-Final 4	Semi-Final 2

1.5 Other Rules

1. Student eligibility is left to each individual school.

2. All contestants on the gym floor must wear shoes appropriate to the gym floor surface as determined by the sponsoring BEST organization.

3. Each team will be provided with their own workspace in the pit area in which they may place a table with a surface area no greater than 2400 square inches, if a table is not provided by the hub. Each team will have access to one electrical plug for battery charging. The exact specifications may vary from hub to hub.

4. Each team may bring a toolbox with basic hand-tools subject to the safety constraints listed in Section 1.2 . If a part is broken during competition and the team cannot repair it with tools or material they have, consult the sponsoring BEST organization. They will make their best effort to help the team replace the part, given local shop and/or spare material availability.

5. At least one practice day will be available preceding Game Day. Consult the sponsoring BEST organization for times and locations. Tables and electricity will be available on a shared basis and teams must provide their own tools. The same safety rules apply to practice days as they do during the competition.

Section 2 Official Kit Contents

The official BEST Kit Lists are shown on the following pages. Refer to section 1.3.1 for details regarding Kit constraints and usage. Each machine must be constructed using only the materials (quantity, type and grade) that are on the returnable and consumable kit lists. The ONLY exceptions are described in Section 1.3.2.3 .

2.1 Returnable Kit

2020 BEST Returnable Kit List

	Check	Qty	Item Description	Required/Optional	Source	Part Number
BEST Control System Kit (VEX 270-1605)		1	Cortex Microcontroller	Req'd[3]	VEX Robotics	278-2194
		1	VEXnet Joystick	Req'd	VEX Robotics	276-2192
		2	VEXnet Key 2.0	Req'd	VEX Robotics	276-3245
		4	Motor Controller 7.2V 4A	Req'd	VEX Robotics	276-2193
		2	Large Motor	Req'd	VEX Robotics	276-1611
		2	Small Motor	Req'd	VEX Robotics	276-1610
		2	7.2 V 3000 mAhr NiMH battery - modified w/ PowerPoles	Req'd[1]	VEX Robotics/Other	276-1491
		2	Charger Adapter (for Cortex and Battery Charger)	Req'd[2,3]	None - Hub Assy Reqd	n/a
		8	Screw Terminal Sensor Interface Cable 3-wire	Req'd[4]	VEX Robotics	276-3071
		4	Screw Terminal Motor Interface Cable (red and black wires)	Req'd	VEX Robotics	276-1608
		4	Servo Power Adapter Cable	Req'd	VEX Robotics	276-2195
		1	Smart Battery Charger & power cord	Req'd[2,3]	VEX Robotics/Other	276-2519, 276-2520

		1	8-bay AAA Smart Battery Charger & power cord	Req'd[2]	VEX Robotics/Other	276-1622
		6	AAA NiMH Rechargeable Batteries (installed in Joystick)	Req'd	VEX Robotics/Other	276-1696
		1	USB A-A Cable	Req'd[2]	VEX Robotics/Other	276-1403

	Check	Qty	Item Description	Required/Optional	Source	Part Number
BEST Servo Kit (VEX 270-1682)		4	Futaba 3003/3004 or HiTec HS-422/HS-425BB Servos	Req'd	various	
		4	servo horn screw	Req'd	various	
		5	Servo horn (radius not to exceed 1”)	Req'd	various	
		2	24" servo extension cable (600 mm also allowed)	Req'd	various	
		2	40" servo extension wire (36" or 1000 mm also allowed)	Req'd	various	
		16	rubber grommet	Opt[5]	various	
		16	brass spacer	Opt[5]	various	
		16	servo mounting screw	Opt[5]	various	
BEST Motion Components Kit (VEX 270-4395)		1	1/4" bore, 24 tooth, (small) drive pulley	Req'd	VEX Robotics	270-4395
		1	1/4" bore, idler (dia. to match 24 tooth pulley)	Req'd	VEX Robotics	
		1	1/4" bore 120 tooth, (large) drive pulley	Req'd	VEX Robotics	
		1	170 tooth, 3 mm pitch, 9 mm wide HTD loop belt	Req'd	VEX Robotics/Other	
		1	3 mm pitch, 9 mm wide HTD strip belt, 3 ft long	Req'd	VEX Robotics/Other	
		1	1/4" dia. shoulder screw w/ #10-32 thread	Req'd	VEX Robotics/Other	

		1	76mm roller blade wheel (78A to 82A) w/ bearings and 6mm spacer	Req'd	VEX Robotics/Other	
		1	6mm roller blade wheel axle (any style)	Req'd	VEX Robotics/Other	
		4	R4AZZ Ball Bearing (0.25 ID x 0.75 OD x 0.28 wide)	Req'd	VEX Robotics/Other	

	Check	Qty	Item Description	Required/Optional	Source	Part Number
Hub Provided		1	spare (replacement) servo horn screw	Req'd	various	
		3	BEST IR Sensor Kit (1 assembled)	Req'd	BEST Robotics	
		3	6" servo extension cable (150mm, 8" or 200mm also allowed)	Req'd	various	
		3	24" servo extension cable (600 mm also allowed)*	Req'd	various	
		1	18" (or less) USB extension cable (between Cortex and VEXnet key)	Opt[5]	various	5431
		1	VEX Programming Hardware Kit	Opt[2,5]	VEX Robotics	276-2186
		2	Metal wheel hubs (1.5" max dia, 0.5" max thk, 0.250" bore, with set screw)	Req'd	VEX Robotics/Other	270-6430
		2	window alarm sensor	Req'd	McMaster-Carr	8039A12
		2	1/4" shaft coupler, with set screws	Req'd	ServoCity	625104
		any	containers, bags, boxes	Req'd[2]	Hub Supplied	

Notes: [1] Only one battery can be used on the robot at any given time.

[2] These items cannot be used on the robot.

[3] Cortex and battery charger may be converted (by the Hub only) to PowerPole connectors, eliminating the need for the adapters.

[4] Up to (6) of the three wire sensor interface cables(VEX P/N 276-3071) may be sub'd with old style two-wire sensor cables (VEX P/N 276-1734). A total of (8) sensor interface cables are required.

[5] Teams may use these Returnable Kit optional items even if they are not supplied by their Hub.

* Any shroud protecting the male pins must be removed (so it can be plugged into Cortex).

2.2 Consumables Kit

2020 BEST Consumable Kit List (provided by hub)

Type	Check	Qty	Item Description
igus® Donated Parts		1 meter	Energy Chain, P/N E2-15-20-028-0, w/ 2 each mount brackets (P/N E2.150.20.1 & .2)
		2 ea	DryLin® N Linear Guide system, P/N NK01-27-2-450
		6 ea	igubal® Flange Mount Spherical Bearing, 1/4", P/N EFOI-04
		6 ea	igubal® Pillow Block Mount Spherical Bearing, 1/4", P/N KSTI-04
		6 ea	iglide® G300 Flanged Bushing, 1/4", P/N GFI-0405-06
		6 ea	igubal® 1/4" Rod End Bearing, 1/4"-28 Thread, P/N EBRI-04
		2 ea	DryLin® S, 1/4" diameter, hard anodized Aluminum Shaft, P/N AWI-04, 18 inch length
Plastic and Metal Stock		1 ea	1/4" thick polypropylene sheet, 12" x 24"
		1 ea	1/8" thick PVC Type 1 sheet 12" x 24"
		1 ea	0.5" thick x 2" wide 6061-T6 aluminum flat, 12" long
		1 ea	0.063" thick 5052-H32 aluminum sheet, 12" x 12"
		2 ea	0.25" diameter AISI 1018 steel round, 24" long
		4 ea	piano wire, 0.063" diameter, 12" long
Wood Stock		1 ea	5/16" to 3/8" thick 2' x 4' plywood, any grade
		1 ea	3/16" to 1/4" thick 2' x 4' plywood, any grade
		2 ea	1" x 4" (nominal) #2 whitewood, 2 ft long
		1 ea	1/4" dia. oak dowel, 3 ft long

Pipes and Fittings		2 ea	3/4" schedule 40 PVC pipe, 5 ft long
		1 ea	1" schedule 40 PVC pipe, 5 ft long
		10 ea	3/4" PVC 90 degree elbow (slip)
		10 ea	3/4" PVC tee (slip)
		1 ea	PVC cement, 4 oz or 8 oz
Hardware		4 ea	2.5" x 5/8" steel ZN, corner angle bracket
		4 ea	2" x 3/8" steel ZN, flat angle bracket
		2 ea	2.5"H x 1.75"W x 0.055" narrow hinge w/removable pin
		2 ea	1.5"H x 1-3/8"W x 0.05" narrow hinge w/nonremovable pin & 4 screws
		1 ea	3/4" metal pipe hanger tape, 28 gauge, 10 ft long
Electrical		12 ft	18 gauge stranded copper wire, red insulation, single conductor
		12 ft	18 gauge stranded copper wire, black insulation, single conductor
		12 ft	CAT3 24 gauge, 4 twisted pairs of conductor wire
		16 ea	snap-plug terminals (bullet connectors), insulated, male (optional*)
		16 ea	snap-plug terminals (socket for bullet connectors), insulated, female (optional*)
		20 ea	quick-disconnect terminal, insulated, female, ~1/8" wide (optional*)
		10 ea	quick-disconnect terminal, insulated, female, ~3/16" wide (optional*)
		4 ea	sub-mini snap action switch, SPDT, 0.1 A, Omron P/N SS-01GL13PT
		2 ea	rotary potentiometer, linear, 10K ohm, 300°, panel mount, 6mm (approx.) shaft
		2 ft	heat shrink tubing, 1/4" OD expanded, 2:1 ratio, polyolefin
		10 ea	11" long x 0.18" wide nylon cable tie
		20 ea	4" long x 0.1" wide nylon cable tie

Tapes and Adhesives		1 ea	vinyl electrical tape, 3/4" wide, 60 ft
		1 ea	friction tape, 3/4" wide, 60 ft
		1 ea	all purpose duct tape, 2" (or 1.88") wide, 50 to 60 yd, (color optional)
		1 ea	painters tape, 1" (or 0.94") wide, 30 to 60 yd.
		1 ea	carpenters wood glue, 4 oz
		1 ea	5 minute epoxy, 0.85 oz
Threaded Fasteners		1 ea	1/4"-20 threaded rod, 3 ft long, steel
		25 ea	1/4"-20 hex nut, steel
		25 ea	1/4" SAE flat washer, steel
		25 ea	1/4" medium split lock washer, steel
		6 ea	1/4-28 x 1" screw, nylon (mates with igus rod end)
		6 ea	#10-32 x 1" socket head screw, high strength (150 KSI min) steel**
		25 ea	#10-32 x 1-1/2" machine screws, steel, round/pan head, phillips **
		25 ea	#10-32 machine screw nuts, steel
		25 ea	#10 flat washer, steel
		100 ea	#8-32 x 1-1/4" machine screw, steel, round/pan head, phillips **
		100 ea	#8-32 machine screw nuts, steel
		25 ea	#8 medium split lock washer, steel (optional*)
		100 ea	#8 flat washer, steel
		25 ea	#4-40 x 1" machine screws, round/pan head, steel **
		25 ea	#4-40 machine screw nuts, steel
		10 ea	#2-56 x 1" machine screws, round/pan head, phillips, stainless **

		10 ea	#2-56 machine screw nuts, steel
		10 ea	#2 flat washer, steel
		100 ea	#8 x 1" sheet metal screw, steel, hex head
		100 ea	#6 x 1" wood screws, steel, flat head
		25 ea	#4 x 3/4" wood screw, steel, slotted drive, round head
Miscellaneous		5 ft	3/4" nylon sticky back hook and loop fastener
		1 ea	#18 twisted nylon or polypropylene seine twine, 225 to 250 ft long (color optional)
		4 ft	1/4" polypropylene covered shock cord (color optional)
		1 ea	bicycle inner tube (26" x 1.5" to 2.00")
		25 ea	#10 Rubber Band (1/16" wide x 1-1/4" long)
		25 ea	#32 Rubber Band (1/8" wide x 3" long)
		100 ea	1 1/4" long paper clips, 0.033 dia wire (No. 1 Regular)
		1 ea	VEX motor mounting kit (4 mounts + screws)

Approved Optional Items (provided by team) [1]

Qty	Item Description
10 ea	wooden spring type clothes pins
2400 sq in	corrugated cardboard, 1/4" maximum thickness
2 ea	empty food/beverage PETE container with screw on cap/lid (2 liter max.) [2]
3 ea	wire coat hangers with or without plastic coating, 1/8" dia. max.

3 ea	solid core golf balls
1 ea	5 minute epoxy, 0.85 oz
3 ea	~10oz empty metal soup can with lid removed
24 lb	pennies (cannot be altered; bank wrappers allowed)
1 ea	8 oz. PVC primer
36 ea	craft "Popsicle" sticks (maximum dimensions; 4.75" long, 0.44" wide, 0.10" thick)
1 ea	metal paint grid for 5 gallon bucket
4 ea	CD or DVD disk (standard size: 120mm diameter x 1.2 mm thick)
25 ea	deck or drywall screws; 2-1/2" maximum length
25 ea	wire management clips/ties/wraps (can only be used on wiring)
1	¾” or 1” rigid foam board insulation, 1’ x 4’
2 ea	Team Custom Part [3]

Notes:

* Teams may use these optional items even if they are not supplied by the hub.

** Teams may substitute shorter screws of the same type and grade.

[1] These items can be used *in addition* to the items that are supplied by the hub.

[2] PET or PETE (polyethylene terephthalate) is identified by a number 1 recycling symbol.

[3] See *Team Custom Part Guide* for further explanation and examples.

2.3 Design and Programming Software Tools

BEST Robotics provides various design tools and programming software at no cost to participating BEST teams. This currently includes:

- Sketching software – 2D sketching
- Computer-Aided Design (CAD) software – 2D & 3D Solid Modeling
- Computer-Aided Manufacturing (CAM) software – 2-axis and 3-axis tooling
- Software Development (programming) and Simulation Environments
- Mathematics, Computational and Research software
- 3D Printer Driver software
- Technical Documentation Tools

Software access instructions are provided on your BEST National Registry Team Workflow page and should remain confidential. There may be specific system requirements, internet access requirements, account creation requirements or other stipulations for team/team member use of the software. Unless otherwise indicated, all software and software licenses should only be used by BEST participants for the purpose of competing in the BEST program.

Section 3 Game Specific Rules

3.1 Introduction

There are 3 levels of competition supported by the *Outbreak* game.

Table 3.1. BEST Robotics Competition Options

Competition	# Teams Competing	Field Configuration
Multi-team Competition	Multiple teams up to 4	Physical Field, 4 Quadrants
Classroom Competition	Single team	Physical Field, Single Quadrant
Online Competition	Single team	Virtual Field, Single Quadrant

The field is designed to support all 3 of these possible configurations. Rules throughout this section apply to all physical field configurations. The specific rules differences for virtual field configuration are provided in Section 3.9 .

In the multi-team competition, multiple teams compete in head-to-head matches at the same time. In the single team competitions (classroom, online), the team competes in individual time trials against the clock. For the purposes of these game rules, a single match is equivalent to a single time trial.

3.2 Game Premise

Infection within the human body begins to spread at the cellular level. Infected cells spread disease to neighboring cells rapidly, which then spread the disease to their neighboring cells, and so on as the infection grows to take over the body. BEST Robotics is experimenting with the use of micro-robotics to isolate infected cells from others and apply localized vaccines to slow or stop the spread. Robots that can operate at this level quickly and efficiently will prove invaluable to the medical world. Micro-robots directed by medical professionals should be capable of sampling, identifying, and separating individual cells to isolate the infected areas, as well as applying the vaccines where needed to immunize groups of cells. Self-directed robots that can operate on their own without direction from a medical professional to collect cell samples for testing are also highly desired.

3.3 Overview and Objectives

Teams are tasked with optimizing the health of cells that exist in a finite area. Cells within this space are one of three types:

1. Infected
2. Uninfected
3. Immune

Outwardly, the cells all appear to be the same; however, the characteristics can be distinguished through a testing protocol. An infected cell can pass the infection on to un-infected cells, but not to cells with immunity. Proximity to the other cells determines whether the infection can be passed from an infected cell to another cell.

Teams have at their disposal a limited supply of a vaccine that will protect un-infected cells from becoming infected, and multiple isolation zones that create a barrier between the cells contained within the zone and those outside the zone.

3.4 Game Field

Each team plays on a 7x7 gridded field, approximately 10 ½ ft on each side, that is constructed using 1-inch wide tape. The floor of the field can be any hard surface (concrete, tile, wood, laminate) or low-pile indoor/outdoor carpeting. The grid dimensions are 18-inches square to the centers of the tape. Note that the robot starts just outside the grid area. Driver and spotter remain in the designated areas adjacent to the robot starting area.

The 7x7 gridded field (also called a quadrant) is shown in Figure 3.1 and is the configuration used for single team time trials during a ***classroom competition*** or a ***virtual online competition***, conducted by a single team in both cases.

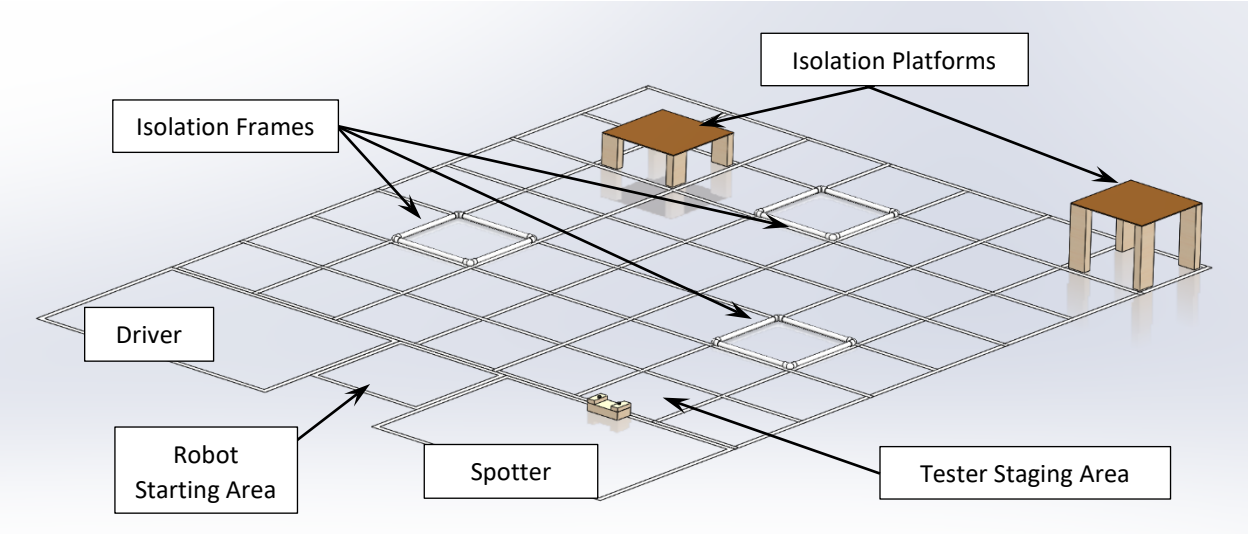


Figure 3.1 Single Quadrant Game Field for Single Team Competition

A multi-team competition field has 4 color-code quadrants, separated by a neutral zone as shown in Figure 3.2. Game pieces are assigned to a single quadrant and each robot operates within their own quadrant.

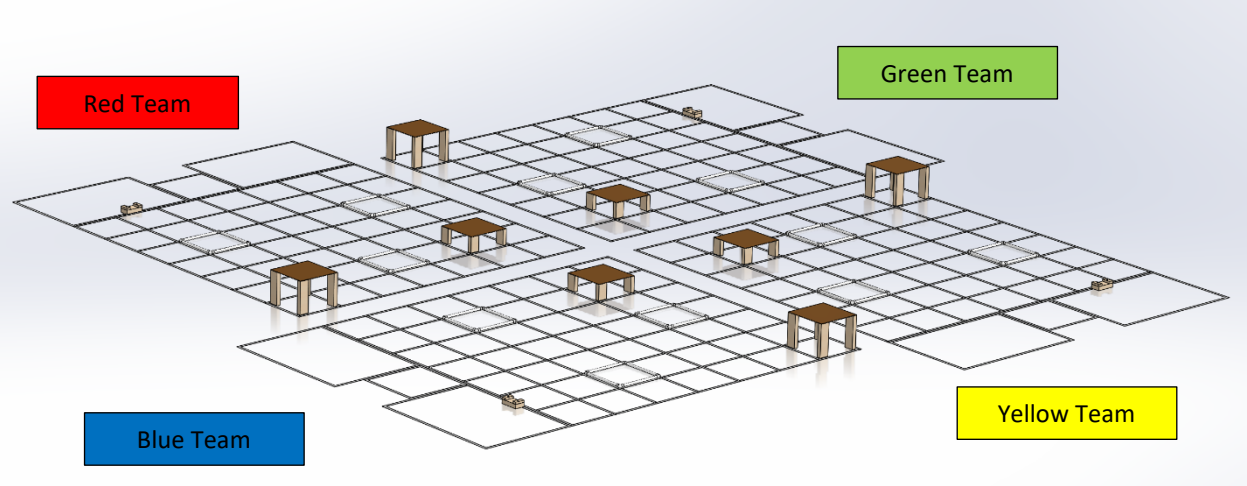


Figure 3.2 Full Playing Field for Multi-Team Competitions

In either the single-team or multi-team field configurations, the robot can leave the quadrant, but game pieces may not leave the quadrant. The robot may not enter the driver or spotter areas or other team quadrants.

3.4.1 Robot Starting Area

The Robot Starting Area is centered along one side of the quadrant, just outside the field border. A team's Robot Starting Area is designated by colored tape and measures 24" x 24" from the outside edge of the tape line.

3.4.2 Driver and Spotter Areas

Each competing team has one driver and one spotter at the field. The driver and spotter areas are designated by colored tape and both measure 51 ½" x 36". The Driver Area is located to the left of the Robot Starting Area. The Spotter Area is located to the right of the Robot Starting Area.

3.4.3 Tester Staging Area

Distinguishing between cell types (Infected, Uninfected, Immune) is the key to preventing the spread of infection. The Cell Tester available in the Spotter Area gives a visual indication of the cell type. The Spotter may use the Cell Tester on cells located within the Tester Staging Area, a designated grid space adjacent to the Spotter Area.

3.4.4 Isolation Frames

There are three isolation frames within each quadrant. As shown in Figure 3.3, the isolation frame is constructed from ½-inch PVC pipe and is approximately 18-inches to the outside of the frame. Figure 3.1 shows the starting location of the isolation frames. They robot may move isolation frames during game play.

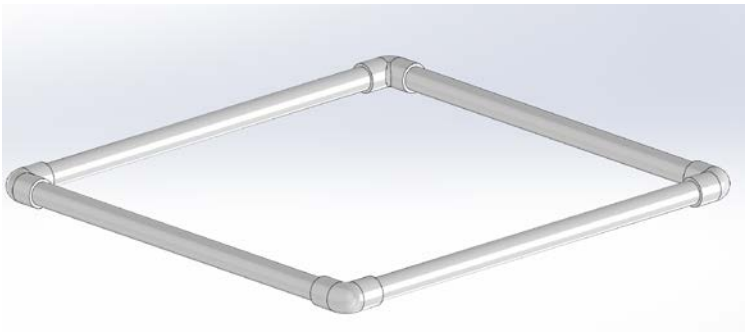


Figure 3.3 PVC Isolation Frame

3.4.5 Isolation Platforms

Each quadrant also includes two isolation platforms, a low platform (nominally 6-inches high) and a high platform (nominally 12-inches high) as shown in Figure 3.4. The top surface of the platform is square and is approximately 16-inches on each side. Isolation platforms are at fixed locations in the quadrant and are not intended to be moved. If moved accidentally, they will be put back in the starting locations, at the end of the match, before scoring.

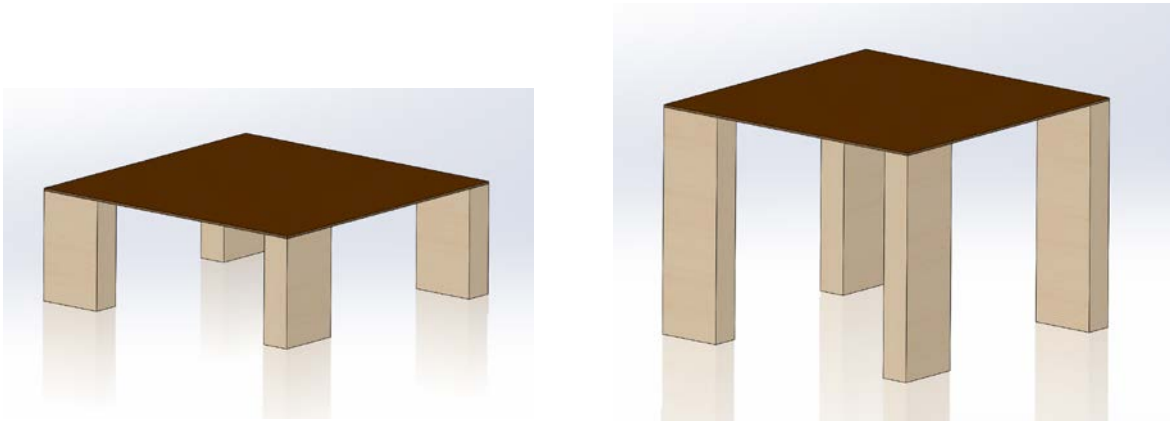


Figure 3.4 Isolation Platforms

3.5 Game Pieces

3.5.1 Cells

The cells are constructed from 2x4's (roughly 3 ½ x 3 ½ x 1 ½) as shown in Figure 3.5. Each cell has two 1/8" diameter holes drilled in opposite sides (one side is shown in the figure). These holes will either have magnets inserted and will then be filled or will be filled without magnets. The intent is to provide cells of different types that all appear to be the same. The number of cells of each type and the number of magnets for each type of cell is shown in Table 3.2. During a ***multi-team competition***, cells will be color-coded to match the team quadrant color. Each hole with a magnet will contain 2 total magnets.

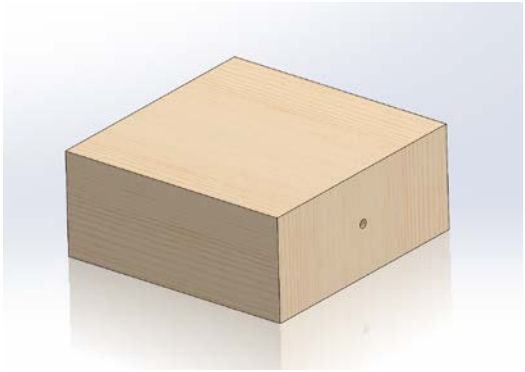


Figure 3.5 Cell (made from 2x4 – 21 total per quadrant)

Table 3.2 Cell Count and Characteristics

Cell Type	Holes Filled With Magnets	Number of Cells Per Quadrant
Infected	2	3
Uninfected	0	12
Immune	1	6

3.5.2 Simple Vaccines

The simple vaccine is represented by a tennis ball. Each team has three doses of the simple vaccine available at the start of the match.

Figure 3.6 Simple Vaccine (3 per team)

3.5.3 Super Vaccine

The super vaccine is represented by a 3 ½" x 3 ½" wooden block, painted white with red cross symbol. It will only be available to the team after successful completion of the autonomous cell sampling task.

Figure 3.7 Super Vaccine (1 possible per team)

3.5.4 Quantity and Starting Locations

Figure 3.8 shows the locations of the cells within one quadrant of the field at the beginning of the match. The cells are arranged in groups of three in the same seven grid spaces at the start of the match. The type of cell in each location is random and is expected to change (randomly) from match to match. In the starting locations where there are isolation platforms, two of the cells will be placed beneath the platform and the other cell will be placed on top of the platform. The cells' location within each grid space is random. Each cell will be placed so that the 3 ½ x 3 ½ side is flat against the floor or platform surface.

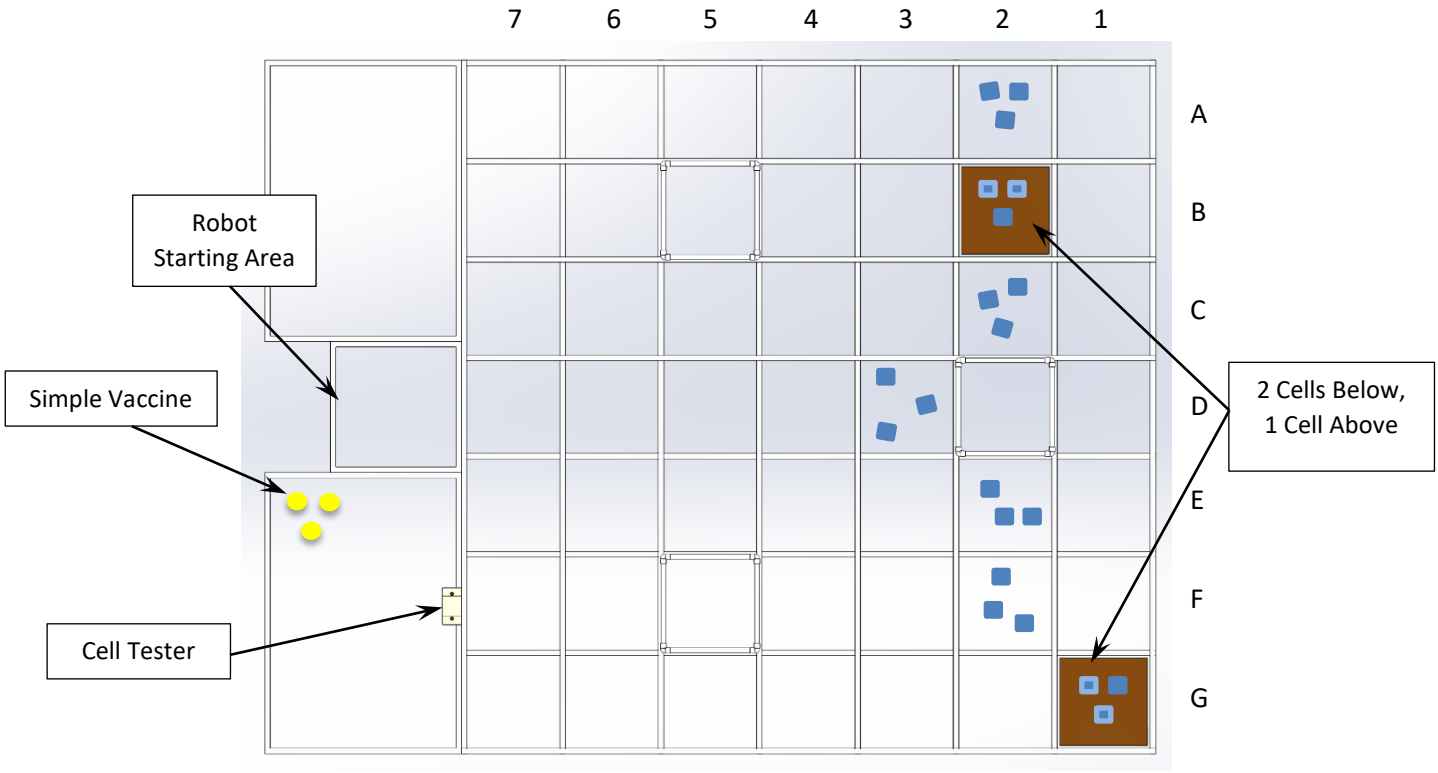


Figure 3.8 Starting Locations for Cells

The vaccine doses are located within the spotter area (adjacent to the robot starting area) at the beginning of the match. The spotter may load vaccines onto the robot after the match starts. Only the simple vaccine is available at the start of the match; the super vaccine must be earned through successful autonomous cell sampling (*see section 3.7.3*).

3.6 Interaction Rules

3.6.1 Interaction with Other Robots, the Field and Game Pieces

a. The robot must remain fully inside the Robot Starting Area and in the 24" x 24" x 24" starting configuration until the match begins.
b. The robot may leave the field (or team quadrant) and return during the same match.
c. During a ***multi-team competition***, the robot may not enter another team's quadrant. Violation of this rule will result in a 20-sec penalty.
d. The robot may not enter the driver or spotter areas.
e. Cells are not allowed "leave" the team's quadrant. Note: If a cell does exit the team's quadrant (for whatever reason), it will be assumed to reside in the closest grid space for scoring purposes.

3.6.2 Driver and Spotter Rules

The following rules apply to the driver and spotter. All rules are cumulative and must all be satisfied.

a. The spotter may touch the field or robot inside the Robot Starting Area during interactions with the robot (loading of vaccines or during the autonomous setup period).
b. The spotter may touch the field, game pieces and/or robot inside the Tester Staging Area during interactions
    i. with the robot (loading super vaccine) or
    ii. with game pieces (testing cells)
c. The spotter may reposition the robot during the autonomous setup period. Refer to rule 3.7.3 (g).

Any violation of the following rules (d through f) will result in a **disqualification** for the current match.

d. The driver may not touch any part of the field, any game piece, or the robot during the match.
e. A team's vaccines must stay within the Spotter's Area during the match until they are placed on the robot.
f. Throwing or tossing of game pieces is not allowed.

Any violation of the following rules (g through s) will result in a **20 second penalty** during the current match.

g. The driver must keep his/her feet within the Driver's Area during the match.
h. The spotter must keep his/her feet within the Spotter's Area during the match.
i. The spotter may interact with the robot when any part of the robot is inside the Robot Starting Area or Tester Staging Area.
j. The spotter may not be touching the robot or any part of the field when the driver is touching the joystick.
k. The driver must maintain "hands off" the controller while the spotter is
    i. loading game pieces onto the robot,
    ii. manipulating the robot during the autonomous setup period.
l. The joystick must be placed on a "hands free" surface (chair, desk, box, other) or on the floor before the spotter touches the robot and remain there during periods of interaction with the robot. "Hands free" means no touching the joystick during this time.

m. After the match starts, the spotter may place any number of vaccine doses onto the robot when any part of the robot is inside the Robot Starting Area (note rules j, k). The robot is considered inside the starting area when any part of the robot has broken the plane of the starting area.
n. After a successful autonomous cell sampling, the spotter may load the super vaccine onto the robot when any part of the robot is inside the Tester Staging Area (note rules j, k).
o. Cells must be inside the Tester Staging Area to be handled by the spotter.
p. The robot must be outside of the Tester Staging Area before the spotter handles any cells within the Tester Staging Area.
q. The spotter may pick up any cell within the Tester Staging Area, test it and immediately return it to the Tester Staging Area (note rule p).
r. After testing, the spotter may return the cell to the Tester Staging Area only. The cell may not be returned to any other grid space.
s. A cell placed in the Tester Staging Area may be moved by the robot after the spotter is no longer touching it (note rule p).

3.7 Game Play

The primary objective is to stop the spread of the infection. The infection spreads according to the rules in section 3.7.1. Possible robot tasks include:

- ***Separation of cells***
  - Separate the uninfected cells from infected cells by at least one full grid space.
- ***Isolation of cells***
  - Move cells into an isolation zone (i.e., isolation frame or platform) to avoid infection spreading to/from grid spaces outside the boundary of the isolation zone.
  - Note: infection within the isolation zone is not protected and WILL spread to other cells within the same isolation zone.
- ***Vaccination of a grid space***
  - Place the simple vaccine to immunize all uninfected cells within a grid space.
  - Place the super vaccine to immunize all uninfected cells within a grid space and all adjacent grid spaces.
- **Autonomous cell sampling**
  - Retrieve ANY cell from its starting position and return it to the Tester Staging Area without driver control. See section 3.9.2 for virtual game autonomous cell sampling challenge.

3.7.1 Understanding the Spread of Infection

The spread of the infection is determined at the end of the match, or time trial. The rules regarding spread of the infection are as follows:

a. Any uninfected cell that is in the same grid space as an infected cell becomes infected.
b. Any uninfected cell that is in a grid space that is adjacent to a grid space with an infected cell becomes infected. Adjacent grid spaces share either an edge or a corner with a grid space to which they are adjacent. This means that a non-edge grid space has eight adjacent grid spaces as shown in Figure 3.9.

c. A cell that became infected through proximity (adjacency) with another infected cell has the same ability to infect cells in adjacent grid spaces as the cell from which it received the infection.
d. Any uninfected cell that is in the same grid space as a vaccine becomes vaccinated and cannot infect other cells.
e. Any uninfected cell that is in the same grid space or adjacent grid space as a super vaccine becomes vaccinated and cannot infect other cells.
f. When the number of cells (of any type) in a grid space exceeds 3, the uninfected cells within that grid space become infected. The upper and lower portions of a grid space with an isolation platform is considered the same grid space.
g. Isolation frames prevent the infection from breaching the border of the isolation frame. That is, infected cells in adjacent grid spaces do not affect cells within the isolation frame, and infected cells within the isolation frame do not affect cells in adjacent grid spaces (but do affect cells within the isolation frame). Note: isolation frames are movable and may cross grid space lines.
h. Isolation platforms function similarly to the isolation frames, except that the cells must be placed on top of the platform to be isolated and there must not be any cells (or vaccines) in the grid space below the platform. Any cells beneath the platform effectively eliminate the isolation function of the platform.

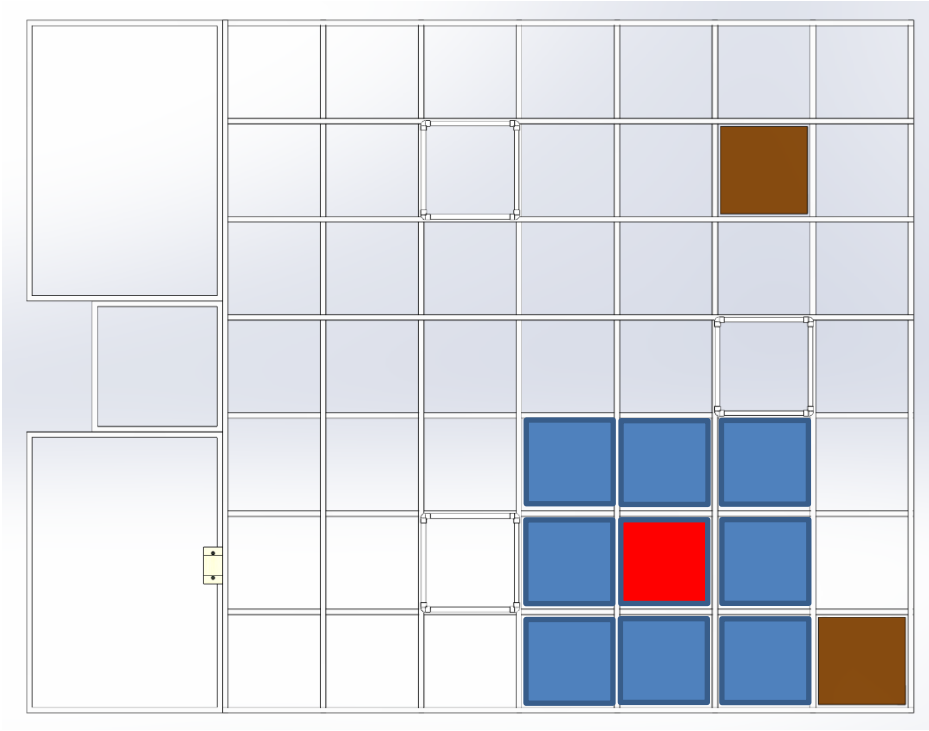


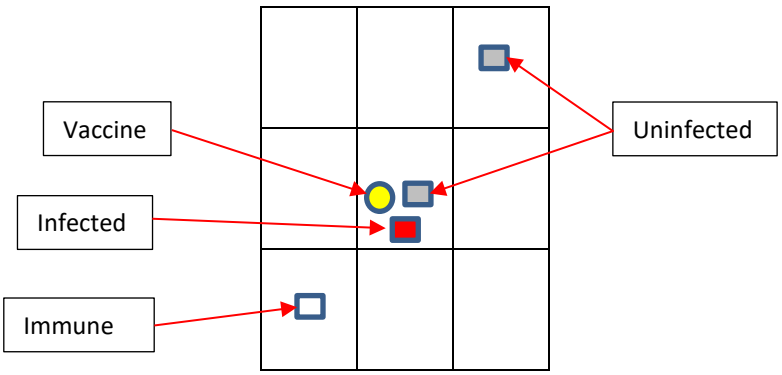
Figure 3.9 The Blue Grid Spaces are Adjacent to the Red Grid Space

3.7.2 Applying Vaccines

a. Simple vaccines only affect the uninfected cells in the same grid space as the vaccine.
b. All “uninfected” cells in the grid space where the simple vaccine is located will become vaccinated.

c. The super vaccine is only available if the autonomous cell sampling task was completed successfully.
d. The super vaccine immunizes (i.e., vaccinates) uninfected cells in the grid space that it resides in and all adjacent grid spaces.
e. Any vaccine (simple or super) placed in an isolation zone (frame or platform) will only affect the cells within the frame/platform. Likewise, super vaccines placed adjacent to an isolation frame/platform will not affect cells within that frame/platform.
f. Vaccines have no effect on “infected” or “immune” cells. Infected cells in the vaccinated grid space(s) will still infect cells in adjoining grid spaces. See the example in Figure 3.10.

Before infection spreads:



After infection spreads:

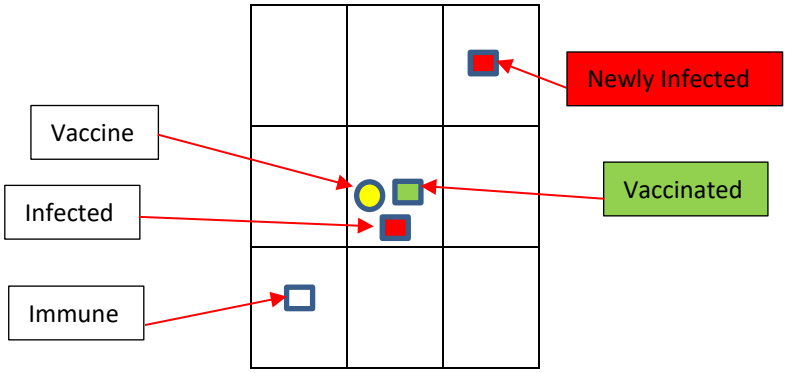
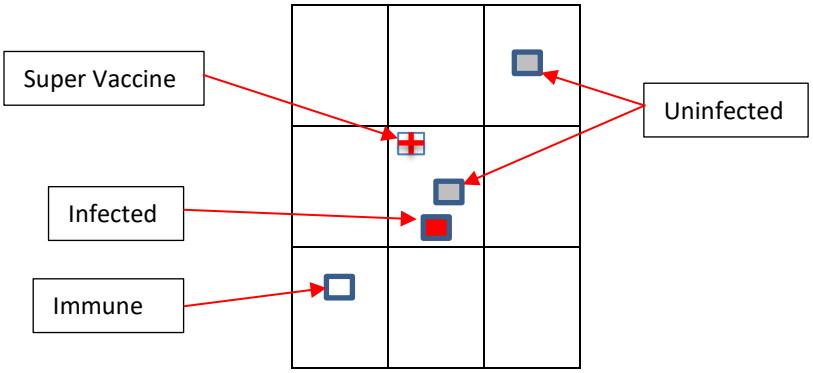


Figure 3.10 Effect of Simple Vaccine on Cells

Before infection spreads:



After infection spreads:

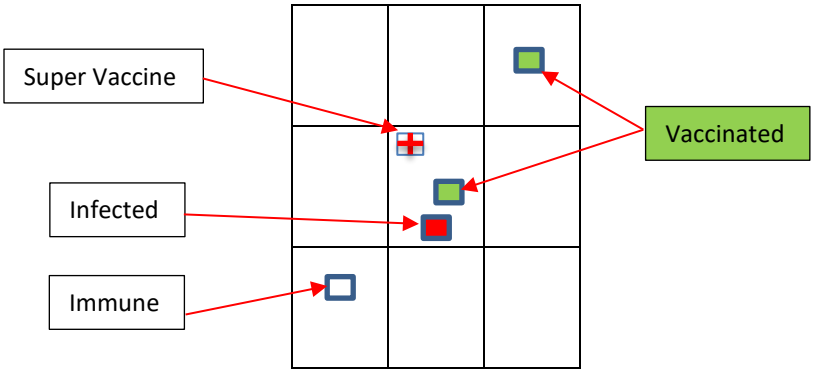


Figure 3.11 Effect of Super Vaccine on Cells

3.7.3 Autonomous Cell Sampling

It is often useful to perform cell sampling of infected areas to determine the location and extent of the infection. This frequently proves invaluable in the development and deployment of powerful vaccines known as super vaccines.

In the autonomous cell sampling task, the robot must retrieve ANY cell and return it to the Tester Staging Area under its own control. Only cells that are retrieved from their original starting location will be effective; retrieving a cell that has already moved from its starting location will be useless. If one cell sample is successfully retrieved, the super vaccine will become available for use by the team.

Task Description

a. Robots shall collect a cell sample from any initial cell starting position. The type of cell collected is not important.
b. Robots must collect cell samples autonomously (i.e., with no driver control).
c. The team may attempt the cell sample collection as many times as desired until successful. An attempt concludes when the driver touches the joystick or the end of match (time=0:00) is reached.
d. Each cell sampling attempt must begin with the robot battery inside the Robot Starting Area.

Procedure

e. The autonomous cell sampling can be attempted at any time during the match. The driver must notify the referee of the attempt before initiating any autonomous sampling operation.
f. An autonomous setup period will begin when any part of the robot is inside the robot starting area and the driver is no longer touching the joystick.
g. During the autonomous setup period, the spotter may orient the robot within the Robot Start Area prior to the driver initiating the autonomous cell sampling operation so long as any part of the robot remains within the Robot Start Area.
h. The spotter may not be touching the robot or any part of the field when the autonomous cell sampling attempt is initiated by the driver.
i. The driver will initiate the autonomous cell sampling period by pressing any combination of buttons on the joystick without lifting it from the hands-free surface.
j. The autonomous cell sampling period ends when the driver touches the joystick or the end of match (time=0:00) is reached.
k. If the driver picks up the joystick or touches it prior to the retrieved cell reaching the Tester Staging Area, the attempt ends and a new attempt must be started from the Robot Start Area.
l. The driver cannot initiate the final action that "scores" the cell sample (e.g., releasing/dropping the cell).
m. The retrieved cell is only required to be in the Tester Staging Area at the end of the autonomous sampling period; once scored by the referee (by a thumbs up or thumbs down), the cell may move.
n. The retrieved cell is not required to be tested by the spotter.

Evaluation

o. At the end of the autonomous cell sampling period, the referee will evaluate the attempt and score the cell sampling as successful or unsuccessful.
p. An Autonomous Cell Sampling attempt is scored as "successful" when
   - the driver touches the joystick on the hands-free platform, and
   - a new retrieved cell resides inside the Tester Staging Area, and
   - the cell is not resting on the robot, and
   - the cell was retrieved from its match starting location (grid space).
q. An Autonomous Cell Sampling attempt is unsuccessful if the driver touches the joystick and the retrieved cell is NOT inside the Tester Staging Area.

r. If the autonomous sampling is successful, the spotter will receive a single super vaccine from the referee or trusted agent. There is only ONE super vaccine available per team.

3.8 Scoring

The final score is determined at the end of the match by:

- identifying the final location and type of all cells
- evaluating the spread of the infection (for newly infected cells)
- calculating the score based on Table 3.3, plus any bonuses

To aid in scoring, the field grid will use the labeling shown in Figure 3.12. Each grid space can be referenced by its location in the grid. For example, the isolation platforms are in grid spaces B2 and G1. The isolation frames start in grid spaces B5, D2 and F5.

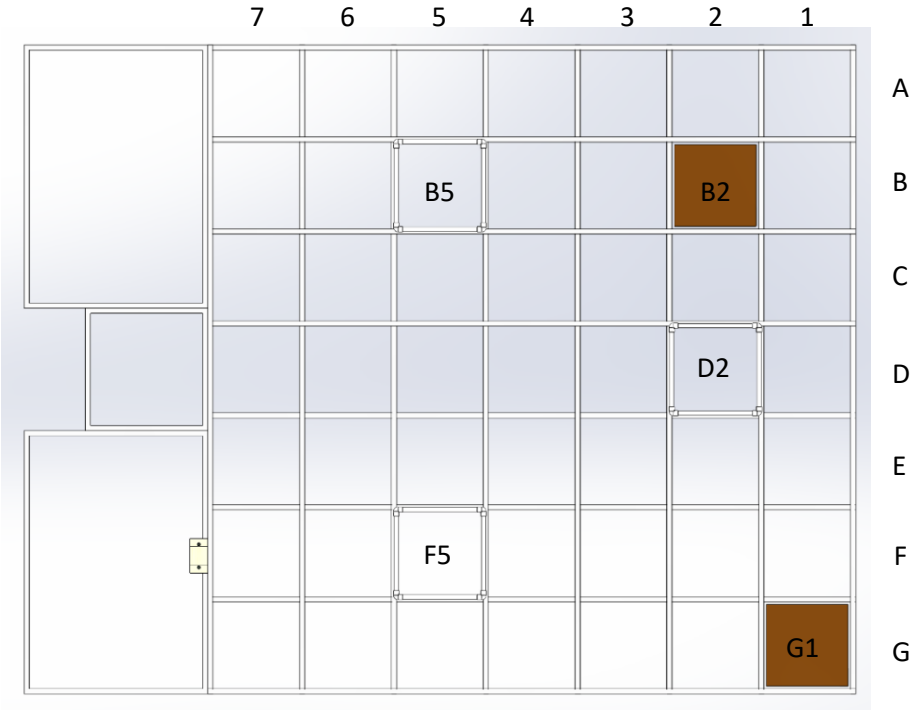


Figure 3.12. Grid Space Reference Labels

3.8.1 Analyzing the Spread of Infection

Scoring is determined by examining the previously uninfected cells within each grid space at the end of the match to determine if their state has changed due to spread of the infection. The infection spreads infinitely and instantaneously at the end of the match. The immunity of cells does not spread.

Notes:

- The 3 original “infected” cells (see Table 3.2), are not counted during scoring.
- The 6 original “immune” cells (see Table 3.2), are not counted during scoring.
- Only the 12 original “uninfected” cells (see Table 3.2) are used to determine the final score.

a. All points are determined at the end of the match (or time trial).
b. Any cell that is held by the robot or spotter at the end of the match will be treated as if it were in the nearest grid space.
c. Any vaccine that is held by the robot or spotter at the end of the match will not apply.
d. Cells are scored based which grid space they are inside at the end of the match. Cells do not need to be touching the ground to score.
e. Prior to computing scores, any cell touching a tape line will be pushed to the nearest grid space based where a majority of the cell lies (as determined by the referee).
f. Prior to computing scores, a vaccine that is resting on a grid space tape line will be pushed to the nearest grid space based on where a majority of the vaccine lies (as determined by the referee).
g. Any cell touching/leaning on an isolation frame (PVC) will be considered belonging to the grid space area where the cell touches the floor.
h. Any cell that is balanced on the isolation frame (i.e., not touching the ground) will be considered inside the frame.
i. For any cell or vaccine considered inside an isolation frame at the end of the match, grid space tape lines are disregarded when scoring the cell.
j. A vaccine outside of the field boundary will have no effect on any grid space.
k. After applying rules (a)-(j) above, an analysis of the spread of infection is conducted to determine its effect on uninfected cells, before any points are awarded. This analysis results in uninfected cells potentially changing status to “vaccinated” or “newly infected”.

3.8.2 Score Calculation

The score starts with a 200-point offset and the scores listed in Table 3.3 are used to compute the total score. Note that if the calculated score is less than zero, the resulting score will be zero.

Table 3.3. Cell Scoring Values

Location	Status of Cell After Spread of Infection (Points)		
	Newly Infected	Vaccinated	Uninfected
Grid Space	-10	+20	+10
Isolation Frame	-15	+40	+15
Low Isolation Platform	-25	+50	+25
High Isolation Platform	-40	+80	+40

3.8.3 Autonomous Cell Sampling

a. No additional points are awarded for successful completion of the Autonomous Cell Sampling. Refer to Section 3.7.3 for details of the expected sequence, evaluation and rewards of successfully cell sampling.

3.8.4 Bonuses

a. A 200-point bonus is awarded if all 3 infected cells have been placed within the same isolation zone (frame or platform) where no other cells are present.

3.8.5 Scoring Definitions

Resting – touching such that the entire weight of the object is supported by what it rests on.

Inside, In, Within – within the imaginary infinite vertical planes defined by the innermost sides of a container/area or the inner edge of a tape line defining the boundaries of an area or grid space. The robot start box is the exception where the boundaries are defined by the outer edge of the tape line.

3.8.6 Example Scoring

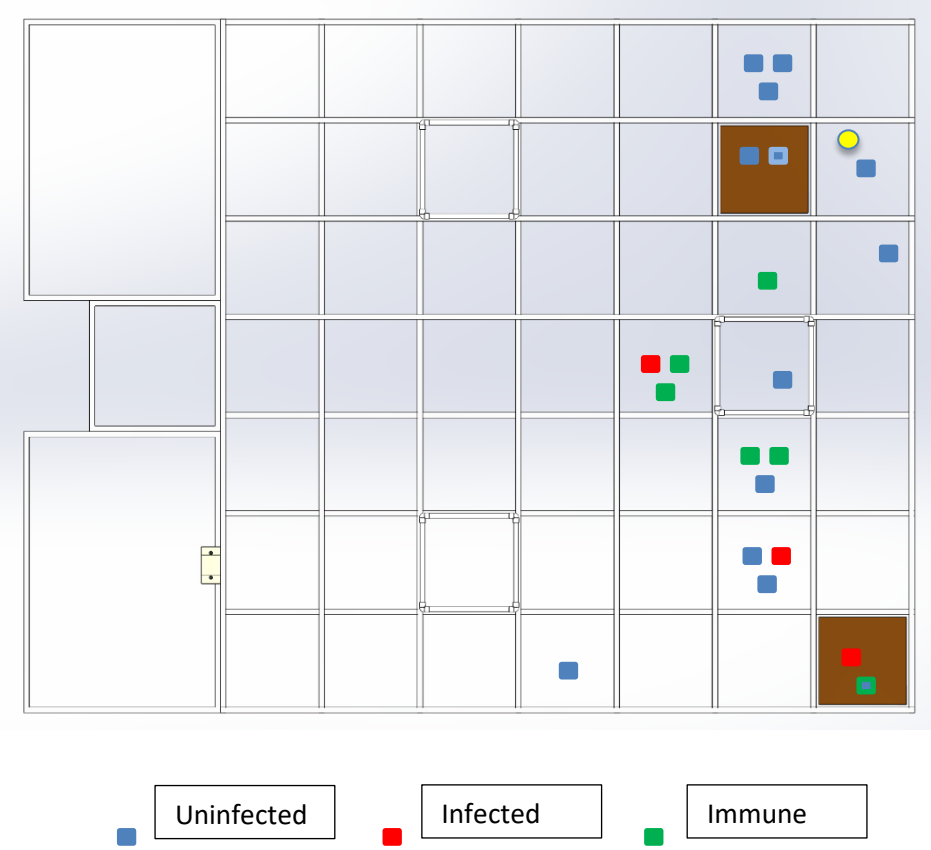


Figure 3.13. Example – End of Match, Before Analyzing Infection Spread

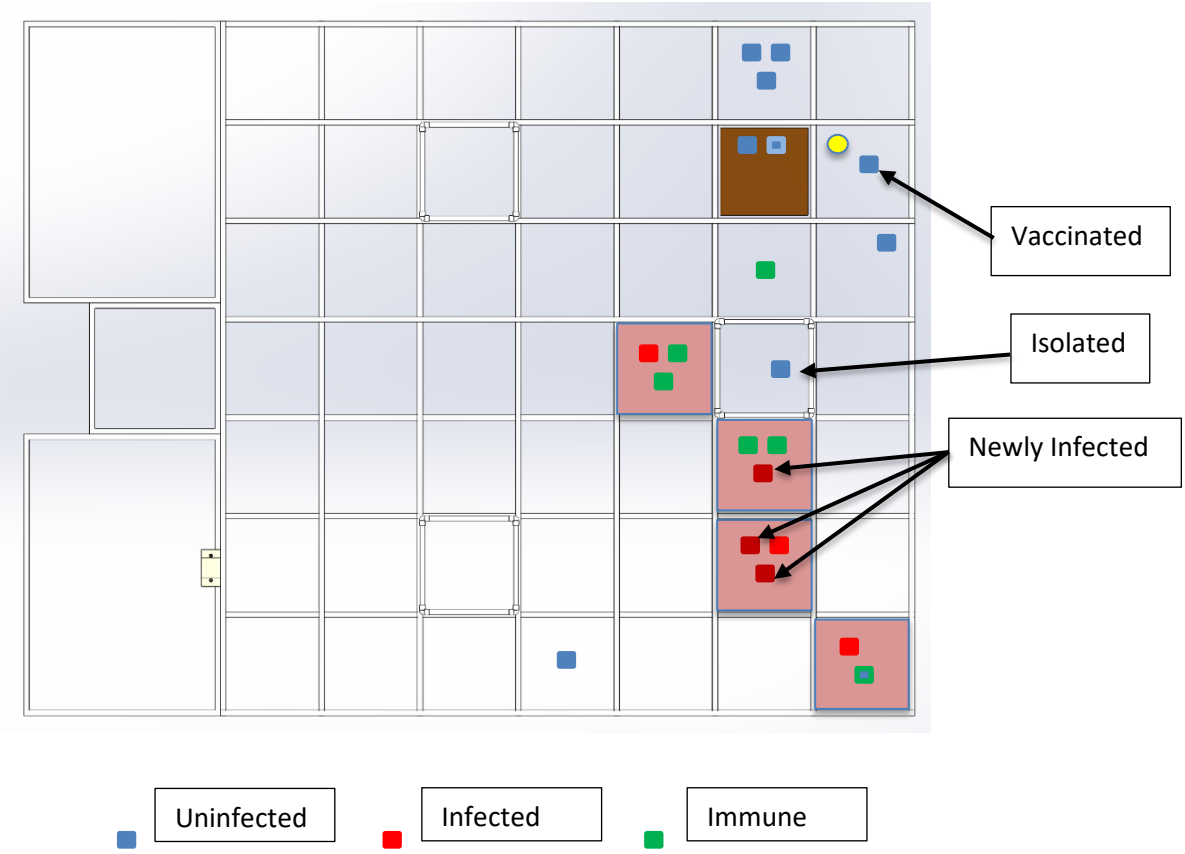


Figure 3.14. Example – After Spread of Infection

Table 3.4. Example Scoring Calculation

Item **(after infection spread analysis)**	**Qty**	**Point Value**	**Total** **Points**
Starting Point Offset			**200**
Newly Infected			
Grid Space	3	-10	-30
Isolation Frame		-15	
Low Isolation Platform		-25	
High Isolation Platform		-40	
Vaccinated			
Grid Space	1	+20	+20
Isolation Frame		+40	
Low Isolation Platform		+50	
High Isolation Platform		+80	
Uninfected			
Grid Space	7	+10	+70
Isolation Frame	1	+15	+15
Low Isolation Platform		+25	
High Isolation Platform		+40	
Bonus (all 3 infected cells isolated)			
TOTAL	12 cells, 0 bonus		275

3.9 Virtual Game Play and Scoring

When teams participate in time trials within the ***Outbreak Online Competition***, they will play the game on a virtual field as shown in Figure 3.15. This section describes the differences in game play and scoring related to the time trials performed in the Outbreak Online Competition.

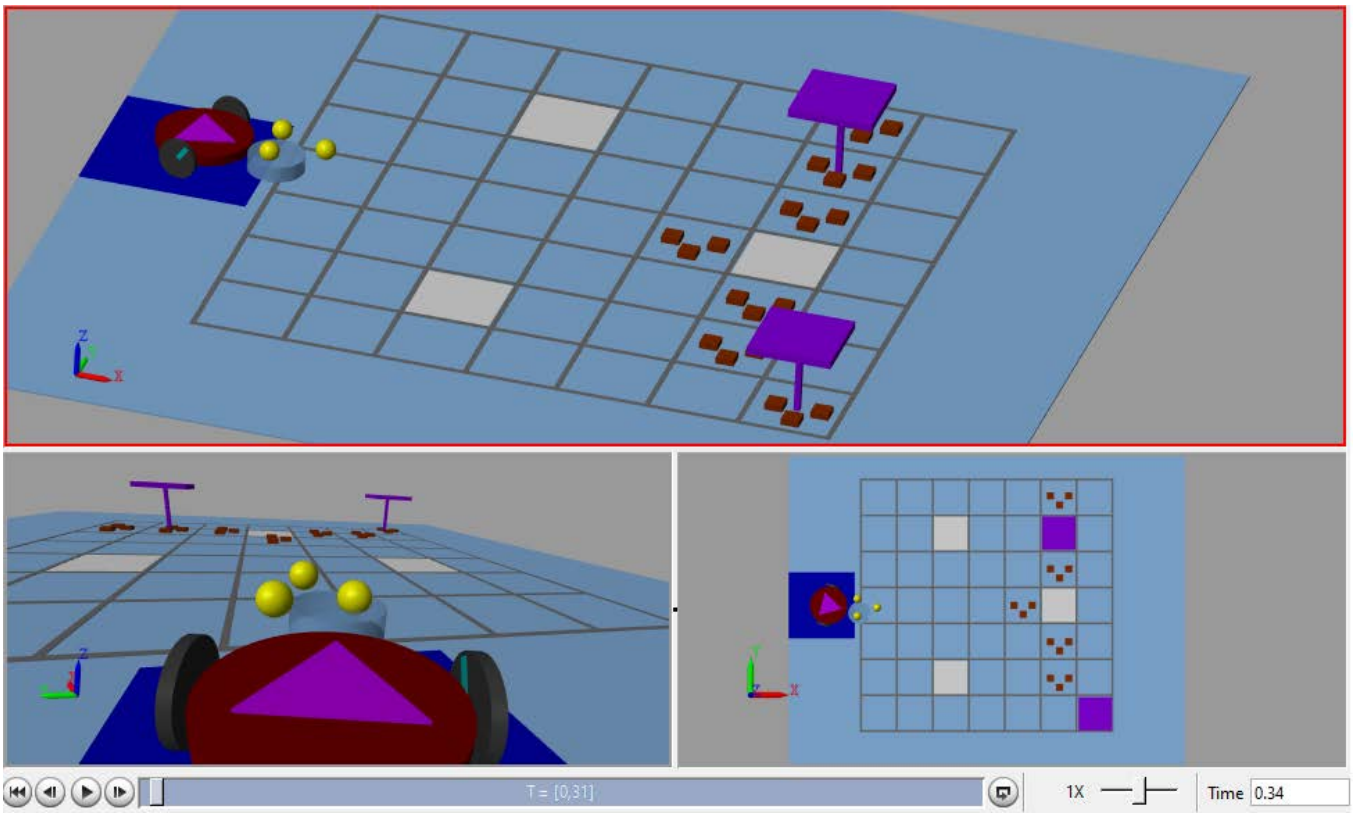


Figure 3.15. Virtual Game Field

In the virtual game,

a. Driver rotation is not applicable. It is highly desired to have multiple students participate as drivers but due to potential limited access we are not requiring a driver rotation in the virtual game.
b. There is no spotter; rules in Section 3.6.2 do not apply.
c. The driver controls the robot through a computer interface (keyboard or joystick); rules in Section 3.6.2 do not apply.
d. The isolation frames do not have any simulated raised border; at the end of a time trial, any cell touching/crossing an isolation frame border will be considered belonging to the grid space area where a majority of the cell lies. Rules 3.8.1 (g) and 3.8.1 (h) do not apply.

e. The isolation frames will not move during a single time trial but the starting location may change from one trial to another during driver-controlled time trials; since physical movement during the time trial is not modeled, starting the frames in a different location may be used to simulate movement that could occur during a match.
f. The isolation frames will be in the same starting location as shown in Figure 3.1 for all autonomous time trials.
g. The isolation platforms are identical in height.
h. There is no super vaccine;
    i. Section 3.5.3 does not apply
    ii. rules 3.7.2 (c) an 3.7.2 (d) do not apply
i. The driver-controlled and autonomous challenges will be run as separate time trials from one another. Scores will be computed separately for each.

3.9.1 Driver-Controlled Rules Summary

a. Teams will perform a minimum of 3 and a maximum of 8 independent driver-controlled time trials.
b. Total score for the driver-controlled time trials will be the average points for all time trials.
c. Game play and scoring will be identical to a physical competition with the exceptions in section 3.9 .
d. The initial position of cells will be determined at the beginning of the trial and unknown to the team. The judge/referee will provide a new configuration file for each trial at the time of the trial. The configurations used during the competition runs will be unique among teams.
e. A simulation time of 180 seconds will be used for all driver-controlled competition time trials, as shown in Figure 3.16.
f. The “Activate Gripper Sensor” checkbox must be unchecked for all driver-controlled time trials, as shown in Figure 3.16.
g. The “Autonomous Configuration” checkbox must be unchecked for all driver-controlled time trials as shown in Figure 3.16.
h. A playback speed of 1X will be used for all competition time trials, as shown in Figure 3.15.

3.9.2 Autonomous Challenge Rules Summary

a. Teams will perform a minimum of 3 and a maximum of 8 independent autonomous time trials.
b. Total score for the autonomous time trials will be the total accumulated points for all trials.
c. During the autonomous time trials, the robot should attempt to retrieve as many cells as possible and return them to the Robot Starting Area within the allotted simulation time.
d. The total score for each autonomous time trial will be determined based on the number and type of cells collected in the Robot Starting Area at the end of the simulation, as indicated in Table 3.5, and the points awarded for vaccines and isolation platforms.
e. 20 points will be awarded for each isolation frame containing a vaccine at the end of the time trial.
f. 25 points will be awarded for each isolation platform that is cleared; there are no cells resting on the raised platform.
g. Each time trial will start with a 200-point initial offset score.
h. The initial position of cells for each autonomous trial will be provided to the team at Kickoff. The autonomous challenge configuration files for each trial will be available via the National Registry Team Workflow page. The configurations provided at Kickoff will be the same for all participating teams within the hub.
i. At the time of the autonomous trials, new autonomous configuration files will be provided that have the same cell locations but the cell types are randomized.

j. A simulation time of 180 seconds, as shown in Figure 3.16, must be used for all autonomous challenge time trials.
k. The “Autonomous Configuration” checkbox, shown in Figure 3.16, must be checked for all autonomous challenge time trials.

Table 3.5. Virtual Autonomous Time Trial Scoring

Cell Type Collected	Opportunities	Point Value
Infected Cell	3	-20
Immune Cell	6	-10
Uninfected Cell	12	+10
Vaccine Delivered to Isolation Frame	3	+20
Platform Cleared	2	+25

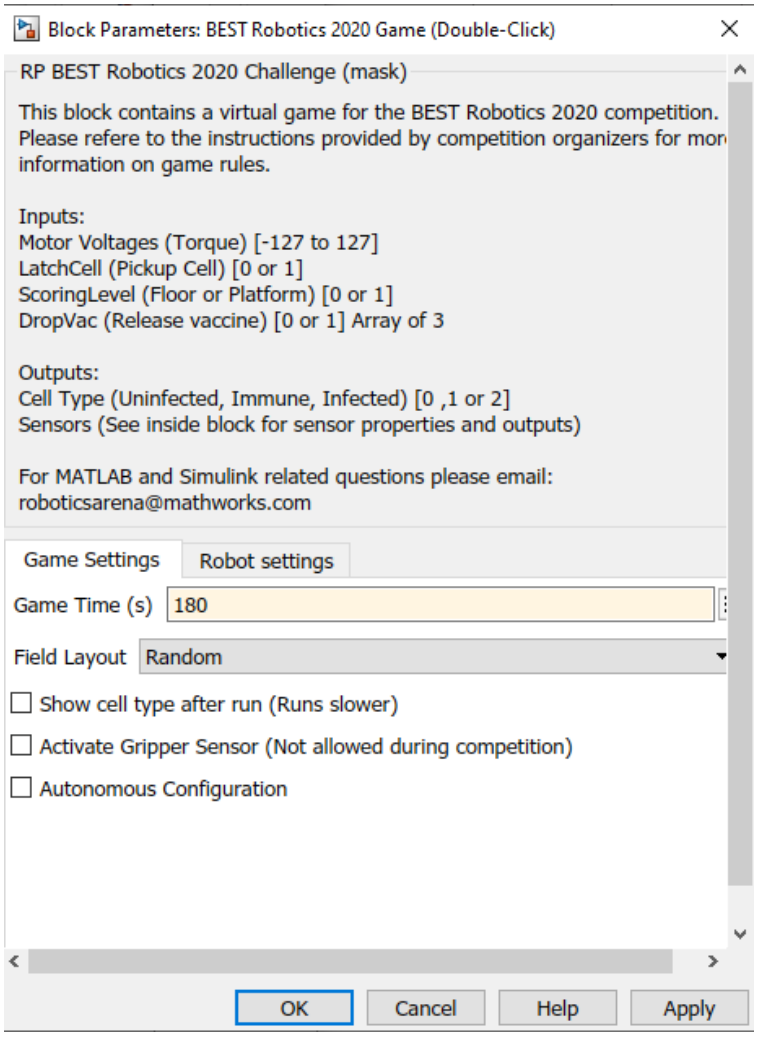


Figure 3.16. Virtual Game Time Trial Settings

Table 3.6. Example Autonomous Trial Scoring

Task Completed	Qty Possible	Qty Scored	Point Value	Total Points
Starting Point Offset				**200**
Infected Cell	3	1	-20	-20
Immune Cell	8	1	-10	-10
Uninfected Cell	12	2	+20	+40
Vaccine Delivered to Isolation Frame	3	1	+20	+20
Isolation Platform Cleared	2	1	+25	+25
TOTAL	21 cells, 2 platforms, 3 frames	4 cells, 1 platform, 1 frame		**55**

Section 4 Awards and Judging

4.1 Head-to-Head Competition / Robot Performance Judging

The head-to-head competition / robot performance results for a team are dependent on the following criteria:

- The Post Season Survey must be completed by all students on the team roster prior to competing in any head-to-head, classroom or virtual competition. Refer to the BEST National Registry Team Workflow for due dates.
- An Engineering Notebook must be submitted by the participating team prior to competing
- All team members (students, teachers, mentors) must individually register in the BEST National Registry prior to competing on Game Day.
- A participating team must be compliant with the General Rules (constraints, etc.) and successfully pass the Robot Compliance Check prior to competing

Any team that does not meet these criteria may be eliminated from consideration of awards and/or advancement.

The Final head-to-head competition ranking is determined through robot performance using the Game Specific scoring rubric defined in Section 3 .

- For Outbreak Hub Competition, this will consist of the head-to-head competition results (all phases executed)
- For Outbreak Classroom Competition, this will consist of results from the Robot Performance Time Trials.
- For Outbreak Online Competition, this will consist of results from the Robot Performance (a.k.a., Driver Controlled) Time Trials.

4.2 The BEST Award

The BEST Award is presented to the team that best embodies the concept of *Boosting Engineering, Science, and Technology.* This concept recognizes that inclusiveness, diversity of participation, exposure to and use of the engineering process, sportsmanship, teamwork, creativity, positive attitude and enthusiasm, and school and community involvement play significant roles in a team's competitive experience and contribute to student success in the competition beyond winning an award.

In accordance with the BEST philosophy, **materials submitted by teams must be the work of students.** The involvement of student peers in auxiliary roles to support a school's official BEST team – i.e., journalists, photographers, artists, musicians – is encouraged.

Space constraints at each regional championship site will determine the number of teams that can compete for the BEST Award at the championship (check with the specific guidelines published by each regional championship). For a team to be eligible to compete for the BEST Award at any of the regional championships, the team: (1) must have placed in the top 3 teams in the BEST Award judging at their local hub competition, and (2) must agree to compete in all five of the BEST Award component categories at the regional championship.

4.2.1 Judging Evaluation and Criteria

Evaluation of competitors will be based on the criteria outlined here. An evaluation score of 100 possible points will be composed of the following components:

Component I - Engineering Notebook (mandatory for ALL teams)

Component II - Marketing Presentation (at hub's discretion for BEST Award inclusion)

Component III – Team Exhibit and Interviews (at hub's discretion for BEST Award inclusion)

~~Component IV - Spirit and Sportsmanship (mandatory for BEST Award)~~

Component V - Robot Performance (mandatory for BEST Award)

Hubs competitions are required to judge at least four of the five components using one of the three following scenarios:

Scenario 1: (**preferred**)

Judged Components	**Point Value**
Engineering Notebook	30 points
Marketing Presentation	25 points
Team Exhibit and Interviews	20 points
~~Spirit and Sportsmanship~~	~~10 points~~
Robot Performance	15 points
	Total 90 points

Scenario 2:

Judged Components	**Point Value**
Engineering Notebook	30 points
Marketing Presentation	25 points
~~Spirit and Sportsmanship~~	~~10 points~~
Robot Performance	15 points

Total 70 points

Scenario 3:

Judged Components	Point Value
Engineering Notebook	30 points
Team Exhibit and Interviews	20 points
~~Spirit and Sportsmanship~~	~~10 points~~
Robot Performance	15 points

Total 65 points

Refer to Section 5 for details on each of the Judged Components.

Refer to the ***2020 Awards and Judging – Hub Logistics*** document for the specific judging scenario at your local hub. Championship events will always employ Scenario 1. Teams that advance to a championship as eligible to compete for the BEST Award must compete in all four components.

4.2.2 Judging Procedure

- A distinguished team of judges from private and public sectors with technical and non-technical expertise will evaluate teams. Judges will serve on a rotation schedule.

- As each team completes a component, it will be assigned a component score that is the average of individual scores of the judges reviewing it.

- The organizing hub/championship may choose to drop the lowest judges' score for any judged component at their discretion.

- Teams should know in advance that scores among many teams frequently differ by only fractions of a point.

4.2.3 Judging Results

- Each team advancing to the regional championship will be provided with a copy of its score sheets following their local competition. Score sheets of non-advancing teams will be provided upon request.

- Teams advancing to the regional championship can use judges' comments to make improvements as they wish subject to the schedule restrictions of the regional championship (e.g., Engineering notebook due dates).

4.2.4 BEST Award Recognition

The teams ranked first, second, and third in the BEST Award judging will receive trophies superior to the teams finishing first through third in the Head to Head robot competition.

4.3 Simulink Design Award

The "BEST Simulink Design Award" sponsored by MathWorks is an award open to all teams participating in the competition. The award is presented to one team in each of the 3 BEST championship regions (South's, Texas, and Denver) that best applies the 'Simulink Support Package for VEX' based on the judging criteria below and their robot's performance in the competition. Any team using MathWorks MATLAB/Simulink to design their software (i.e., robot program) is eligible.

4.3.1 Applying for the Award

To apply for the award, teams are required to submit their best Simulink model and a short video describing their program design using Simulink. The entries must be submitted before 11 PM (local time) two weeks before their respective regional championship. See the ***2020 Awards and Judging – Hub Logistics*** document and the BEST Robotics website for more information on deadlines.

Information that teams need to provide when submitting their entry:

- Name of School
- BEST Hub (know which hub you belong to)
- Team Contact
- Team Contact Email Address (**important:** all entries are tied to the email address)
- # Students on the Team
- Simulink Model File (.slx file)
- Link to YouTube Video (3 minutes maximum)
- Brief Description (256 chars) of how the team used Simulink to program their robot

A PASSCODE may be required to submit your entry. The PASSCODE will be the same as the current year's Game File Password. Contact your Hub to get the PASSCODE.

4.3.2 Simulink Design Award Guidelines

- Only one entry per team is allowed.
- All teams can participate for the award within their region. There will 1 winner per region.
- Every entry should include the following items:
    - 1 Simulink model file (*.slx)
    - 1 video link (use YouTube only)
- The Robot program must be created using Simulink. Submissions of programs designed using other software will not be accepted. The submitted Simulink file should not be a pre-built example model or the default program. It should be your own program or a modification of the existing examples or default program.
- The video should be no more than 3 minutes in length and include at least a 1.5 minute overview about the program design (e.g. a screencast of the Simulink model with voice over).
- Multiple submissions may be made by a team prior to the submission deadline always using the same email address during submission. Only the last submitted entry will be scored.
- Final submissions for this award must be uploaded at http://www.bestinc.org/simulink_award/form.php before the stated deadlines.

4.3.3 Simulink Design Award Evaluation

The award will be given to one team from each region and be based on the judging criteria and robot performance in the competition. The following criteria will be used for judging each entry using a maximum 100pt scale. The Simulink model is worth up to 70 points and the video is worth up to 30 points.

Simulink Model		**Possible Points**
Creativity	Innovative, creative and original work	5
Functionality	Error-free and designed to achieve the game tasks	10
Software Design Practices	Best practices like commenting, block naming, etc.	15
Difficulty and Mastery	Level of Simulink knowledge demonstrated in executing the tasks	20
Readability	Clean, organized and easy to comprehend	15
	TOTAL	**70**
(YouTube) Video		**Possible Points**
Creativity	Interesting, innovative and informative	5
Quality of the video	Video making process and technical execution	10

Concept	Engaging, coherent and appropriate	10
Clarity	Message is clear and well-communicated	4
Adherence to Guidelines	Video length and content on Simulink usage	1
	TOTAL	**30**
	Total Possible Points	**100**

4.3.4 Simulink Design Award Recognition

The winning teams will be awarded the following:

- Cash award
- Trophy with inscription 'BEST Simulink Design Award – by MathWorks', and
- a MathWorks hat for each team member

The winning teams from each region will be recognized on the BEST website (www.bestinc.org) and their regional championship website.

4.4 Robot Critical Design Review

The intent of the Robot Critical Design Review (CDR) is for students to explain their design in detail, including design features/functionality, the requirements and strategies that influenced certain design features, the methods and results of each design discipline, and design risk assessment.

4.4.1 Robot CDR Guidelines

The CDR is a multi-disciplined technical review, conducted at both system-level and component-level, to ensure that an initial product baseline is established and that all customer requirements have been addressed to satisfaction.

- Each team will present a Critical Design Review (CDR) of their robot design to a panel of judges.
- The format and content of the review is determined by the team.
- The goal of the CDR is to ensure that the final design will meet the application requirements. The application requirements consist of the rules for robot construction and the game play objectives.
- The CDR consists of explaining the details of the design and game strategy and presenting how it will satisfy the objectives.
- Judges are expected to ask questions that will require detailed knowledge about specific functionality or components of the robot and every design discipline involved. Students presenting the CDR should be capable of answering with specific details.

- The review will take no more than 20 minutes. Judges will have 5 minutes for question and answer.
- At least 3 students will actively participate as presenters in the CDR.
- The CDR will review results from the following design disciplines:
    - Systems, Mechanical, Electrical, Software, Test, Human Factors, Risk Assessment
- The CDR will provide a detailed review of:
    - Requirements
    - Functionality Overview
    - Design Specifications (Component and System)
    - Risk and Lessons Learned

4.4.2 Robot CDR Evaluation

The Robot Critical Design Review will be judged as an independent award. Its score will not influence the BEST Award Score. Robot CDR presentations will be evaluated considering the following:

- ***Requirements***
    - Did the team present requirements (and strategies) that influenced their design specifications?
    - Did the team present both stated and derived requirements?
    - Did the team present how the requirements influenced their design?

- ***Functionality***
    - Did the team describe the functionality of the robot in detail? Including how each of the robot's tasks will be performed.
    - Did the team present block diagrams of major robot components?
    - Did the team discuss any prototyping or modeling that was performed (either successful or unsuccessful)?

- ***Research***
    - Did the team present any research performed regarding technical solutions (e.g., drive mechanisms, lift mechanisms, etc.)?

- ***Design Specifications (component and system)***
    - Did the team present component and system-level specifications? (e.g., capabilities and technical specs)
        - e.g., weight, dimensions, speed, lift, structural integrity, power, processing, accuracy, etc.
    - Did the team use diagrams, tables, graphs, equations, calculations, simulations, and/or explanations to show "how" they arrived at specifications?

- ***Multi-discipline review***

  - Were multiple design disciplines represented in the review? Systems, mechanical, electrical, software, test, human factors, etc.

- ***Risk Assessment***
  - Did the team review known risks in their design, including alternate or back-up plans if the mission objectives are not able to be accomplished?

- ***Innovation***
  - Were innovative design elements or processes used?

- ***Lessons Learned***
  - Did the team share lessons learned?

4.5 Skills Challenges

New skills challenges are being offered at select hubs. Various awards will be provided for teams that finish in the top of a skills challenge category. The complete rules, instructions, and evaluation criteria for each of the challenges is covered in separate documents.

The following skills challenges are required to be offered for the Outbreak Online competition. They may optionally be offered for the Outbreak Hub competition and Outbreak Classroom competition.

- Autonomous Programming Skills (See Section 3.9)
- BESTMania Skills Quiz
- Outbreak Minecraft Challenge

The following skills challenges may be offered at the hub's discretion for any competition format. Because these skills challenges are optional, the rules, instructions, and evaluation criteria for each of the challenges is covered in separate documents.

- Robot Modeling Challenge
- Engineering Drawings Challenge
- Website Design Challenge
- Video Design Challenge

4.6 Additional Awards

Refer to Section 7 for details on additional awards provided at the Hub and Championship levels.

Section 5 BEST Award Components

5.1 Engineering Notebook (30 Points)

- The Engineering Notebook will be worth 30 points towards the BEST Award.

5.1.1 Notebook Requirements

- ALL participating teams are required to submit an Engineering Notebook at both the local competition and the regional championship following the requirements stated herein. All notebooks will be evaluated on a 30-point scale.
- For competitions having 32 or fewer total teams, the notebook scores of all teams will be used to determine which 4 teams earn a chance to participate in the single "wildcard" match. The winning wildcard team will be one of eight total teams that advance to the semifinals phase.
- For competitions having greater than 32 total teams, the notebook scores of all teams will be used to determine which 8 teams earn a chance to participate in one of the two "wildcard" matches. The two winning wildcard teams will be two of sixteen total teams that advance to the semifinals phase.
- The purpose of the notebook is to document the process the team used to design, build, and test their robot.
- The notebook may be delivered in electronic format (PDF only) or in physical format as determined by the local hub and regional championship.

  NOTE: The preferred delivery format is electronic (PDF). Please see the ***2020 Awards and Judging – Hub Logistics*** document for the specified format and information on when and how the notebook is to be submitted.

- The notebook must meet the following specifications:
  - All physical notebooks must be submitted in a *standard* 3-ring binder with a maximum 2" ring size
  - A cover sheet / title page must identify the school, team name, teacher contact, and team number
  - 35 typed **single-sided** pages or less (note that title/cover page and Table of Contents page(s) will not be counted as part of the 35 pages)
  - Standard, 8 ½" x 11" paper, double-spaced, 1" margins, and Times New Roman (preferred) or similar business-style font no smaller than 12 pt. Single-spacing is acceptable in tables and outlines.
  - Teams may include a supplemental appendix of no more than 20 double-sided sheets (40 total pages) of information. The appendix may include support documentation such as drawings, photos, organization charts, minutes of team meetings, test results, etc. *This material should directly support the process described in the primary document and NOT reflect activities related to community or promotional efforts, spirit development, or team building.*

5.1.2 Notebook Evaluation

- The notebook will be judged on the documentation of the team's:
  - ***Implementation of the Engineering Design Process***
    - Evidence that the engineering process was effectively used.
  - ***Research Paper***
    - Correlation between the current year's game theme and how related technological practices or scientific research is being used at a company/industry/research lab in the team's state or region; Any information related to the game theme, such as history, famous inventor(s), or major milestones; Analysis of the game theme/problem and the related technology's impact on the human experience, our needs, adaptations, and progress with solutions throughout history; Creativity in linking the game theme to appropriately related science/technology content; Proper use of grammar and composition throughout the paper; citations of sources used to gather information for the paper
    - The research paper must be a minimum of 2 pages and maximum of 5 pages (of the allotted 35 pages)
  - ***Brainstorming Approaches***
    - How well organized and productive was the brainstorming approach used? How well was the brainstorming approach documented?
  - ***Analytical Evaluation of Design Alternatives***
    - Use of analytical and mathematical skills in deciding upon and implementing design alternatives
  - ***Offensive and Defensive Evaluation***
    - Analysis of the gaming strategies and design elements used to achieve specific team goals
  - ***Software Development Process***
    - Evidence that a software development process was effectively used including
      - Project scope/requirements/specification ("what" the robot should do without stating how)
      - Design ("how" the software will achieve the scope/requirement/specification)
      - Implementation (tools, methods and techniques used in your programming)
      - Test/Verification (methods used to verify correct operation of the robot program)
      - Deployment (source code management, release, download frequency, etc.)
    - Evidence that software design methods/techniques were explored and utilized.
  - ***Safety***
    - Evidence that safety training took place and safe practices were followed to prevent students' misuse of tools and other devices/equipment that may result in personal injury or damage to property

- ***Support Documentation***
    - Team organization, team minutes, test results, CAD/other drawings, photos, etc. that support the main document
- ***Overall Quality and Completeness of Notebook***
    - Organization, appearance, adherence to specifications, quality of content

5.2 Marketing Presentation (25 Points)

- The Marketing Presentation will be worth 25 points towards the BEST Award.

5.2.1 Purpose and Context

- The purpose of the Marketing Presentation is for students to learn how to address the needs of a potential client, share product and brand information and navigate the business environment.
- The Team's Role: To create a company that designs and manufactures robots (the product).
- The Judge's Role: To serve as the client who is looking to purchase a robot(s) to solve a problem(s).
- The Problem: Refer to the Game Specific Rules and research real-world relevance in the manufacturing sector.

The context for the presentation is as follows:

Your team is a business pitching your latest invention/product to a group of decision makers at BEST Inc. headquarters in response to a Request For Proposal (RFP). Your goal is to inform, persuade, and build trust between your company and your potential client.

Your company's brand promise will establish a shared understanding of the client's problem and how your product delivers the solution. The only details about the engineering team and the manufacturing process that need to be included are those that highlight the unique characteristics or how the characteristics differentiate your product from a competitor. Storytelling should be an important tool to add personality to your brand and create a stronger connection with your client.

BEST Inc. is very involved in community outreach. Share how your team, as a potential vendor embraces the same social responsibility.

To close the meeting, formalize an action statement for the client.

5.2.2 Marketing Presentation Guidelines

- A minimum of 4 and maximum of 8 students may participate in the room for the presentation. Each student present must have an active role in the presentation.
- Each BEST Award team will sign up for a presentation time to occur at a time designated by the local hub or regional championship.
- Only students may participate in the presentation/discussion, including setting-up and dismantling the presentations. Teachers, parents, mentors and other loving adults are not permitted to watch the presentation.

- The only printed or other materials that teams may give to the judges are a brochure and business cards. No gifts for the judges please.
- Robots and models may be used during the presentation for demonstration purposes.
- Teams should represent diversity in grades, gender, race, ethnicity and abilities. Teams are encouraged to share and demonstrate how their efforts are inclusive.
- Videotaping/photographing the presentation by students will be allowed; however, the person(s) handling recording devices will be counted in the maximum students allowed and therefore s/he will need to contribute to the presentation beyond capturing footage or images.
- The presentation format is the prerogative of the team.
- The team must provide any equipment it wishes to use or check with the local hub or championship for information about what equipment can be provided. See the ***2020 Awards and Judging – Hub Logistics*** for details of equipment provided at your hub/championship event.

5.2.3 Marketing Presentation Logistics

- There will be a check-in station in the general area of the presentation rooms where teams should check in prior to their time slot.
- The presentation/meeting will last for no more than twenty-five (25) minutes including any setup/breakdown. Teams are expected to begin with formal presentation.
- The meeting may become conversational with judges beginning to ask questions after ten (10) minutes of uninterrupted presentation by the team. The team may instigate a conversational format at any time, if desired. This is to encourage a business meeting atmosphere.
- Teams should use the judges' questions as cues and adapt their conversation. Be prepared to go off script and have a dialog exchange with the judges.
- At least five (5) minutes will be scheduled between presentation sessions to allow breaks for judges, rotations and additional time to confer without the team present.
- The local hub or championship will provide event-specific information (times, locations, etc.). Refer to the ***2020 Awards and Judging – Hub Logistics*** document for these additional details.

5.2.4 Marketing Presentation Evaluation

Presentations will be evaluated with consideration of:

- ***Introduction, Problem Solving for Clients and Closing the Sale***
  - The team introduced themselves and explained their roles within the company.
  - The team (company) was knowledgeable and referenced the client's (judge's) needs listed in the Request For Proposal (the Game Story). The team defined the problem to solve.
  - The team explained their product's features and how the product's benefits solve the client's problem.
  - The team proposed the product's cost, delivery, warranty and avenues for training of the client's workforce to operate the new product.

- The team included its social responsibility and sustainability of their company and the impact it has on their community.
- The team provided an action statement for the client.

- ***Brand Promise***
  - The team created a consistent brand and brand promise.
  - The team clearly defined how the product is unique, desirable and produces a benefit(s) to the client.
  - The team provided a value proposition and how the value/trust can be acknowledged by the client.
  - The team expressed a mission statement for their company.
  - The team identified factors that differentiate their brand and product from the competition.
  - The team created a strong visual identity integrated into the brand, value and mission statement.

- ***Business Processes and Professionalism***
  - The team met the 4-8 participant guidelines and was dressed professionally or theme based.
  - The team was conversational and engaged in discussion.
  - The team utilized active listening techniques to keep the client engaged.
  - The team used storytelling or testimonials.
  - The team acted in a professional manner and was on brand.
  - The team used creative visual impact of presentation (i.e. infographics, etc.)

5.3 Team Exhibit and Judges Interview (20 Points)

- The Team Exhibit and Judges Interview will be worth 20 points towards the BEST Award.
- The purpose of the Team Exhibit is for students to display a visual story of the team's outcomes and impact. It is designed within the annual game theme and depicts the team's work in three realms: Robot/Product Features, Marketing/Branding, and Community Outreach/Advocacy.
- The purpose of the Interview is to
  - strengthen students' communication skills- (as listeners and speakers),
  - validate their knowledge and understanding of the work done by the entire team, and
  - spotlight unique design features, activities, or learnings.

5.3.1 Virtual Exhibit and Interview Guidelines

- All Team Exhibits will be implemented as virtual exhibits through a dedicated WordPress website for your team.
- The Virtual Team Exhibit must use the system provided through the BEST National Registry Team Workflow page.
- Only those themes and widgets available through the virtual exhibit template can be use.
- Native html coding is allowed.
- Primary exhibit content should be placed on the front page.

- The criteria for Team Exhibit content is the same as for a physical exhibit. See the Evaluation section for details.
- Pages other than the HOME page are allowed for additional content. The Virtual exhibit should not exceed 3 additional pages.
- During the scheduled interview time, at least one student representative from the team must be present who is able to respond to informal questions asked about the exhibit. In addition, student representatives should be aware that judges may ask questions concerning robot design and construction. These questions will be part of the interview evaluation of the team.
- Teams should expect to be visited by three to four different judges during a single interview period.
- In addition to the scheduled judges' interview with the team members, the team can arrange for and host an online public exhibition to showcase their exhibit to the public and video chat with the public online.

5.3.2 Exhibit and Interview Evaluation

- ***Exhibits*** (10 points) will be evaluated on:
- Social Responsibility
  - The team used visuals within the exhibit to effectively share outreach information, methods, audience and outcomes.
  - The team used testimonials and/or storytelling effectively to communicate impact in their school and community.
  - The exhibit reflects the diversity of the team (company) and their school and community (target audiences).
  - Team, Hub and national BEST sponsors are clearly displayed.
  - Hub and national BEST Robotics logos and/or branding are visible.
- Product and Brand
  - The exhibit tells a story based on visual impression and brand promise is evident.
  - The team showcased information of their product (robot) in an informative manner.
  - The team embraced technology and used it in a meaningful and relevant way.
  - The exhibit is cohesive, engaging, interactive and creative.
- Exhibit Design/Manufacturing and Adherence to Specifications
  - The exhibit effectively balances the use of print, models, multi-media, graphics and other technology.
  - The team adhered to all specifications set forth by the Hub/Championship
- ***Interviews*** (10 points) will be evaluated on:
- Company Elevator Speech
  - Clearly defines what benefits the product (robot) delivers.
  - Explains outreach and social responsibility.
  - Conveys the company's brand through tone and language.
- Testimonials and sharing the Brand

- Students communicated the brand personality.
- Students explained how their product (robot) provides brand advantage.
- The team used testimonials to communicate impact in their school and community.
- Outreach efforts and outcomes were shared.

- Game Theme and Learning Experience
  - Students clearly articulated an understanding of the game theme/problem.
  - The students showed evidence they were the primary designers and builders of their product (robot), exhibit and all materials.
  - Students clearly articulated lessons learned through the BEST experience.
  - Students communicated the impact of the BEST Robotics program on his/her path toward STEM or career choice.

5.4 Spirit and Sportsmanship (10 Points)

The Spirit and Sportsmanship component will not be judged in 2020 competitions. There will be zero points awarded for this component for all teams.

5.5 Robot Performance (15 Points)

- The *Robot Performance* component will determine the final 15% of possible BEST Award points. These 15 points will be based on the total game points earned
  - throughout the seeding phase of the head-to-head competition (for Outbreak Hub competitions), or
  - during the driver-controlled time trials (for Outbreak Classroom or Outbreak Online competitions),

  according to the following scale:

  - Team finishes in top 20% of all teams competing at hub — 15 Points
  - Team finishes in top 40% of all teams competing at hub — 12 Points
  - Team finishes in top 60% of all teams competing at hub — 9 Points
  - Team finishes in top 80% of all teams competing at hub — 6 Points
  - Team finishes in top 100% of all teams competing at hub — 3 Points
  - Team is unable to score any points during the competition — 0 Points
- Up to 15 Robot Performance points will be added to the total BEST Award points

5.6 BEST Robotics Brand Usage Guidelines for Teams

Although BEST Robotics does not require teams to design websites or tee shirts or maintain a certain level of presence on social media, students are encouraged to explore options and we support their creativity. BEST Robotics also wants to ensure that our brand is presented in a clear and consistent manner across our footprint. Therefore, we ask students to follow these guidelines:

- Include the BEST Robotics national logo on all digital and printed materials.
- Team websites should include
  - On the homepage - the national logo and a link to national website

    - Storytelling from students (video or quote with pictures)
    - Testimonials from community leader (video or quote with pictures)
- Tee shirts should include the national logo, set apart from other sponsors or positioned above all other sponsors
- All social media posts during or about your team's outreach activities should include the hashtag: #BESTRobotics and tag @BESTRobotics.

Section 6 Advancement to Regional Championship Competition

The total number of teams a hub will be allowed to send to a regional championship is determined by the regional championship. Traditionally this number is related to the number of teams competing at the hub, the total number of teams in the region, and the maximum number of teams that the regional championship venue can accommodate.

If a regional championship is offered, the advancing teams will be selected using the following priority order:

1. BEST Award 1st Place
2. Game Head-to-Head/Time Trials 1st Place
3. BEST Award 2nd Place
4. Game Head-to-Head/Time Trials 2nd Place
5. BEST Award 3rd Place
6. Game Head-to-Head/Time Trials 3rd Place
7. BEST Award 4th Place
8. Game Head-to-Head/Time Trials 4th Place
9. BEST Award 5th Place
10. BEST Award 6th Place
11. BEST Award 7th Place
12. etc…….

The list above is intended to illustrate the qualification order, not necessarily the exact number of teams advancing from each hub. In 2020, hubs will have the option of foregoing any playoff phases (wildcard, semifinals, finals) and ranking Game head-to-head place based on seeding phase or dedicated time trials alone.

Exception to the qualification order:

A hub has the option to advance a Game winner OR a BEST Award winner at their discretion IF the hub is limited in the number of advancing teams that can participate in the BEST Award at the regional championship, and IF a BEST winner also places as a Game winner.

For example, if a regional championship allows four advancing teams per hub, BUT only two advancing teams can participate in the BEST Award, AND a Game winner is also a BEST Award winner at the hub level, a hub could be forced to advance a 3rd place BEST Award team that cannot actually compete in the BEST Award at the Regional level. In such a case, the hub can opt to send the 3rd place Game winner instead of the 3rd place BEST Award winner.

Section 7 Standard Required Awards

7.1 Hub-Level Awards

The following summarizes all hub level awards that will be given. Awards distributed may be dependent upon the competition; see the Competition Specific Awards section for details on which awards will be given at each BEST hub competition. Optional awards are given at the hub's discretion.

BEST Award

Awarded to the team that best embodies the concept of ***Boosting Engineering, Science and Technology***. Winning the BEST Award is considered the highest achievement any team in the competition can accomplish. First, second, and third place finishes will be awarded.

Head-to-Head Competition Award or Robot Performance Award

Awarded to the teams whose machines finish first, second, and third in the head-to-head robotics competition or Robot Performance Time Trials. A fourth place "finalist" may also be awarded.

Most Robust Machine

Awarded to the team whose machine requires the least maintenance during and between matches and is generally the sturdiest machine in the competition.

Founders Award for Creative Design

Awarded to the team that makes best use of the engineering process in consideration of offensive and defensive capabilities in machine design. Awarded in recognition of BEST founders Steve Marum and Ted Mahler.

BEST Critical Design Review Award

Awarded to the team presenting the best overall Robot Critical Design Review to the judges that includes technical discussion of robot design features/functionality, requirements and strategies that influenced feature design, and the methods and results of each design discipline (mechanical, electrical, software, test, human factors, logistics, etc.).

Skills Challenges Awards

Awards are offered for multiple Skills Challenges categories. Awarded to the team with the highest cumulative score in the skill category as determined by the rubric or scoring method for that skill. The skills categories awards are:

- Autonomous Programming Skills Award (1st place, minimum)

- BESTMania Skills Quiz (1st place)
- Minecraft Challenge (1st place)
- BEST Robot Modeling Award
- BEST Engineering Drawings Award
- BEST Website Design Award
- BEST Video Design Award
- BEST Engineering Notebook Award (at Hub's discretion)
- BEST Marketing Presentation Award (at Hub's discretion)
- BEST Team Exhibit Award (at Hub's discretion)

7.1.2 Competition Specific Awards

7.1.2.1 Hub Competition

The following awards will be given at all BEST Hub Competitions, when multiple teams compete in a head-to-head fashion:

- Required awards:
  - BEST Award (1st – 3rd place)
  - Head-to-Head Competition Award (1st-4th place)
  - BEST Critical Design Review Award
  - Founder's Award for Creative Design
  - Most Robust Design Award
- Optional awards (at hub discretion):
  - Any Skills Challenge Awards

7.1.2.2 Classroom Competition

The following awards will be given for all BEST Classroom Competitions:

- Required awards:
  - BEST Award (1st – 3rd place)
  - Robot Performance (1st – 3rd place)
  - BEST Critical Design Review Award
  - Founder's Award for Creative Design
- Optional awards (at hub discretion):
  - Any Skills Challenge Awards

7.1.2.3 Online Skills Competition

The following awards will be given for all BEST Online Skills Competitions:

- Required awards:
  - BEST Award (1st – 3rd place)

  - Robot Performance (1st – 3rd place)
  - Autonomous Programming Skills Award (1st place, minimum)
  - BEST Critical Design Review Award
  - Founder's Award for Creative Design
  - BESTMania Skills Quiz (1st place)
  - Outbreak Minecraft Challenge (1st place)
- Optional awards (at hub discretion):
  - BEST Robot Modeling Award
  - BEST Engineering Drawings Award
  - BEST Website Design Award
  - BEST Video Design Award
  - BEST Engineering Notebook Award
  - BEST Marketing Presentation Award
  - BEST Team Exhibit Award

7.2 Regional Championship Awards

The following awards will be given at all BEST regional championships:

BEST Award

Awarded to the team that best embodies the concept of ***Boosting Engineering, Science and Technology***. Winning the BEST Award is considered the highest achievement any team in the competition can accomplish. First, second, and third place finishes will be awarded.

Head-to-Head Robotics Competition Award or Robot Performance Award

Awarded to the teams whose machines finish first, second, and third in the head-to-head robotics competition or Robot Performance Time Trials. A fourth place "finalist" award may also be awarded.

Founders Award for Creative Design

Awarded to the team that makes best use of the engineering process in consideration of offensive and defensive capabilities in machine design; awarded in recognition of BEST founders Steve Marum and Ted Mahler.

Most Robust Machine

Awarded to the team whose machine requires the least maintenance during and between matches and is generally the sturdiest machine in the competition.

BEST Critical Design Review Award

Awarded to the team presenting the best overall Robot Critical Design Review to the judges that includes technical discussion of robot design features/functionality, requirements and strategies that influenced feature design, and the methods and results of each design discipline (mechanical, electrical, software, test, human factors, logistics, etc.).

BEST Simulink Design Award

Awarded to one team in each of the 3 BEST regions (Denver, South's, Texas) that best applies the 'Simulink Support Package for VEX' based on the specified judging criteria and their robot's performance in the competition.