2   INFINITE RECHARGE^{SM} AT HOME

2.1   Overview

INFINITE RECHARGE^{SM} at Home brings events to teams in two (2) ways:

1. **Judged Awards:** Teams describe their ROBOT's technical qualities by sharing information with judges remotely to compete for traditional machine awards. While access to a team's INFINITE RECHARGE ROBOT is not required, access to pictures, videos, or other representation is.

> While the Judged Awards component does not require any ROBOT inspection, submitted ROBOTS should generally comply with the 2021 INFINITE RECHARGE ROBOT rules (i.e. no major, obvious violations).
>
> The ROBOT used for the Judged Awards does not need to be the same ROBOT used for the Skills Competition, but the same ROBOT must be used for all INFINITE RECHARGE at Home Judged Awards.

2. **Skills Competition**: Teams demonstrate what their ROBOTS and drivers can do in a Skills Competition inspired by the INFINITE RECHARGE game. Scores are posted on the FRC Events Page, and teams virtually compete against each other.
   a. Teams must participate in the Judged Awards component to participate in the Skills Competition.

2.2   Submission Information

See How to Submit and Deadlines for additional details on how to submit. To participate in INFINITE RECHARGE at Home, teams must opt into the Judged Awards component. Teams are asked to provide the following:

- two (2) contact emails (must be mentors)
- time zone
- image(s) of the ROBOT
    - at least one (1) required, up to three (3) images permitted.
    - provided for reference to judges for Judged Awards
    - can be a photo, a CAD image, sketches of specific elements, etc.
    - accepted formats include gif, jpg, jpeg, png.
    - each file must be no larger than 10 MB.

> There are no restrictions on how many times a ROBOT may appear within each image. For example, four images of the ROBOT, saved as a single file, is considered a single image. Please note that Judges are instructed to review the quality of the content; not the quantity of information provided in an image. Judges view images within the Entry

> Submission System, so images should be clear and easy to see without relying on the viewer to download or zoom.

- Optional - a video, consisting of a continuous single shot, of the ROBOT performing an autonomous routine
    - required to be considered for the Autonomous Award, otherwise optional
    - video may be of the ROBOT'S traditional autonomous routine for INFINITE RECHARGE or an autonomous routine from the Skills Competition
    - videos may not exceed three (3) minutes
    - accepted formats include flv, m4v, mov, mp4, mpeg, mpeg4, mpg, ogm, ogx, swf, wmv. Most common codecs used in these containers are accepted, for a complete list of accepted container/codec pairs see Supported Input Codecs and Containers.

> We recommend teams use a minimum resolution of 720p when recording videos.
>
> There is no technical / theoretical limit to supported file size, however, the user's upload bandwidth is likely the limiting factor. 5GB uploads work fine on high-speed internet connections but could take several hours on an average broadband connection. The longer it takes to upload a video, the more likely there could be an interruption to network connectivity, and difficulties completing an upload.

- Optional – flyer about the ROBOT
    - limit to 1-page, no larger than 8.5 in. x 14 in. (~21cm x 35cm) (either portrait or landscape orientations)
    - readable at 100% zoom
    - pdf is the only accepted file format
    - file must be no larger than 10 MB

> This page size is intended to allow for the default settings used by most word processors and slide decks. Teams may use whatever file type they like as long as the submission is uploaded as a pdf and it meets the above requirements.

Do not include links or redirects to additional content outside the bullets described above (e.g. include a link to webpage with additional images or content); such references will not be reviewed.

2.2.1   Additional Requirements for the Skills Competition

The Skills Competition requires submission of the Judged Awards component. Teams that opt into the Skills Competition are asked to provide scores and video proof of completion for each challenge. Teams that do not submit materials for the Judged Awards component by its deadline are ineligible for the Skills Competition and any submitted scores will be discarded.

> As noted in Deadlines, frcathome.org is closed for submissions from March 4th at 3pm to March 8th at 3pm ET. Teams participating in the Skills Competition may submit or update scores before or after that timeframe until the deadline.

See How to Submit and Deadlines for additional details on how to submit. The Skills Competition submission is entered independent of the Judged Awards component and does not need to be submitted at the same time. To participate in the Skills Competition part of INFINITE RECHARGE at Home, teams must provide the following:

- a score for each challenge in which they complete
- a video for each challenge in which they complete
    - accepted video formats include flv, m4v, mov, mp4, mpeg, mpeg4, mpg, ogm, ogx, swf, wmv. Most common codecs used in these containers are accepted, for a complete list of accepted container/codec pairs Supported Input Codecs and Containers.
    - Each video may not exceed six (6) minutes

> Although the videos may be up to six (6) minutes, teams should only keep them as long as needed.
>
> Submitted video may be used to check the accuracy of a reported score or for marketing purposes and will not be made publicly available. Teams are encouraged to make sure that the recorded score is clearly represented in the video, scores which cannot be verified may be discarded.
>
> We recommend teams use a minimum resolution of 720p (1280x720px) when recording videos.
>
> There is no technical / theoretical limit to supported file size, however, the user's upload bandwidth is likely the limiting factor. 5GB uploads work fine on high-speed internet connections but could take several hours on an average broadband connection. The longer it takes to upload a video, the more likely there could be an interruption to network connectivity, and difficulties completing an upload.

2.3   Awards & Judging Logistics

2.3.1   Awards

Teams are required to submit the required information by the deadline and participate in an interview with *FIRST* Robotics Competition judges to be eligible for Judged Awards. The official award guidelines can be found on the At Home Challenges Award Guidelines webpage. Interviews are virtual and hosted on Microsoft Teams. A Microsoft Teams account is not required to join the call, but a free account can be used for remote interview practice. See Using Microsoft Teams for instructions. Teams do not have to participate in the Skills Competition component of INFINITE RECHARGE at Home to be eligible for the Judged Awards, but teams must participate in the Judged Awards to be eligible for participation in the Skills Competition. The Judged Awards are:

- **Autonomous Award *sponsored by Ford*** - Celebrates the team that has demonstrated consistent, reliable, high-performance ROBOT operation during autonomously managed actions. Evaluation is based on the ROBOT's ability to sense its surroundings, position itself or onboard mechanisms appropriately, and execute tasks.

- **Excellence in Engineering Award** - Celebrates the team that demonstrates a professional approach to the design process.
- **Industrial Design Award** *sponsored by General Motors* - Celebrates the team that demonstrates industrial design principles, striking a balance between form, function, and aesthetics.
- **Quality Award** - Celebrates machine robustness in concept and fabrication.
- **Rookie Game Changer** (optional) – Celebrates a rookie team's outstanding success this season.

Teams who opt-in to the Skills Competition are required to submit specific information to be eligible for competition. Teams will be recognized as described below:

- **Skills Competition Winner** – Celebrates a team's outstanding success with the Skills Competition. The winner has the highest Overall Score in their GROUP.
- **Skills Competition Finalist** - Celebrates a team's outstanding success with the Skills Competition. The finalist has the second highest Overall Score in their GROUP.

2.3.2 Judging GROUPS

In INFINITE RECHARGE at Home, teams are divided into GROUPS and compete with other teams regardless of location (e.g. a team from Australia may be placed into the same GROUP as a team from Michigan). A GROUP is the collection of teams that compete against each other for awards in a specific 2021 At Home Challenge. If a team is participating in multiple challenges, the GROUP they are placed in for INFINITE RECHARGE at Home, for example, may not be the same GROUP the team is placed in for the Game Design Challenge.

A team cannot participate in the Skills Competition without participating in the Judged Awards component of INFINITE RECHARGE at Home.

Teams are assigned to a GROUP by *FIRST* Headquarters. After assignments have been made, the GROUP is shown on the [FRC Events webpage](). Each GROUP has between 25-35 teams (with a target of ~30 teams), pending total number of teams participating.

The process used to assign teams to their GROUP is as follows:

1. Determine initial number of GROUPS by assessing the number of teams who have opted-in to the Skills Challenge by the deadline, divided by 30, and rounded up.
2. Rookie teams (2020 and 2021 Rookies) who have opted-in to the Skills Challenge are assigned randomly, team by team, to GROUPS (i.e. team in GROUP A, team in GROUP B, team in GROUP C, etc., returning to GROUP A if necessary).
3. Step 2 is repeated with Veteran teams who have opted-in to the Skills Competition.
4. Add additional GROUPS by assessing the number of teams who have not opted-in to the Skills Competition by the deadline, divided by 30, and rounded up.
5. Step 2 is repeated using Rookie teams who have not opted into the Skills Competition, except into the GROUPS formed in Step 4.
6. Step 2 is repeated using Veteran teams who have not opted into the Skills Competition, except into the GROUPS formed in Step 4.
7. If any GROUP contains less than the minimum of 25 teams, a GROUP is dissolved, and the teams are redistributed into the remaining GROUPS of that type (Skills or non-Skills). This is repeated

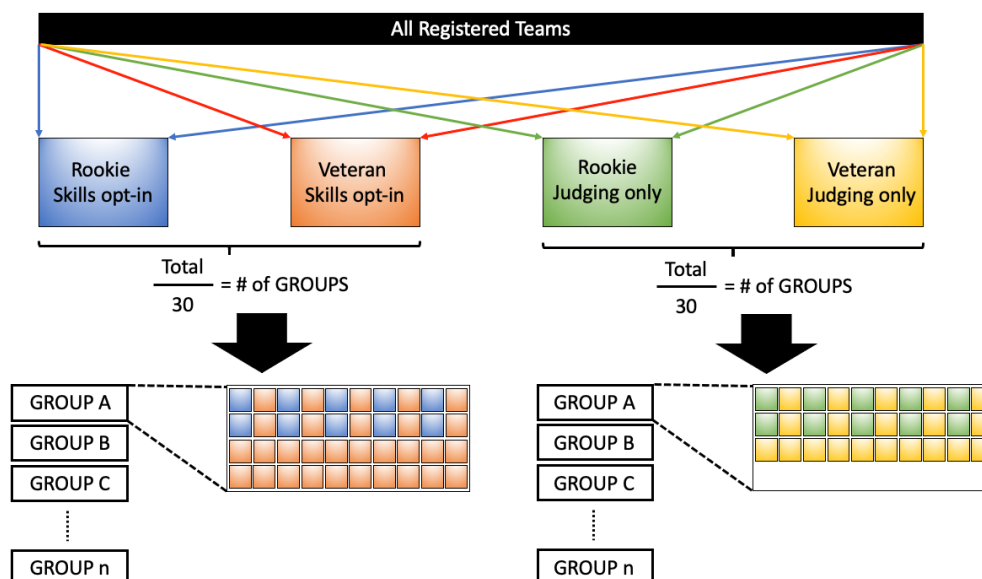until all GROUPS contain the minimum threshold of teams.

Figure 2-1 INFINITE RECHARGE at Home Groups

2.3.3 Judging Process

- Teams must submit all content described in <u>Submission Information</u> by the deadline as described in <u>Deadlines</u>.
- Judge Advisors contact teams (via the email they supplied when submitting) to schedule an interview with a panel of judges.
- Judges 'spread the wealth' within this challenge so no team wins more than one (1) judged award for INFINITE RECHARGE at Home. Skills Competition Awards are not judged awards, so a team may win a Skills Competition Award in addition to a judged award.

2.3.4 Interview Process

Teams with a completed INFINITE RECHARGE at Home submission receive an interview with a panel of *FIRST* Robotics Competition judges. The default format is a video conference, but a call-in number can be provided if needed.

A Judge Advisor will contact the team's mentors identified in the team's submission with the team's assigned time slot. If that slot doesn't work for the team, they should inform the Judge Advisor as soon as possible.

For all At Home Challenges, interviews occur between Monday, March 15th and Sunday, April 11th.

- Interviews are limited to twelve (12) minutes total; up to seven (7) minutes for a presentation by the team and the remaining time (at least five (5) minutes) for questions and answers led by the judges.
    - o The interview time begins after a one (1) minute buffer to allow all team members to be on the call.

- o Recommended presentation is as follows:
  - ▪ What the ROBOT was designed to do
  - ▪ The process used to design the ROBOT
  - ▪ Why a specific ROBOT feature was chosen and how it works
- At least one (1) adult mentor **must** attend the interview.
  - o Mentors are not allowed to provide any assistance during the interview. *FIRST* suggests this mentor provides feedback to the team after the interview based on observations and noting judges' questions. This feedback can be very valuable in helping teams hone their skills. If the mentor provides any assistance during the interview, the judges will respectfully remind the mentor of the rule.
- Teams are allowed to have as many team members in the interview as they believe they need but teams are encouraged to create a succinct presentation for the judges. We recommend no more than five (5) team members.

> Presenters should be ready for (and even expect!) technical difficulties; all team members should be prepared to step in (e.g. know the material, have presentation materials on hand, etc.) in case someone has internet, camera, audio, etc. issues.
>
> Remember to put safety first with social distancing guidelines and compliance with local regulations if team members are in the same physical location.

- Interviews are conducted in English. Teams needing a translator or sign-language interpreter may include an additional person to act as that translator/interpreter. The translator/interpreter does not need to be a team member. For these teams, the duration of the interview is increased by three (3) minutes.
- Presenters may share their screens and play video.
- Recording video, audio, or taking pictures (including screenshots) are prohibited during the interview.

> In addition to *FIRST* prohibiting recording, there may be other legal restrictions governing recording.

2.4 Skills Competition

INFINITE RECHARGE at Home includes a Skills Competition consisting of five (5) challenges, inspired by INFINITE RECHARGE. Teams may opt to compete in as many or as few of the challenges as they would like. Teams should try to complete at least three (3) of the challenges, as each team is awarded points towards their Overall Score for the three (3) challenges they performed the best in, see Overall Score for complete details.

2.4.1 Overview

The Skills Competition has been developed for participation by a 2020 or 2021 INFINITE RECHARGE ROBOT and doesn't require a full competition field. Each challenge has an objective score that teams record and submit. As the Skills Competition is based on INFINITE RECHARGE, many of the defined terms used in this manual are referencing terms from the INFINITE RECHARGE Manual. These terms are not

explicitly defined in this document, but the definitions have been included in the Glossary for ease. For full descriptions, please see the INFINITE RECHARGE Manual.

To participate in the Skills Competition, teams require the following:

- A legal INFINITE RECHARGE ROBOT (reference ROBOT & Inspection Rules)
- an open space, i.e. Challenge Space, to operate the ROBOT
    - ~15 ft. x ~30 ft. (~458 cm x ~915 cm) of playing space is strongly recommended. Additional space is required for drivers and observers.
    - If attempting shooting challenges, adequate height for the ROBOT to shoot POWER CELLS into the POWER PORT representation. Total POWER PORT height is ~10ft. (~305 cm).
    - Carpet is not needed, any surface on which the ROBOT can safely drive is permitted

> Omitting the requirement for carpet is intended to ease the burden on teams in establishing their Challenge Space, i.e. let teams use flooring readily available to them. The intent is not to include flooring design in the scope of the Skills Competition.

- POWER CELLS
    - three (3) POWER CELLS are needed (included in the 2021 Kickoff Kit).
- Team Version Field Elements (wooden or comparable) are not required. For the Interstellar Accuracy Challenge and the POWER PORT Challenge, a representation of the POWER PORT with approximate dimensions is required. See The INFINITE RECHARGE at Home Challenge Space Layout for recommendations.

2.4.2 General Rules

Rules below apply to all team members and while setting up for and attempting a challenge, unless otherwise noted.

SC1. Team members must wear safety glasses.

SC2. Team members must follow organizational and local health and safety regulations and guidance.

> Reference the Safety Guidance for *FIRST* Robotics Competition Teams for COVID-19.
>
> Remember, safety is paramount while working with and around your ROBOT. Best safety practices should always be at the forefront while practicing and completing the Skills Competition. In addition to the rules outlined above, some recommendations for safe practices include:
>
> a. Stay out of the ROBOT Challenge Space unless performing a HUMAN PLAYER task,
> b. Pay attention to where your OPERATOR CONSOLE is located relative to where you are driving/shooting, and
> c. If using a tether, be mindful of the wire (recommend using a 50 ft (~1524 cm) cable)

SC3. While attempting a challenge, team members may not contact the ROBOT.

SC4. While attempting a challenge, and unless challenge requires autonomy, the ROBOT may only be operated by up to two (2) precollege student member(s) of the team.

SC5. Remember to embody *Gracious Professionalism*®, a *FIRST*® Philosophy, when completing these challenges and follow the intent of the rules.

SC6. For any of the Challenges that require timing, teams must use a timing device that indicates time to at least tenths of a second precision.

2.4.3 ROBOT & Inspection Rules

SC7. A ROBOT attempting a challenge must comply with all ROBOT rules in the 2021 Game Manual with the exception of R21, R22 (i.e. BUMPER fabric may be any color and contain any markings), the "via the ARENA Ethernet network" clause of R62, and R92. Rules that reference the ARENA should be interpreted as referencing the Challenge Space for the At Home Challenges.

SC8. All submitted Skills Competition challenges must be completed with the same ROBOT in the same configuration.

> This is not intended to prevent teams from making minor upgrades or enhancements throughout the path of the Skills Competition. The intent of this rule is to prevent teams from making substantial changes to their ROBOT between challenges (e.g. completing the POWER PORT challenge, and then removing all POWER CELL related mechanisms for completion of the Hyperdrive challenge).
>
> Please note that per the Blue Box in Section 2.1, the ROBOT used for the Skills Competition does not need to be the same ROBOT used for the Judged Awards part of INFINITE RECHARGE at Home.

SC9. Teams must self-inspect and certify that the ROBOT used for challenge submissions is compliant with SC7 and SC8.

> A self-inspection checklist is available here.

SC10. A ROBOT attempting a challenge must do so in a way that complies with G1-C in the 2021 Game Manual.

SC11. A ROBOT attempting a challenge must do so in a way that complies with G17 in the 2021 Game Manual.

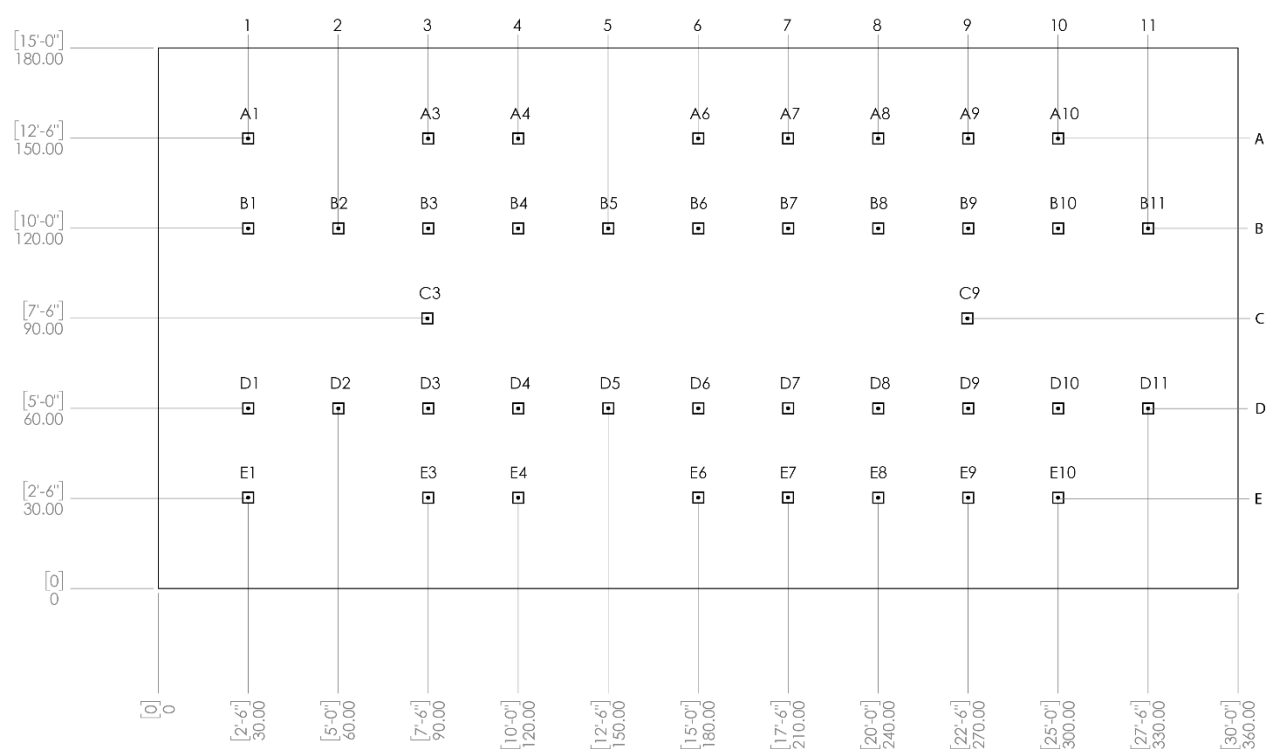### 2.4.4 Challenge Space Layout

Figure 2-2 General Layout Diagram

All of the Skills Competition challenges use a variation of the layout shown in Figure 2-2. The specific locations marked on the Skills Competition General Layout Diagram and used to locate MARKERS or zones for specific challenges are called NAV POINTS. It is recommended, but not required, for teams to measure and place marks on the floor (stickers, tape, etc...) to be able to identify these NAV POINTS later.

> NAV POINTS are different for each challenge, as a result not all of them may be needed in a team's Challenge Space.
>
> One solution to mark this layout, is documented in The INFINITE RECHARGE at Home Challenge Space Layout.

For each challenge, a layout diagram indicates which NAV POINTS are used and the placement of MARKERS. MARKERS are physical objects with a minimal cross-section of 2.5 in (~63 mm) wide by 2.5 in (~63 mm) deep and at least 5 in (~127 mm) tall used to mark specific locations relevant to each challenge. The cross-section of a MARKER may not exceed 1 ft. 1 in. (~330 mm) wide by 1 ft. 1 in. (~330 mm) deep (there is no height limit). MARKERS are to be centered (approximately, and to the best of the team's ability, i.e. there's no specific tolerance on "centered") on their respective NAV POINTS.

> MARKERS on the field should have a contrasting color or otherwise be easily distinguishable, allowing them to be easily recognizable to the operator and throughout the video.

> Some examples of MARKERS include but are not limited to: 4" x 4" lumber, 2 Liter bottles, small cones, etc.

Additional markings may be added on the floor or POWER PORT at team discretion. No other physical elements may be added within the Challenge Space for the purpose of aiding ROBOT or DRIVE TEAM performance. Other static elements outside the Challenge Space may be placed to aid robot navigation, provided the robot does not physically interact with them.

> Note that per GSC2-1, teams may not use placement of static elements to signal to the ROBOT which set of paths is being run.

2.4.5   Filming

Teams must showcase ROBOT performance by taking short videos of their ROBOTS completing each challenge. Scores submitted without a video will be discarded. Recommended guidelines are as follows:

- Each video should be recorded from a fixed position outside the operating space of the ROBOT. The exact distance away from the operating space will depend on the height and orientation of the camera to the field, but it's recommended that the camera always have a full-frame view of the operating space if possible. This may require a distance of up to 6 feet away from the operating space.
  - If the camera cannot be fixed (e.g. using a tripod, table, or ladder), movement of the camera during filming should be minimized.
- Each video does not need to use the same field of view but maintaining a consistent field of view whenever possible provides a more uniform viewing experience.
- Each video should be titled with the team number, a hyphen, challenge title, and omit spaces (e.g. Team0001-InterstellarAccuracyChallenge)

2.4.6   Galactic Search Challenge

In the Galactic Search challenge, teams emulate the Autonomous Period of INFINITE RECHARGE gameplay by locating and collecting POWER CELLS as fast as they can on one of two (2) pairs of paths.

2.4.6.1   Layout

Teams should mark the boundary of zones from the diagram below using at least one MARKER on the NAV POINTS along the zone boundary (e.g., any number of A1-E1 and B11-D11).
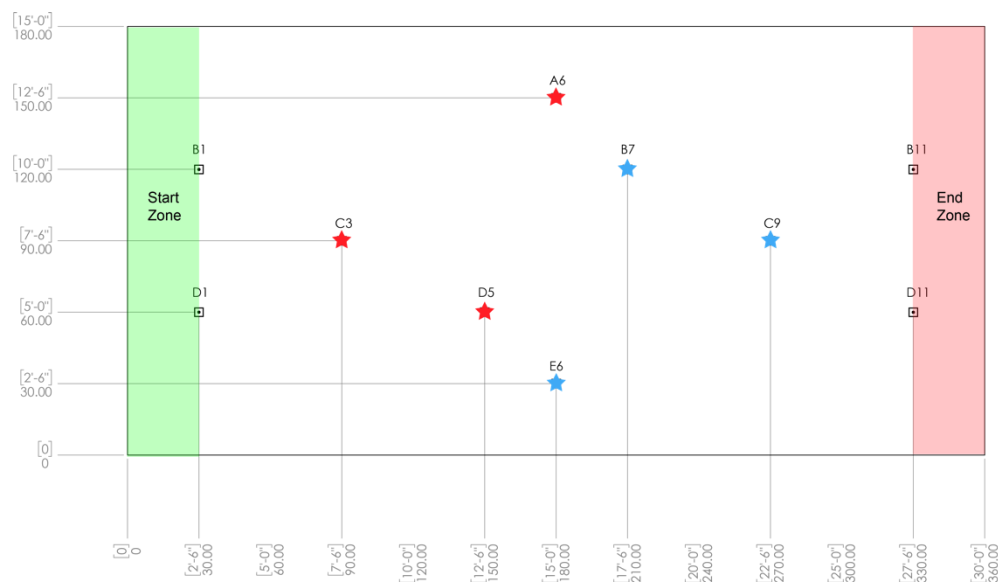
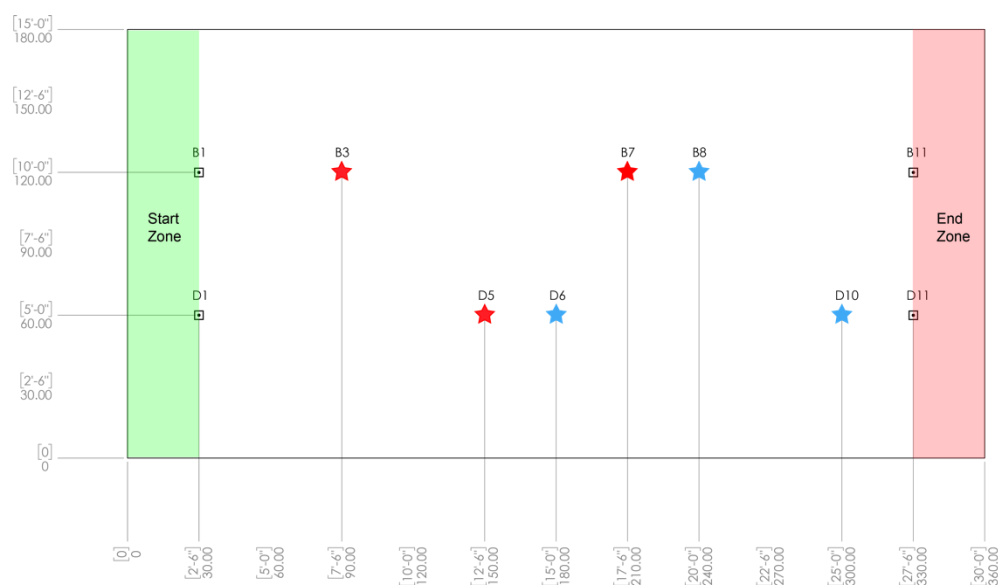*Figure 2-3 Galactic Search Layout – Path A*

Figure 2-4: Galactic Search Layout – Path B

2.4.6.2   Rules

GSC1. A ROBOT must run both paths A and B autonomously.

GSC2. Teams must randomly determine (e.g. coin, die, phone app, etc.) if they run the red or blue paths.

> Teams make a single random determination and then run the same color on both paths.

GSC2-1. Teams may signal neither the path (A or B) nor the GSC2 determination (red or blue) to the ROBOT. Placement of the ROBOT is not considered signaling.

GSC3. Place POWER CELLS only on the corresponding red or blue NAV POINTS.

> If a team's POWER CELLS are not staying in place, try securing an O-Ring, looped cable tie, or hair elastic to the floor and placing the POWER CELL atop.

GSC4. The ROBOT must start in the Start Zone with any part of its BUMPERS breaking the plane defined by B1/D1.

GSC5. Teams must start their timer as soon as the ROBOT is enabled.

GSC6. Teams must stop their timer as soon as the ROBOT is in CONTROL of all three (3) POWER CELLS and any part of its BUMPERS breaks the plane of the End Zone.

GSC7. Teams must record the completion time and video separately for each of the two (2) paths.

2.4.6.3 Scoring

The raw score for this challenge is the sum of completion times (in seconds) for the two (2) path runs. Teams should enter the times for the individual paths exactly as they record them, they will be rounded automatically to the nearest tenth of a second (x.x5 is rounded up to the nearest tenth, e.g. 0.15 is rounded to 0.2) before being combined into the raw score.

2.4.7 AutoNav Challenge

In the AutoNav Challenge teams program their ROBOTS to autonomously drive predetermined routes through three (3) different paths as fast as possible.

2.4.7.1 Layout

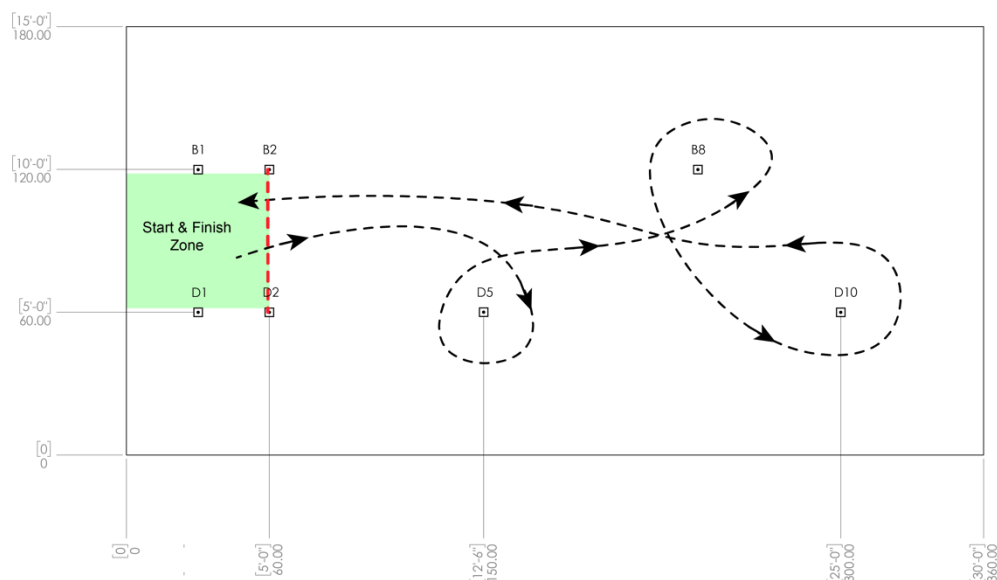For each path, place MARKERS on the NAV POINTS shown in the corresponding diagram.
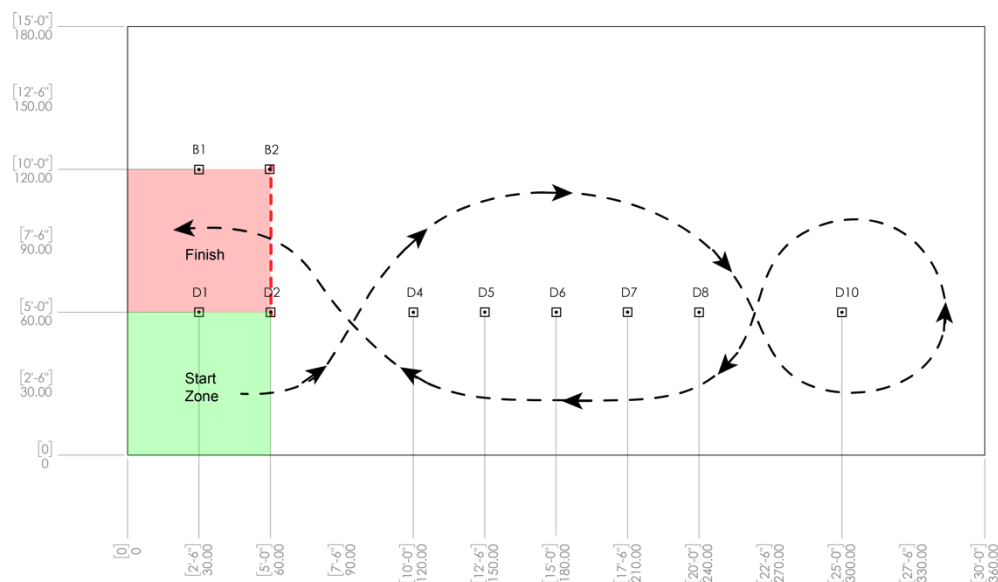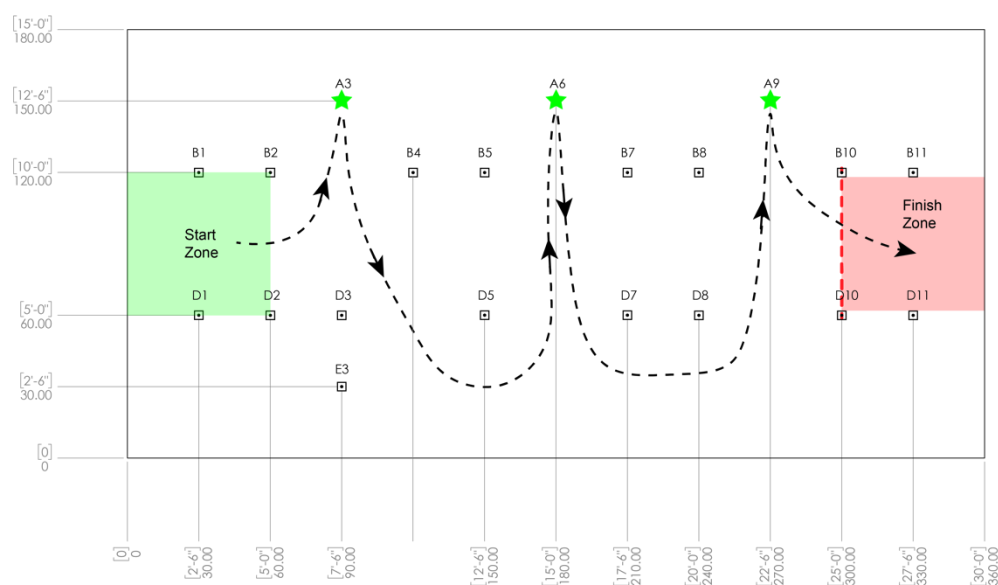

Figure 2-5 Barrel Racing Path

Figure 2-6 Slalom Path

Figure 2-7 Bounce Path

2.4.7.2   Rules

ANC1. The ROBOT must complete each of three paths (barrel racing, slalom, and bounce) autonomously.

ANC2. The ROBOT must start completely within the Start Zone.

ANC3. Teams must start their timer as soon as the ROBOT is enabled.

ANC4. In the Bounce Path, the ROBOT must contact each starred MARKER as it navigates the path. A ROBOT that fails to contact a starred MARKER renders the attempt incomplete and is assigned a sixty (60) second completion time.

ANC5. A ROBOT that contacts a non-starred MARKER while navigating a path incurs a five (5) second penalty each time a MARKER is contacted.

> Clean runs, i.e. navigating the complete path without contacting any non-starred MARKERS, are highly encouraged.

ANC6. Teams may not use a penalty in order to skip MARKERS or complete the path any other way than via the described path marked by the black dashed line in the layout diagrams.

> The exact paths indicated by the dotted lines are for illustration purposes. The ROBOT must navigate the same general path with respect to NAV POINTS and MARKERS.

ANC7. Teams must stop their timer as soon as the ROBOT completes the prescribed path and any part of its BUMPERS breaks the plane defined by the red dashed line on the path's layout diagram.

ANC8. Teams must complete at least one (1) of the three (3) paths in under 60 seconds in order to submit a score. If a team completes only one (1) or two (2) of the paths, any path not completed should be recorded as a completion time of 60 seconds.

ANC9. Teams must record the completion time (including penalties) and video separately for each of the paths.

2.4.7.3   *Scoring*

The raw score for this challenge is the sum of the times (in seconds) for each of the three (3) paths. Teams should enter the times for the individual paths exactly as they record them, they will be rounded automatically to the nearest tenth of a second (x.x5 is rounded up to the nearest tenth, e.g. 0.15 is rounded to 0.2) before being combined into the raw score.

2.4.8   Hyperdrive Challenge

In the Hyperdrive Challenge teams drive their ROBOTS remotely, without the assistance of pre-programmed navigation, through four (4) different paths as fast as possible. The first three (3) paths are the same as those described in AutoNav Challenge, the fourth path is the Lightspeed Circuit path.

2.4.8.1   *Layout*

For each path, place MARKERS on NAV POINTS shown in the corresponding diagram. The first three (3) paths are described in AutoNav Challenge.
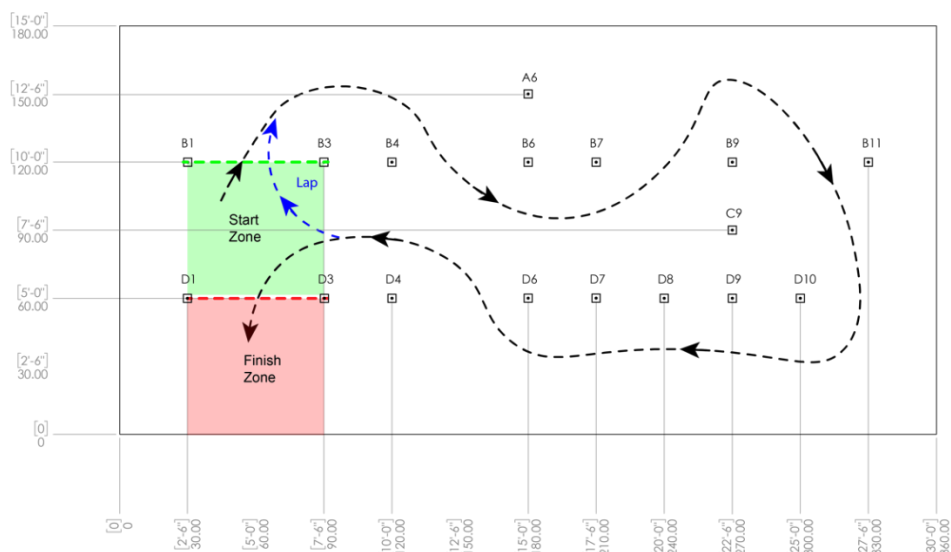
Figure 2-8 Lightspeed Circuit Path

2.4.8.2 Rules

HDC1. Teams remotely drive their ROBOTS to complete each of the four (4) paths (barrel racing, slalom, bounce, and lightspeed circuit)

HDC2. The ROBOT must start completely within the Start Zone.

HDC3. Teams must start the timer as soon as the ROBOT begins motion to navigate the path.

HDC4. ROBOTS follow the prescribed path marked by the black dashed line in the layout diagram for each path. While the exact path indicated on the layout diagram is for illustration purposes only, the ROBOT is expected to navigate the same general path with respect to the MARKERS.

HDC5. In the Bounce Path, the ROBOT must contact each starred MARKER as it navigates the path. Failing to contact a starred MARKER while navigating the "Bounce Path" renders the attempt as "not completed" and must try again.

HDC6. A ROBOT that contacts a non-starred MARKER while navigating a path incurs a five (5) second penalty each time a MARKER is contacted.

> Clean runs, i.e. navigating the complete path without contacting any non-starred MARKERS, are highly encouraged.

HDC7. Teams may not use a penalty in order to skip MARKERS or complete the path any other way than via the described path marked by the black dashed line in the layout diagrams.

> The exact paths indicated by the dotted lines are for illustration purposes. The ROBOT must navigate the same general path with respect to NAV POINTS and MARKERS.

HDC8. In the Lightspeed Circuit Path, the ROBOT must complete two (2) laps around the path. The lap path is indicated on the layout diagram with a blue dotted line – the ROBOT should only follow

the blue lap path once. Once the ROBOT has completed two laps, it may follow the navigation path to the Finish Zone.

HDC9. Teams must stop their timer as soon as the ROBOT completes the prescribed path and any part of its BUMPERS breaks the plane defined by the red dashed line on the path's layout diagram.

HDC10. Teams must record the completion time (including penalties) and video separately for each of the paths.

2.4.8.3 Scoring

The raw score for this challenge is the sum of the times (in seconds) for each of the four (4) paths. Teams should enter the times for the individual paths exactly as they record them, they will be rounded automatically to the nearest tenth of a second (x.x5 is rounded up to the nearest tenth, e.g. 0.15 is rounded to 0.2) before being combined into the raw score.

2.4.9 Interstellar Accuracy Challenge

In the Interstellar Accuracy Challenge teams emulate the shooting challenges of INFINITE RECHARGE gameplay by scoring POWER CELLS into a representation of the BOTTOM PORT, OUTER PORT, AND INNER PORT from four (4) zones. Teams attempt to score as many points as possible with their ROBOT (which is either autonomous and/or remotely controlled) in five (5) minutes.

2.4.9.1 Layout

Teams should mark the boundary of zones from the diagram below using at least one MARKER on the NAV POINTS along the zone boundary (e.g., any number of A3-E3, A5-E5, A7-E7, A9-E9).

Two (2) layouts are provided for teams to choose from. The first layout is intended for flat POWER PORT representations or where a non-flat POWER PORT can be located outside the Challenge Space. The second layout is intended for locating the POWER PORT within the Challenge Space.
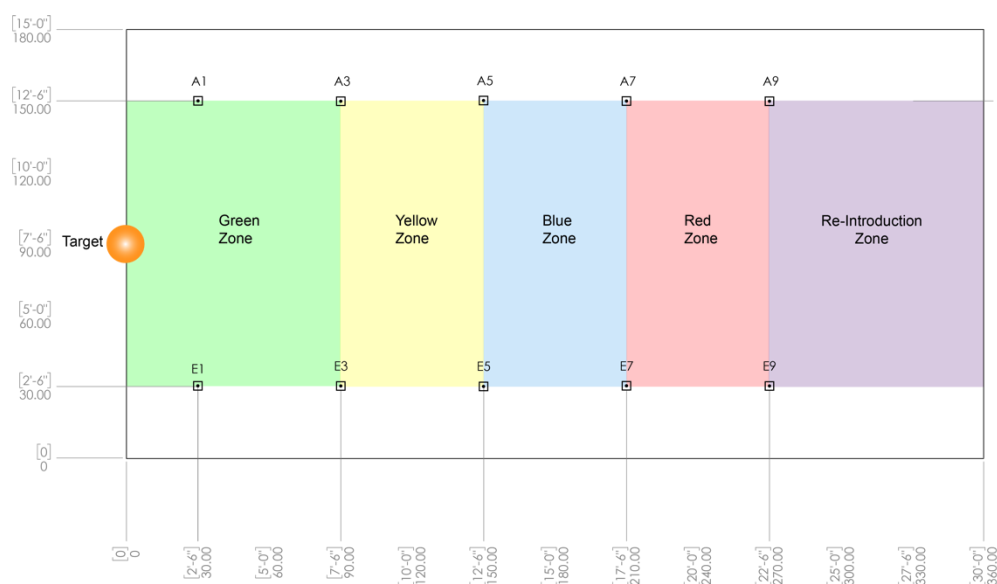
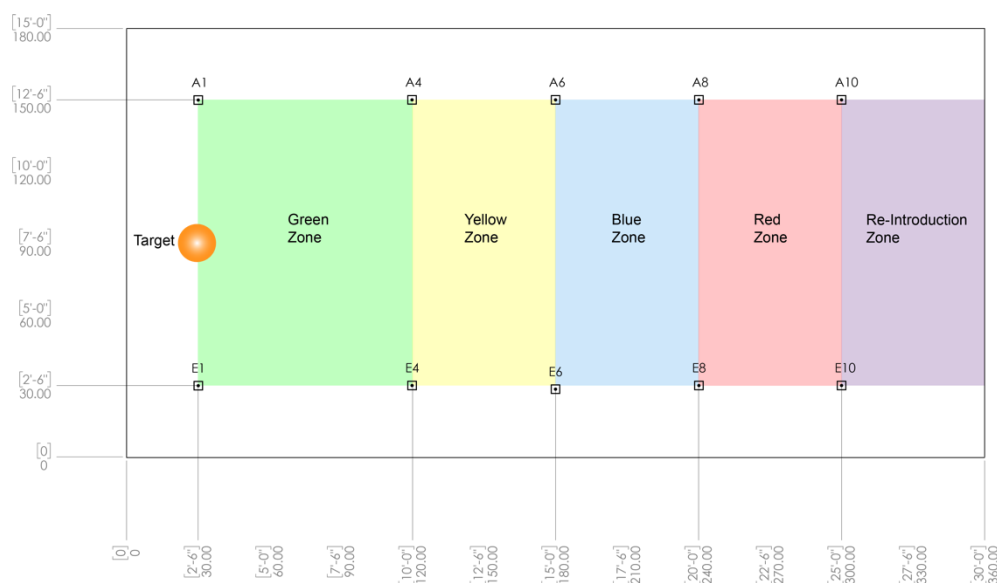*Figure 2-9 Interstellar Accuracy Challenge Layout, no field element*

Figure 2-10 Interstellar Accuracy Challenge, with field element

2.4.9.2   Rules

IAC1.   Teams may not attempt more than fifteen (15) POWER CELL shots.

IAC2.   Teams must allocate at least three (3) POWER CELLS per zone. The remaining three (3) POWER CELLS may be allocated to any of the four (4) zones.

> Allocate means to assign the only zone from which the POWER CELL may be shot. Teams don't have to shoot all fifteen (15) POWER CELLS.
>
> For example, a ROBOT may shoot all remaining three (3) POWER CELLS from NAV POINT A4 in the Yellow zone, or one (1) shot from B1, B4, and B6 in the Green, Yellow, and Blue zones respectively.

IAC3.   The ROBOT may not be preloaded with more than three (3) POWER CELLS such that they are fully and solely supported by the ROBOT.

IAC4.   The ROBOT must start completely within the Green Zone.

IAC5.   Teams must start the timer as soon as the ROBOT begins motion, and the challenge must be completed within five (5) minutes.

IAC6.   The ROBOT may not have greater-than-momentary CONTROL of more than three (3) POWER CELLS at a time, either directly or transitively through other objects.

IAC7.   Shots must be taken with the ROBOT stationary and its BUMPERS completely within the zone.

IAC8.   No more than two (2) people may feed POWER CELLS to the ROBOT.

> Please make sure to play safely! Team members introducing POWER CELLS to the Challenge Space may walk or run; they may roll or throw POWER CELLS. Challenge Space should be clear of trip hazards. Fragile objects should be protected from damage by POWER CELLS, and all team members in or near the Challenge Space should be paying attention to the ROBOT and POWER CELLS.

IAC9. The ROBOT must be completely within the Reintroduction Zone in order to acquire POWER CELLS from humans.

> POWER CELLS may be introduced either directly to the ROBOT or onto the floor.

2.4.9.3 Scoring

The raw score is the total number of points scored within the 5-minute period. Teams must record a raw score greater than 0 to have the challenge count towards calculation of Overall Scores. Points are awarded for each POWER CELL scored in the representation of the POWER PORT at the same values as in INFINITE RECHARGE.

- BOTTOM PORT = 1 Point
- OUTER PORT = 2 Points
- INNER PORT = 3 Points

Any POWER CELLS released by the ROBOT within the 5-minute time period and subsequently scored will count. To avoid timing errors, you can manage the time automatically by using the Practice Timing of the FRC Driver Station set to the correct timing (5,0,0,300,0) as shown here.

If using a 2D POWER PORT representation, a POWER CELL is considered scored if at least 50% of the POWER CELL is inside the boundary. For shots that are indeterminately close to the 50% threshold, the team may consider the POWER CELL scored accordingly.
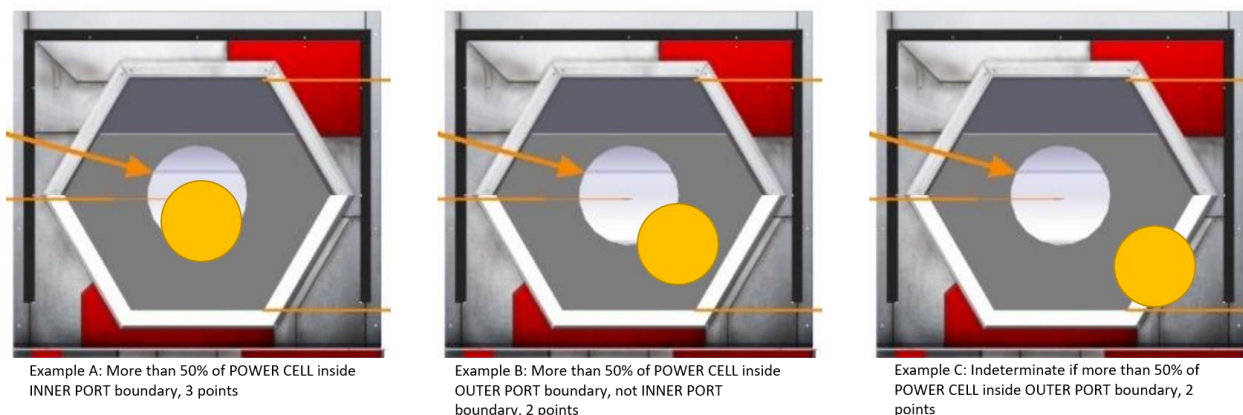

Example A: More than 50% of POWER CELL inside INNER PORT boundary, 3 points

Example B: More than 50% of POWER CELL inside OUTER PORT boundary, not INNER PORT boundary, 2 points

Example C: Indeterminate if more than 50% of POWER CELL inside OUTER PORT boundary, 2 points

Figure 2-11 Examples of shots on two-dimensional INNER and OUTER PORTS

2.4.10 POWER PORT Challenge

In the POWER PORT Challenge, teams emulate the teleoperated portion of INFINITE RECHARGE gameplay by collecting POWER CELLS with their ROBOT (which is either autonomous and/or remotely

controlled) and scoring them into a representation of the POWER PORT. Teams attempt to score as many points as possible in the POWER PORT in one minute.

2.4.10.1 Layout

Teams should mark the boundary of zones from the diagram below using at least one MARKER on the NAV POINTS along the zone boundary (e.g., any number of A6-E6 and A9-E9).

Two (2) layouts are provided for teams to choose from. The first layout is intended for flat POWER PORT representations or where a non-flat POWER PORT can be located outside the Challenge Space. The second layout is intended for locating the POWER PORT within the Challenge Space.
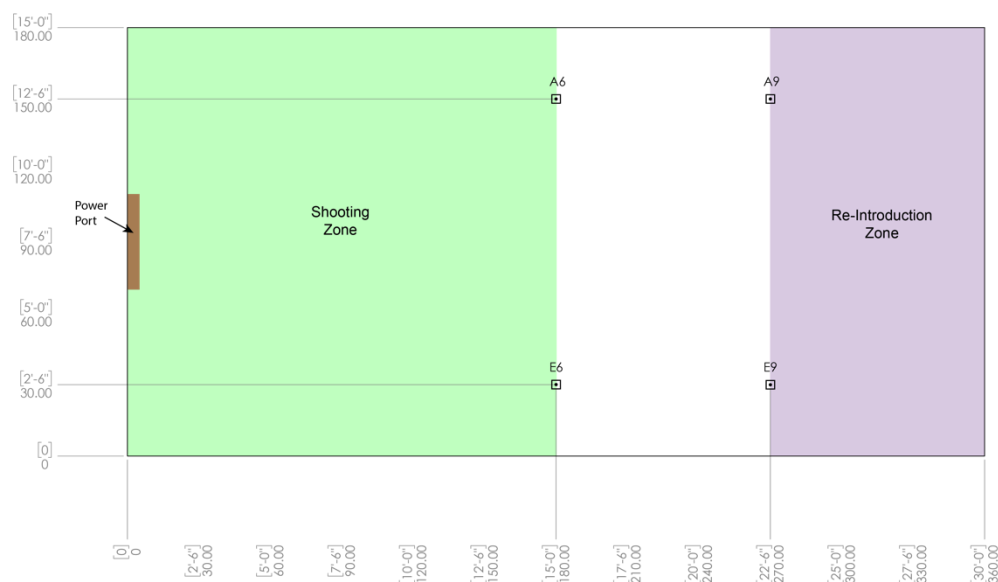

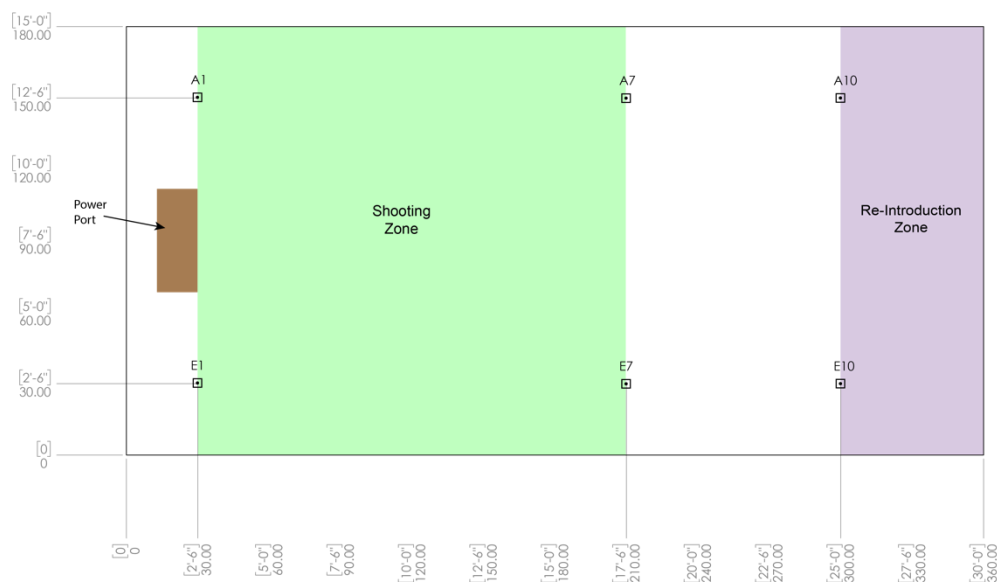*Figure 2-12 POWER PORT Challenge Layout no field element*

Figure 2-13 POWER PORT Challenge Layout with field element

2.4.10.2 Rules

PPC1. Teams may not use more than three (3) POWER CELLS.

PPC2. The ROBOT must start completely within the Challenge Space.

PPC3. The ROBOT may be preloaded with up to three (3) POWER CELLS.

PPC4. The ROBOT may only attempt a shot if its BUMPERS are fully contained within the Scoring Zone which extends 17 ft. 6 in (~533 cm) from the face of the POWER PORT representation (see layout below for details).

PPC5. No more than two (2) people may handle POWER CELLS during the challenge attempt.

> Please make sure to play safely! Team members introducing POWER CELLS to the Challenge Space may walk or run; they may roll or throw POWER CELLS. Challenge Space should be clear of trip hazards. Fragile objects should be protected from damage by POWER CELLS, and all team members in or near the Challenge Space should be paying attention to the ROBOT and POWER CELLS.

PPC6. Humans may only introduce POWER CELLS in the Reintroduction Zone which starts 22 ft. 6 in (~686 cm) from the face of the POWER PORT representation (see layout below for details).

> POWER CELLS may be introduced directly to the ROBOT or onto the floor.
>
> POWER CELLS which land in the Challenge Space may be fielded directly by the ROBOT anywhere in the Challenge Space; they do not need to be reintroduced by a human or into the Reintroduction Zone. The intent of this allowance is to avoid forcing humans to field POWER CELLS in close proximity to the ROBOT. Teams should not use this allowance to attempt to create a "loop" with minimal ROBOT movement. Please note

that scored POWER CELLS are only eligible to be scored again if they enter the Reintroduction Zone per Section 2.4.10.3.

Use of a LOADING BAY (or LOADING BAY mockup) is recommended to minimize risk of human injury by a POWER CELL receiving ROBOT.

2.4.10.3 Scoring

The raw score is the total number of points scored within the 1-minute period. Teams must record a raw score greater than 0 to have the challenge count towards calculation of Overall Scores. Points are awarded for each POWER CELL scored in the representation of the POWER PORT at the same values as in INFINITE RECHARGE. A POWER CELL is only considered scored if, as it scores, it is not in contact with a ROBOT and that POWER CELL has entered the Reintroduction Zone (via ROBOT, by human, or by rolling itself) since the last time that POWER CELL was scored.

- BOTTOM PORT = 1 Point
- OUTER PORT = 2 Points
- INNER PORT = 3 Points

Any POWER CELLS released by the ROBOT within the 1-minute time period and are subsequently scored after the timer expires will count. To avoid timing errors, you can manage the time automatically by using the Practice Timing of the FRC Driver Station set to the correct timing (5,0,0,60,0) as shown here

If using a 2D POWER PORT, a POWER CELL is considered scored if at least 50% of the POWER CELL is inside the boundary. For shots that are indeterminately close to the 50% threshold, the team may consider the POWER CELL scored accordingly. If using a 3D POWER PORT, a POWER CELL is considered scored if it passes completely through the plane defined by the respective opening. A POWER CELL that passes through the OUTER PORT opening and then the INNER PORT opening counts as an INNER PORT score only. A POWER CELL that passes completely through an opening and then bounces back out qualifies as having been scored.

Example A: More than 50% of POWER CELL inside INNER PORT boundary, 3 points

Example B: More than 50% of POWER CELL inside OUTER PORT boundary, not INNER PORT boundary, 2 points

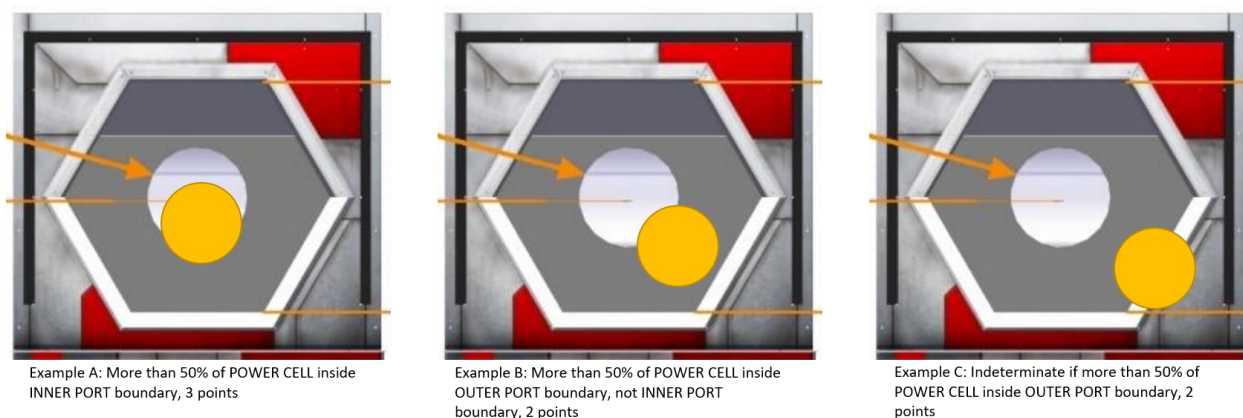Example C: Indeterminate if more than 50% of POWER CELL inside OUTER PORT boundary, 2 points

Figure 2-14 Examples of shots on two-dimensional INNER and OUTER PORTS

2.4.11 Overall Score

Teams in each GROUP are ranked by their Overall Scores. A team's Overall Score is a function of their Raw Scores, the number of teams in their GROUP that participated in each challenge, and the scores of those other teams in their GROUP.

> In addition to the calculation details outlined below, further example calculations can be found in the Example Overall Score Calculations.

The process to determine a team's Overall Score is as follows:

1. **Raw Scores are reported.**
    Each team reports a Raw Score (R) for each challenge in which they participated using the process described in How to Submit.

2. **Raw Scores are converted to Computed Scores.**

    Each Raw Score reported by a team is converted to a Computed Score (C). The conversion process is performed completely within a GROUP and is independent of scores from teams outside the GROUP.

    Generally, teams are awarded between 50 and 150 points (their Computed Score) based on their performance in each challenge (their Raw Score). If five (5) or fewer scores are submitted for an individual challenge, the minimum score will be greater than 50 points as described in the C_{min} calculation below.

    Points are awarded linearly based on a team's Raw Score relative to the range of Raw Scores submitted. This means that, in general, a team that reports a similar Raw Score to another team in their GROUP receives a similar Computed Score, regardless of rank.

    Raw Scores from each challenge are converted to a Computed Score, C, using the process below.

    a. **Determine Computed Score range for the GROUP**
        For each challenge, the maximum Computed Score, C_{max} , is 150 points. The minimum Computed Score, C_{min} , and is calculated as follows:

        $$C_{min} = \max(C_{max} - 20(N - 1), 50)$$

        N = number of teams that submitted a score for this challenge.

    b. **Perform an outlier test for the GROUP.**
        The range of Raw Scores for each challenge, in each GROUP, is limited using an outlier test. The GROUP'S upper and lower bounds for Raw Scores, R_{Upper} and R_{Lower} , are calculated as follows:

        $$R_{Lower} = Q_1 - k(Q_3 - Q_1)$$
        $$R_{Upper} = Q_3 + k(Q_3 - Q_1)$$

        Q_1, Q_3 = lower, upper quartiles of the challenge's Raw Scores set

k = scaling factor, set to 1

> Quartiles are calculated using the following method:
>
> Break the data set into 2 equal halves. If the number of values is odd, include the median if that will make the size of the "half" odd, exclude it otherwise. The median (with interpolation if needed) of each of these halves is Q1 and Q3 respectively.
>
> Example:
>
> {1,2,3,4,5} has 5 values. Half of 5 is 2.5, so we include the median in both sets to make them have an odd size. Thus {1,2,3} and {3,4,5} are our two halves. Q1 is the median of the first half, 2. Q2 is the median of the second half, 4.

   c. **Convert each team's Raw Score (R) to Bounded Score (B).**
   Limit each team's Raw Scores to the same range, between R_{Upper} and R_{Lower}.

$$B = \max\left(\min\left(R_{Upper}, R\right), R_{Lower}\right)$$

   d. **Determine B_{first} and B_{last} based on the GROUP**

B_{first} , B_{last} = the first, last place Bounded Scores in the GROUP. Note that B_{first} will be the lowest time in time-based challenges and the highest point total in points-based challenges.

> If B_{first} and B_{last} are equal, then all teams receive a computed score of C_{max}.

   e. **Compute Computed Score(s) for each team, C, and round to two (2) decimal places:**

$$C = \left|\frac{B - B_{last}}{B_{first} - B_{last}}\right| * (C_{max} - C_{min}) + C_{min}$$

Table 2-1 shows an example of ten (10) teams reporting scores for a time-based challenge and their resulting Computed Scores.

Table 2-1 Sample Computed Score point assignment

Raw Score	10.0	25.0	37.1	38.2	49.3	53.0	56.1	59.5	70.5	120.5
Bounded Score	14.7	25.0	37.1	38.2	49.3	53.0	56.1	59.5	70.5	81.9
Computed Score	150.00	134.67	116.67	115.03	98.51	93.01	88.39	83.33	66.96	50.00

> For this data set, intermediate calculation values can be found below:
>
> Q_1 = 37.1, Q_3 = 59.5, R_{Lower}= 14.7, R_{Upper} = 81.9, B_{first} = 14.7, B_{last} = 81.9

3. **Computed Scores are converted to an Overall Score**.

The team's Overall Score is the sum of their three (3) highest Computed Scores, rounded to two (2) decimal places. Teams that have completed less than three (3) challenges will still have an Overall Score computed using the Computed Scores from all challenges they completed.

4. **Teams are ranked within their GROUP.**

Teams within a GROUP are ranked using their Overall Score and the sorting criteria defined in Table 2-2.

Table 2-2 Skills Challenge ranking criteria

Order Sort	Criteria
1st	Overall Score
2nd	Highest Computed Score
3rd	Second highest Computed Score
4th	Fourth highest Computed Score
5th	Fifth highest Computed Score
6th	Random sorting

Note that "third highest Computed Score" is omitted because it's moot if the Overall Score, highest Computed Score, and second highest Computed Score are tied.

2.4.12 Guides

FIRST Robotics Game Designers assembled supplemental Guides to help teams consider how they may practice and improve skills helpful in these challenges. These Guides are entirely optional, and completion of the activities is not part of the judging process. Though these Guides were designed around the specific 2021 Skills Competition, teams are encouraged to think about how to develop and incorporate similar activities into their season in 2022 and beyond.

The Guides include high level overviews of autonomous navigation and vision targeting, driver selection, and driving practice.