



*FIRST® GAME CHANGERS™ powered by Star Wars: Force for Change*

2021 *FIRST®* Robotics Competition

# At Home Challenges Manual

---

# CONTENTS

---

1	Introduction.....	1
1.1	About <i>FIRST</i> ®.....	1
1.2	In Memoriam .....	1
1.3	<i>FIRST</i> ® Robotics Competition.....	1
1.4	<i>Gracious Professionalism</i> ®, a <i>FIRST</i> ® Philosophy.....	2
1.5	<i>Coopertition</i> ® .....	3
1.6	This Document & Its Conventions.....	4
1.7	Translations & Other Versions .....	5
1.8	Team Updates.....	5
1.9	Question and Answer System Sponsored by Autodesk®.....	5
1.10	How to Submit.....	6
1.11	Deadlines .....	7
2	INFINITE RECHARGE <sup>SM</sup> at Home.....	8
2.1	Overview .....	8
2.2	Submission Information.....	8
2.2.1	Additional Requirements for the Skills Competition .....	9
2.3	Awards & Judging Logistics .....	9
2.3.1	Awards .....	9
2.3.2	Judging GROUPS .....	10
2.3.3	Judging Process.....	11
2.3.4	Interview Process .....	11
2.4	Skills Competition.....	12
2.4.1	Overview .....	12
2.4.2	General Rules .....	13
2.4.3	ROBOT & Inspection Rules .....	13
2.4.4	Challenge Space Layout .....	14
2.4.5	Filming.....	14
2.4.6	Galactic Search Challenge.....	15
2.4.7	AutoNav Challenge .....	16
2.4.8	Hyperdrive Challenge.....	19
2.4.9	Interstellar Accuracy Challenge .....	20
2.4.10	POWER PORT Challenge .....	23
2.4.11	Overall Score.....	25
2.4.12	Guides .....	27

3	Game Design Challenge .....	28
3.1	Overview .....	28
3.2	Submission Information.....	28
3.3	Design Considerations .....	29
3.3.1	Game Design Challenge ELEMENT .....	30
3.4	Awards & Judging Logistics .....	30
3.4.1	Awards .....	30
3.4.2	Judging GROUPS .....	31
3.4.3	Judging Process.....	31
3.4.4	Interview Process .....	32
3.5	Advancement .....	32
3.6	Activities .....	33
4	<i>FIRST</i> <sup>®</sup> Innovation Challenge presented by Qualcomm.....	34
4.1	Overview .....	34
4.2	Challenge .....	35
4.2.1	Criteria.....	35
4.3	Submission Information.....	35
4.3.1	Additional Requirements for Semi-Finalists .....	35
4.4	Awards & Judging Logistics .....	36
4.4.1	Semi-Finalist Awards .....	36
4.4.2	Judging GROUPS .....	37
4.4.3	Judging Guidelines.....	37
4.4.4	Judging Process.....	38
4.4.5	Interview Process .....	38
4.5	Interview Details.....	39
4.5.1	The Business Pitch (2 min) .....	39
4.5.2	Uninterrupted Presentation (3 min) .....	40
4.5.3	Judge's Question & Answers (Q&A, 10 min) .....	40
4.6	Advancement .....	40
4.7	The <i>FIRST</i> <sup>®</sup> Global Innovation Awards powered by <i>Star Wars: Force for Change</i> .....	40
4.7.1	<i>Preparing for the FIRST</i> Global Innovation Awards .....	41
4.7.2	Timeline .....	41
4.8	Intellectual Property Protection .....	41
4.9	Content Series – Innovation, Inspiration & Education .....	42
5	Traditional Submitted Awards .....	43
5.1	Overview .....	43

5.2	Awards & Judging Logistics .....	43
5.2.1	Interview Process .....	45
6	Glossary .....	46

# 1 INTRODUCTION

---

## 1.1 About *FIRST*®

*FIRST*® (For Inspiration and Recognition of Science and Technology) was founded by inventor Dean Kamen to inspire young people's interest in science and technology. As a robotics community that prepares young people for the future, *FIRST* is the world's leading youth-serving nonprofit advancing STEM education. For 30 years, *FIRST* has combined the rigor of STEM learning with the fun and excitement of traditional sports and the inspiration that comes from community through programs that have a proven impact on learning, interest, and skill-building inside and outside of the classroom.

*FIRST* provides programs that span a variety of age groups:

- *FIRST*® Robotics Competition for grades 9-12, ages 14-18
- *FIRST*® Tech Challenge for grades 7-12, ages 12-18
- *FIRST*® LEGO® League for grades PreK -8, ages 4-16\*
  - *FIRST*® LEGO® League Challenge for grades 4-8 (ages 9-16\*)
  - *FIRST*® LEGO® League Explore for grades 2-4 (ages 6-10)
  - *FIRST*® LEGO® League Discover for grades PreK-1 (ages 4-6)

\*Ages and grades vary by country

Please visit our website: [www.firstinspires.org](http://www.firstinspires.org) for more information about *FIRST* and its programs.

## 1.2 In Memoriam

In October 2019, Dr. Woodie Flowers, an innovator in design and engineering education and the Distinguished Advisor to *FIRST* and supporter of our mission, passed away. As thousands of heartfelt tributes to Woodie have poured in from around the world, it is clear his legacy will live on indefinitely through the gracious nature of our community and our ongoing commitment to empowering educators and building global citizens.



Figure 1-1 Dr. Woodie Flowers, 1943-2019

## 1.3 *FIRST*® Robotics Competition

*FIRST*® Robotics Competition combines the excitement of sport with the rigors of science and technology. Teams of students are challenged to design, build, and program industrial-size robots and compete for awards, while they also create a team identity, raise funds, hone teamwork skills, and advance respect and appreciation for STEM within the local community.

Volunteer professional mentors lend their time and talents to guide each team. It's as close to real-world engineering as a student can get. Plus, high school students gain access to exclusive scholarship opportunities from colleges, universities, and technical programs.

Prior to the 2021 season, a new, challenging game was introduced each January at an event known as "Kickoff." Due to the 2020 season being disrupted by the COVID-19 pandemic, the 2021 Kickoff presented a modified version of the 2020 game, INFINITE RECHARGE<sup>SM</sup>. Each exciting competition combines the practical application of science and technology with the fun, intense energy and excitement

of a championship-style sporting event. Teams are encouraged to display *Gracious Professionalism*<sup>®</sup>, help other teams, and cooperate while competing. This is known as *Coopertition*<sup>®</sup>.

The 2021 season includes a series of three new challenges in which teams can engage from “home” and virtually compete with teams from around the world.

1. **INFINITE RECHARGE at Home** invites teams to engage in two ways: compete for judged awards using their 2020/2021 robot and compete in a Skills Competition, a series of challenges for teams who have access to their robot.
2. **The Game Design Challenge** invites teams to design a *FIRST* Robotics Competition game and compete for judged awards and an opportunity to share their design with *FIRST* Robotics Competition game designers.
3. **The *FIRST* Innovation Challenge presented by Qualcomm** invites teams to identify a real-world global issue and develop an innovative solution.

This manual and details about the At Home Challenges were presented at the 2021 *FIRST* Robotics Competition Kickoff on Saturday, January 9, 2021.

At the 2020 Kickoff, teams:

- saw the 2020 game, INFINITE RECHARGE, for the first time
- learned about the 2020 game rules and regulations
- received a Kickoff Kit that provided a starting point for robot build

At the 2021 Kickoff, all teams:

- learned details about the 2021 At Home Challenges, for the first time
- were provided resources for the 2021 game, which is a modified version of the 2020 game, INFINITE RECHARGE
- gained access to the *FIRST* Choice component of the [2021 Kit of Parts](#)

## 1.4 *Gracious Professionalism*<sup>®</sup>, a *FIRST*<sup>®</sup> Philosophy

*Gracious Professionalism*<sup>®</sup> is part of the ethos of *FIRST*. It's a way of doing things that encourages high quality work, emphasizes the value of others, and respects individuals and the community.

*Gracious Professionalism* is not clearly defined for a reason. It can and should mean different things to everyone.

Some possible meanings of *Gracious Professionalism* include:

- Gracious attitudes and behaviors are win-win.
- Gracious folks respect others and let that respect show in their actions.
- Professionals possess special knowledge and are trusted by society to use that knowledge responsibly.
- Gracious Professionals make a valued contribution in a manner pleasing to others and to themselves.

In the context of *FIRST*, this means that all teams and participants should:

- Learn to be strong competitors, but also treat one another with respect and kindness in the process.
- Avoid leaving anyone feeling as if they are excluded or unappreciated.

Knowledge, pride and empathy should be comfortably and genuinely blended.

In the end, *Gracious Professionalism* is part of pursuing a meaningful life. When professionals use knowledge in a gracious manner and individuals act with integrity and sensitivity, everyone wins and society benefits.



---

*The FIRST spirit encourages doing high-quality, well-informed work in a manner that leaves everyone feeling valued. Gracious Professionalism seems to be a good descriptor for part of the ethos of FIRST. It is part of what makes FIRST different and wonderful.*

*- Dr. Woodie Flowers, (1943 – 2019)  
Distinguished Advisor to FIRST*

---

It is a good idea to spend time going over this concept with your team and reinforcing it regularly. We recommend providing your team with real-life examples of *Gracious Professionalism* in practice, such as when a team loans valuable materials or expertise to another team that they will later face as an opponent in competition. Routinely highlight opportunities to display *Gracious Professionalism* at events and encourage team members to suggest ways in which they can demonstrate this quality themselves and through outreach activities.

## 1.5 Coopertition<sup>®</sup>

At FIRST, *Coopertition<sup>®</sup>* is displaying unqualified kindness and respect in the face of fierce competition. *Coopertition* is founded on the concept and philosophy that teams can and should help and cooperate with one another even as they compete. *Coopertition* involves learning from teammates and mentors. *Coopertition* means competing always but assisting and enabling others when you can.

---

### *A Message from Woodie Flowers Award Recipients*

*The Woodie Flowers Award is the most prestigious mentoring award in FIRST. The prior award recipients created an important message for all FIRST Robotics Competition teams as we approach the challenges for the 2021 season.*

*Performing at your best is important. Winning is important. This is a competition.*



*However, winning the right way and being proud of what you have accomplished and how you have accomplished it is more important. FIRST could create rules and penalties to cover almost any scenario or situation, but we prefer an understandable challenge with simpler rules that allow us to think and be creative in our designs and solutions.*

*We want to know that everyone is playing at their best in every challenge. We want to know they are playing with integrity and not using strategies based on questionable behaviors.*

*As your team prepares for the challenges of the 2021 season, implements your ideas and solutions, executes your strategies, and live your daily lives, remember what Woodie said time and time again, and let's 'Make your Grandmother proud.'*

---

Woodie Flowers	Paul Copioli (3310, 217)	Fredi Lajvardi (842)
Liz Calef (88)	Rob Mainieri (812, 64, 498,	Lane Matheson (932)
Mike Bastoni (23)	2735, 6833)	Mark Lawrence (1816)
Ken Patton (51, 65)	Dan Green (111)	Eric Stokely (258, 360, 2557,
Kyle Hughes (27)	Mark Breadner (188)	& 5295)
Bill Beatty (71)	John Novak (16, 323)	Glenn Lee (359)
Dave Verbrugge (5110, 67)	Chris Fultz (234)	Gail Drake (1885)
Andy Baker (3940, 45)	John Larock (365)	Allen Gregory (3847)
Dave Kelso (131)	Earl Scime (2614)	Lucien Junkin (118)

## 1.6 This Document & Its Conventions

The *2021 At Home Challenge Manual* is a resource for all FIRST Robotics Competition teams for information specific to the various 2021 At Home Challenges and Traditional Submitted Awards. Its audience will find the following detail:

- an overview for each At Home Challenge
- award and submission details for each At Home Challenge
- descriptions and details of how to participate in each At Home Challenge
- rules, requirements, and/or considerations for each At Home Challenge

Optional Guides and Activities that contain brainstorming and other collaboration resources are provided to teams participating in the At Home Challenges (though can be used to help with other team efforts too). These documents are optional and supplementary, and do not carry the same weight as this document.

The intent of this manual is that the text means exactly, and only, what it says. Please avoid interpreting the text based on assumptions about intent, implementation of past rules, or how a situation might be in “real life.” There are no hidden requirements or restrictions. If you’ve read everything, you know everything.

Specific methods are used throughout this section to highlight warnings, cautions, key words and phrases. These conventions are used to alert the reader to important information and are intended help teams when developing content for a challenge and in constructing a robot that complies with the rules in a safe manner.

Links to other section headings in this manual and external articles appear in [blue underlined text](#).



Key words that have a particular meaning within the context of the *FIRST* Robotics Competition and the At Home Challenges are defined in the [Glossary](#) section and indicated in ALL CAPS throughout this document.

Warnings, cautions and notes appear in blue boxes. Pay close attention to their contents as they're intended to provide insight into the reasoning behind a rule, helpful information on understanding or interpreting a rule, and/or possible "best practices" for use when implementing systems affected by a rule.

While blue boxes are part of the manual, they do not carry the weight of the actual rule (if there is an inadvertent conflict between a rule and its blue box, the rule supersedes the language in the blue box).

Imperial dimensions are followed by comparable metric dimensions in parentheses to provide metric users with the approximate size, weight, etc. Metric conversions for non-rules (e.g. FIELD dimensions) round to the nearest whole unit, e.g. "17 in. (~43 cm)" and "6 ft. 4 in. (~193 cm)." Metric conversions in rules round such that the metric dimension is compliant with the rule (i.e. maximums round down, minimums round up). The metric conversions are offered for convenient reference only and do not overrule or take the place of the imperial dimensions presented in this manual and the field drawings (i.e. field dimensions and rules will always defer to measurements using imperial units).

## 1.7 Translations & Other Versions

The *INFINITE RECHARGE Game Manual* and the *At Home Challenge Manual* are originally and officially written in English and are occasionally translated into other languages for the benefit of *FIRST* Robotics Competition teams whose native language is not English.

Text-based English versions can be provided only for use with assistive devices for visually and hearing-impaired persons, and not for redistribution. For more information, please contact [frcteamadvocate@firstinspires.org](mailto:frcteamadvocate@firstinspires.org).

In the event that a rule or description is modified in alternate versions of these manuals, the English pdf versions as published on the [FIRST Game and Season Materials webpage](#) are the commanding versions.

## 1.8 Team Updates

Team Updates are used to notify the *FIRST* Robotics Competition community of revisions to the official season documentation (e.g. the manuals, drawings, etc.) or important season news. Between Kickoff and February 2, 2021, Team Updates are posted each Tuesday and Friday. Additional Team Updates and their posting frequency will be announced if an in-person season is approved. Team Updates are posted on the [Game and Season Materials web page](#) and are generally posted before 5 pm, Eastern.

Generally, Team Updates follow the following convention:

- Additions are highlighted in yellow. **This is an example.**
- Deletions are indicated with a strikethrough. ~~This is an example.~~
- Notes that are added for clarity or explanation for the change but are not retained as part of the manual appear in bold. **This is an example.**

## 1.9 Question and Answer System Sponsored by Autodesk®

The Q&A sponsored by Autodesk® is a resource for clarifying 2021 *INFINITE RECHARGE Game Manual*, 2021 *At Home Challenge Manual*, [Awards web page](#), and/or [FIRST Robotics Competition Event Experience web page](#) content. Teams can search for previously asked questions and responses or pose

new questions. Questions can include examples for clarity or reference multiple rules to understand the relationships and differences between them.

The Q&A opens on January 13, 2021, 12:00 PM Eastern. Details on the Q&A can be found on the [Game and Season Materials web page](#). The Q&A may result in revisions to the text in the official Manuals (which are communicated using [Team Updates](#)).

The responses in the Q&A do not supersede the text in the manuals, although every effort will be made to eliminate inconsistencies between them. If you have concerns about enforcement trends by volunteer authorities, please notify *FIRST* at [firstroboticscompetition@firstinspires.org](mailto:firstroboticscompetition@firstinspires.org).

The Q&A is not a resource for firm predictions on how a situation will play out an event. Questions about the following will not be addressed:

- rulings on vague situations,
- challenging decisions made at past events, or
- design reviews of a robot system for legality.

Weak questions are overly broad, vague, and/or omit rule references. Examples of questions that will not be answered in the Q&A include:

- Is this part/design legal?
- How should the REFEREE have ruled when this specific game play happened?
- Duplicate questions
- Nonsense questions

Good questions ask generically about features of parts or designs, gameplay scenarios, or rules, and often reference one or more relevant rules within the question. Some examples of questions that will likely be answered in the Q&A are:

- A device we are considering using on the ROBOT comes with purple AWG 40 wire, does this comply with R?? and R??
- We're not sure how to interpret how Rule G?? applies if Blue ROBOT A does X and Red ROBOT B does Y, can you please clarify?
- If a robot does this specific action, is it doing what this defined term is describing?

Questions from "FRC 99999" represent content asked by key volunteers (e.g. Referees, Inspectors, etc.), answered by *FIRST* headquarters, and are considered relevant to teams.

## 1.10 How to Submit

In order to be eligible for the At Home Challenges, teams must upload their submission in English through the [frcathome.org](http://frcathome.org) portal. Lead Coach/Mentors 1 or 2 can retrieve their team access code from the Team Registration System, and complete the following steps:

1. In the Team Dashboard, go to the 'Team Options' section
2. Click on 'Payment & Product.'
3. Click on 'Passwords/Voucher Codes'
4. Locate the 12-character code listed under *FIRST/FRC* at Home Key that begins with "F".

Teams should use this code to access the [frcathome.org](http://frcathome.org) portal for submission instructions and to opt into the At Home Challenges in which the team wishes to participate. If teams have technical issues, they should contact [frcathome@firstinspires.org](mailto:frcathome@firstinspires.org).

A team may only submit one entry for each challenge.

## 1.11 Deadlines

The following are the important deadlines for the 2021 At Home Challenges:

- Thursday, February 4<sup>th</sup> at noon ET – Submission portal opens
- Thursday, March 4<sup>th</sup> at 3pm ET – Submission portal closes.
  - Submissions due for the following:
    - Game Design Challenge
    - INFINITE RECHARGE<sup>SM</sup> at Home (Judged Award component)
    - *FIRST* Innovation Challenge presented by Qualcomm
  - Submissions temporarily closed
    - INFINITE RECHARGE<sup>SM</sup> at Home (Skills Competition)
- Monday, March 8<sup>th</sup> at 3pm ET – Submission portal reopens for Skills Competition only
- Thursday, April 8<sup>th</sup> at 3pm ET – Submission portal closes. Submissions due for Skills Competition for teams that opted into INFINITE RECHARGE at Home.

The deadlines for the Traditional Submitted Awards can be found on the [Award Page](#).

## 2 INFINITE RECHARGE<sup>SM</sup> AT HOME

---

### 2.1 Overview

INFINITE RECHARGE<sup>SM</sup> 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).

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.
- Optional - a video 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/codecs 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.

### 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](https://frcathome.org) is closed for submissions from March 4<sup>th</sup> at 3pm to March 8<sup>th</sup> 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/codecs 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. 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.

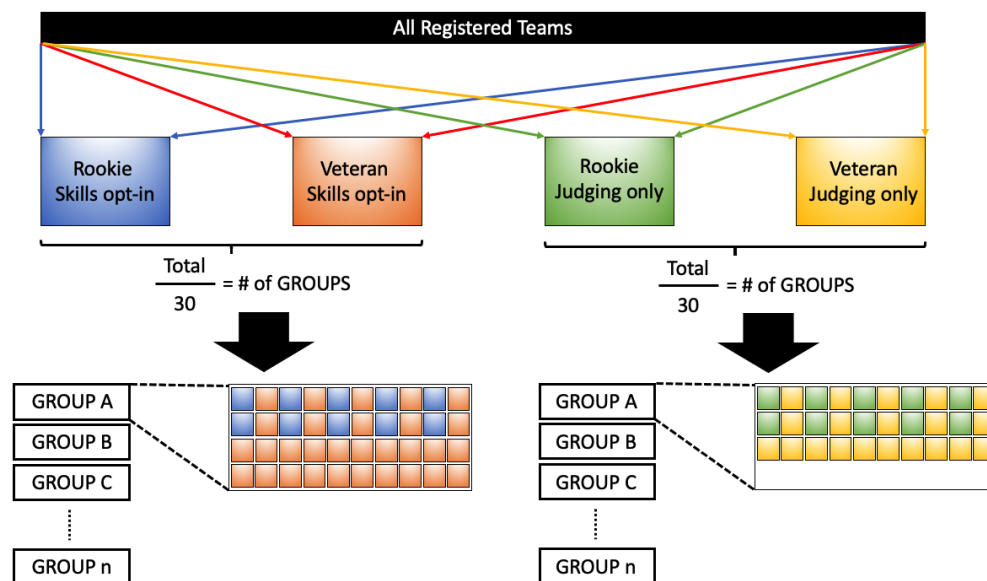


Figure 2-1 INFINITE RECHARGE at Home Groups

### 2.3.3 Judging Process

- Teams must submit all content described in the Submission Information by the deadline.
- 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.

- 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.
  - The interview time begins after a one (1) minute buffer to allow all team members to be on the call.
  - 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.
  - 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.
  - **Exception:** If necessary, the mentor may provide translation services for students needing foreign language or sign language translation.
- 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.

- 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
- 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 a precollege student member 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 and R22 (i.e. BUMPER fabric may be any color and contain any markings).
- SC8.** All Skills Challenge runs should 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).

- 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 [on the Game and Season page](#).

### 2.4.4 Challenge Space Layout

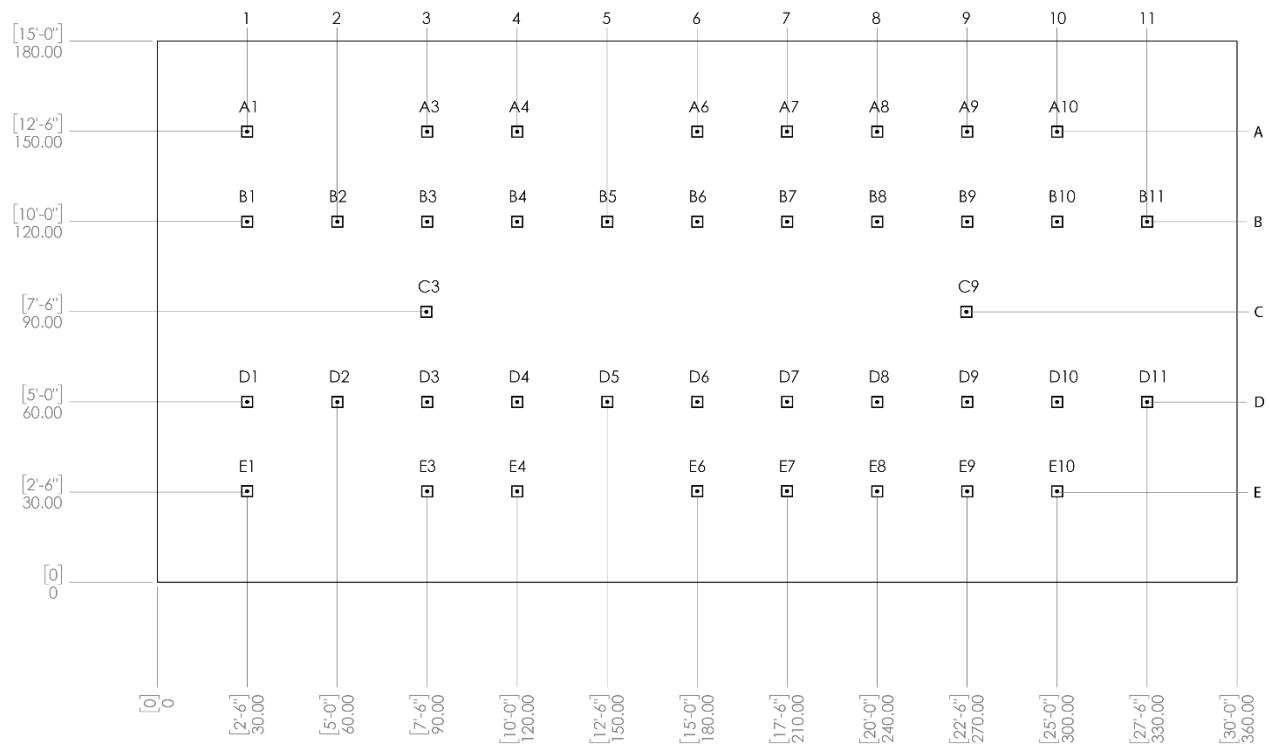


Figure 2-2 General Layout Diagram

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 6 in (~152 mm) tall used to mark specific locations relevant to each challenge.

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.

### 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

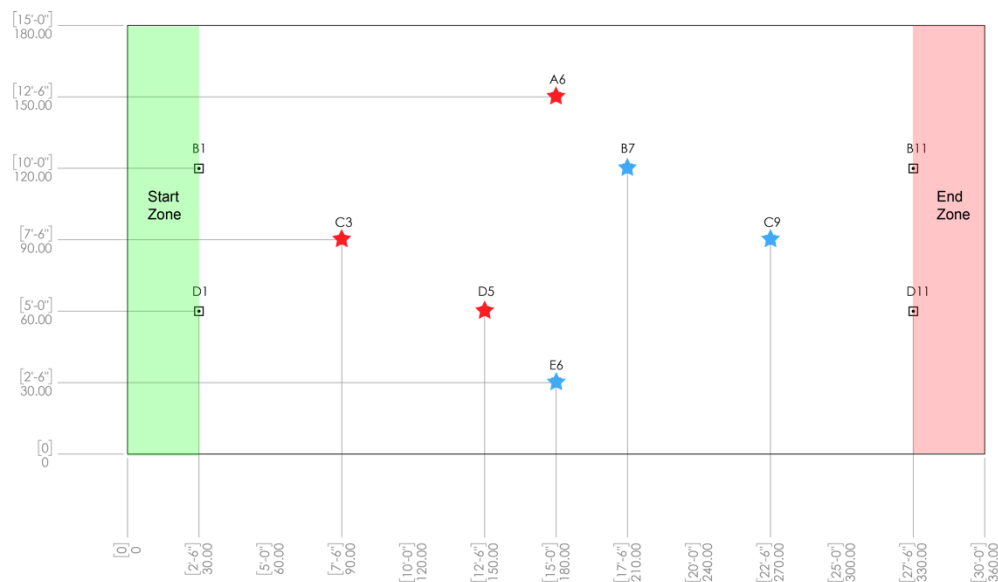


Figure 2-3 Galactic Search Layout – Path A

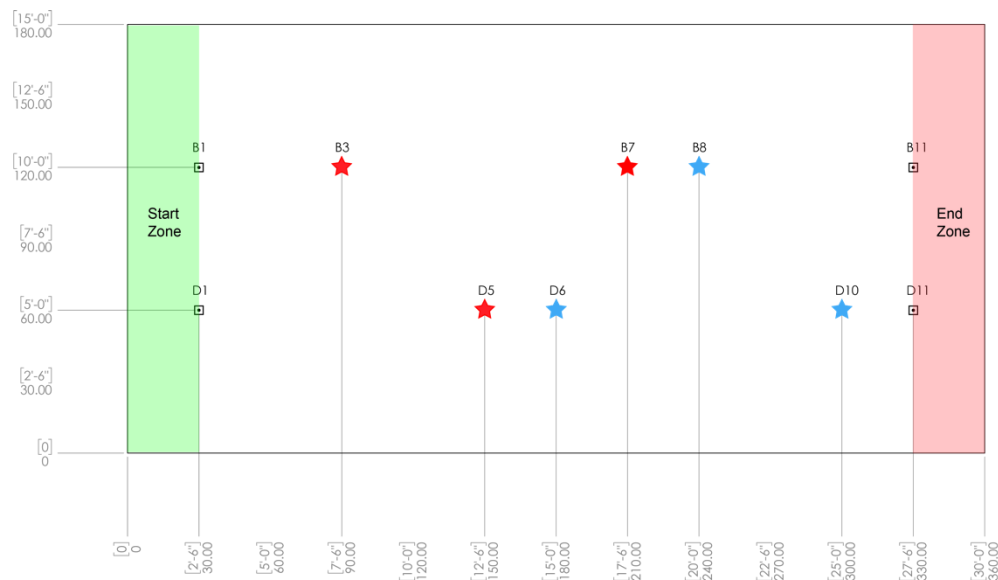


Figure 2-4: Galactic Search Layout – Path B

### 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.  
The intent is that teams do not signal directly to the ROBOT which option has been chosen. 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 A1/B1.

**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 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.

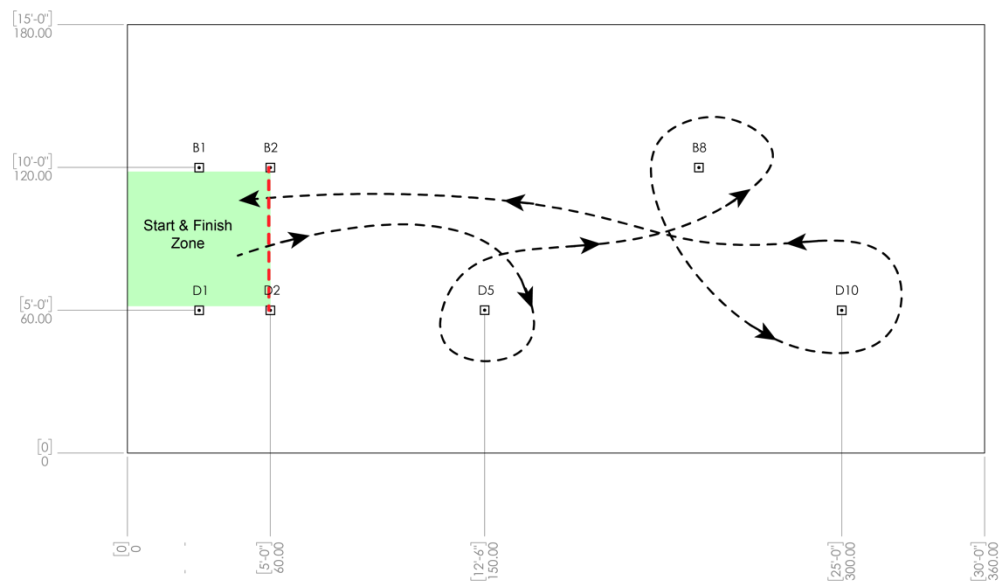


Figure 2-5 Barrel Racing Path

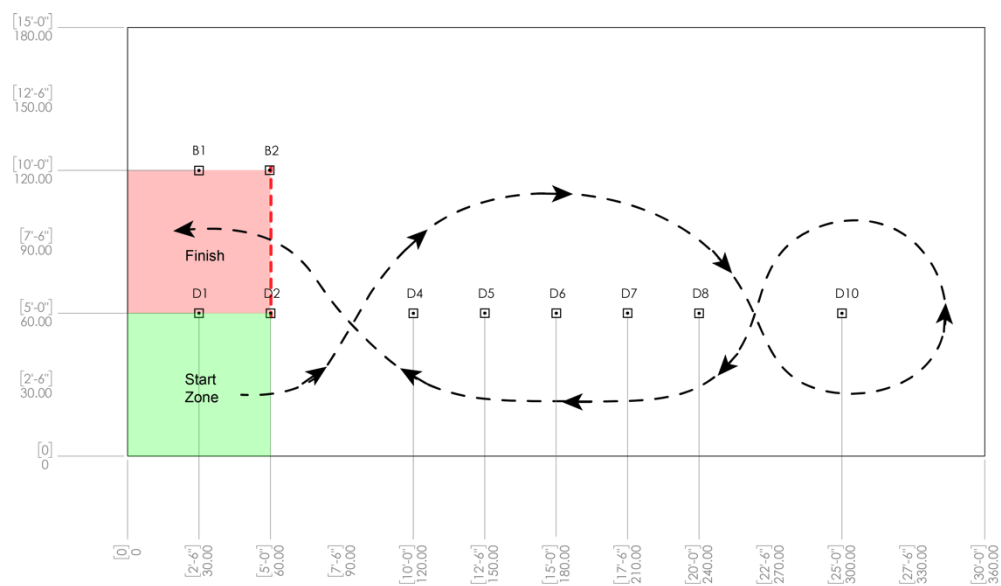


Figure 2-6 Slalom Path

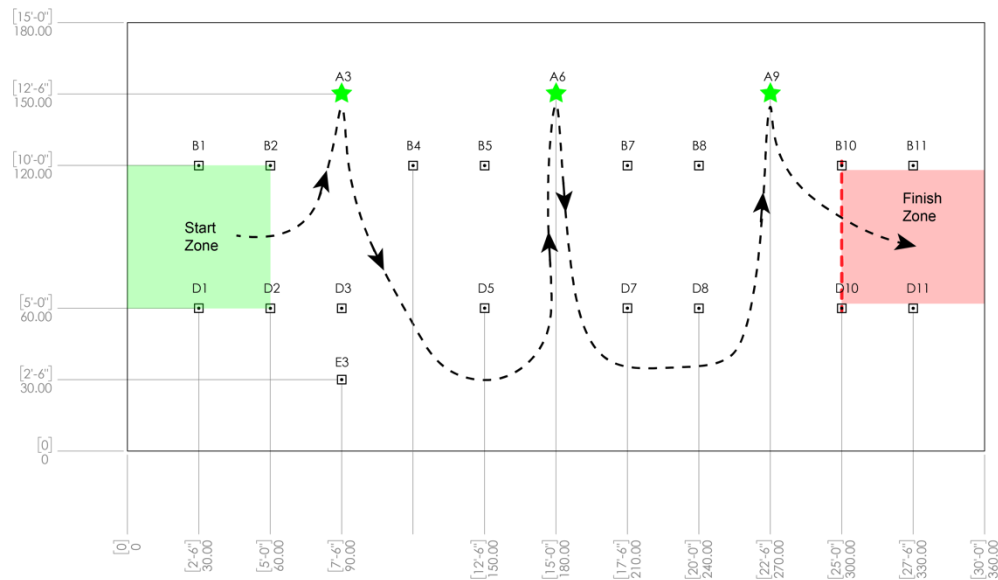


Figure 2-7 Bounce Path

#### 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 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.

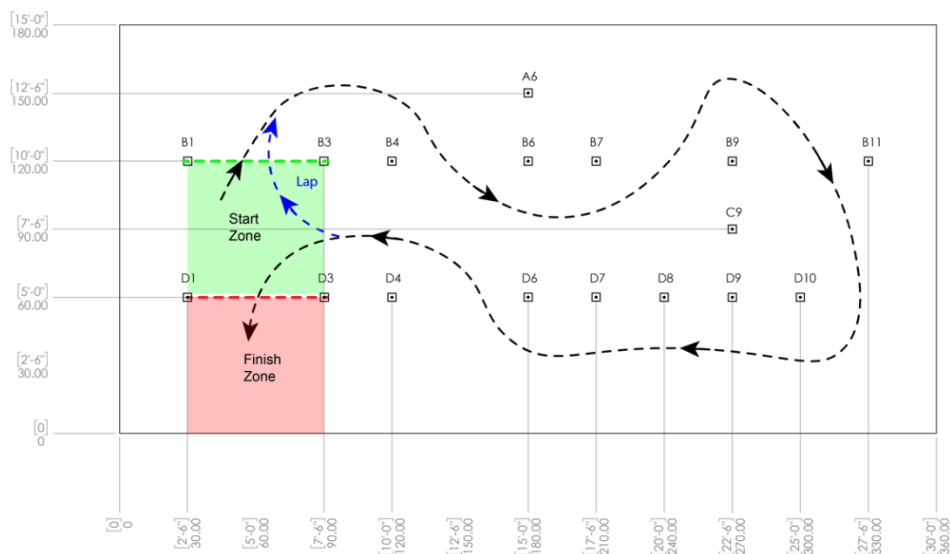


Figure 2-8 Lightspeed Circuit Path

### 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 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 will attempt to score as many points as possible 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.

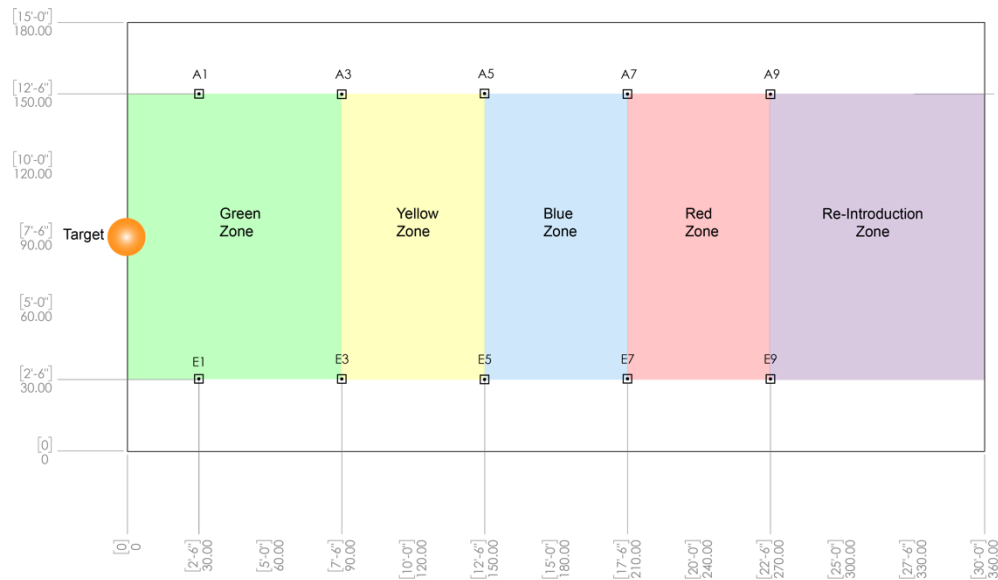


Figure 2-9 Interstellar Accuracy Challenge Layout, no field element

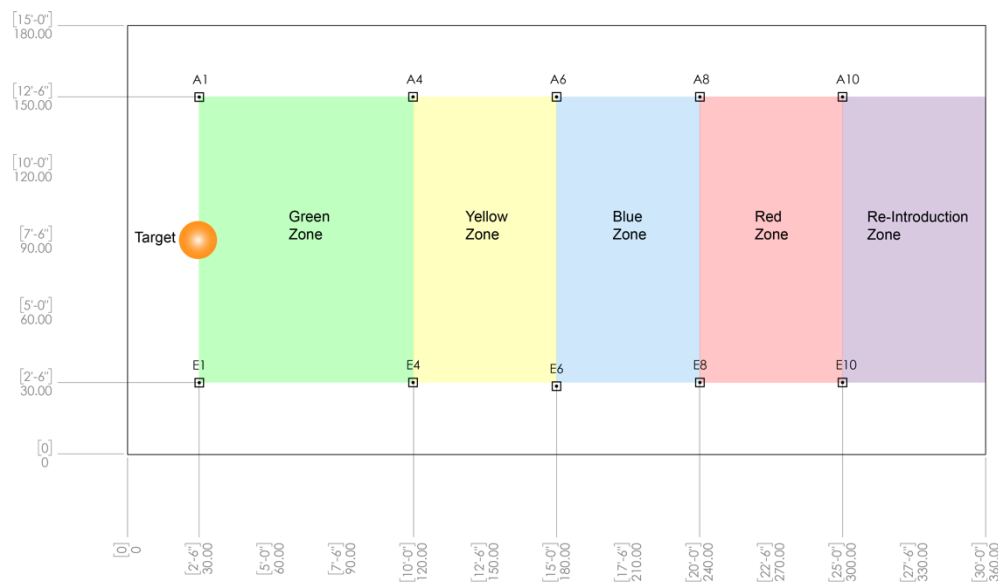


Figure 2-10 Interstellar Accuracy Challenge, with field element

### 2.4.9.2 Rules

- IAC1.** Teams may not attempt more than fifteen (15) POWER CELL shots.
- IAC2.** Teams must attempt at least three (3) POWER CELLS per zone. The remaining three (3) POWER CELLS may be shot from any of the four (4) zones.

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.

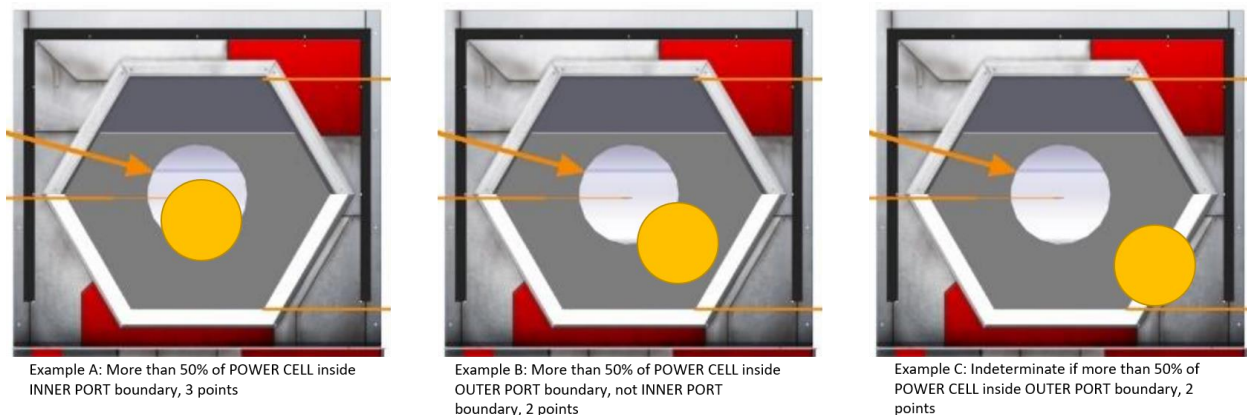


Figure 2-11 Examples of shots on two-dimensional INNER and OUTER PORTS

### 2.4.10 POWER PORT Challenge

In the POWER PORT Challenge teams emulate the teleoperated portion of INFINITE RECHARGE gameplay by collecting POWER CELLS 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.

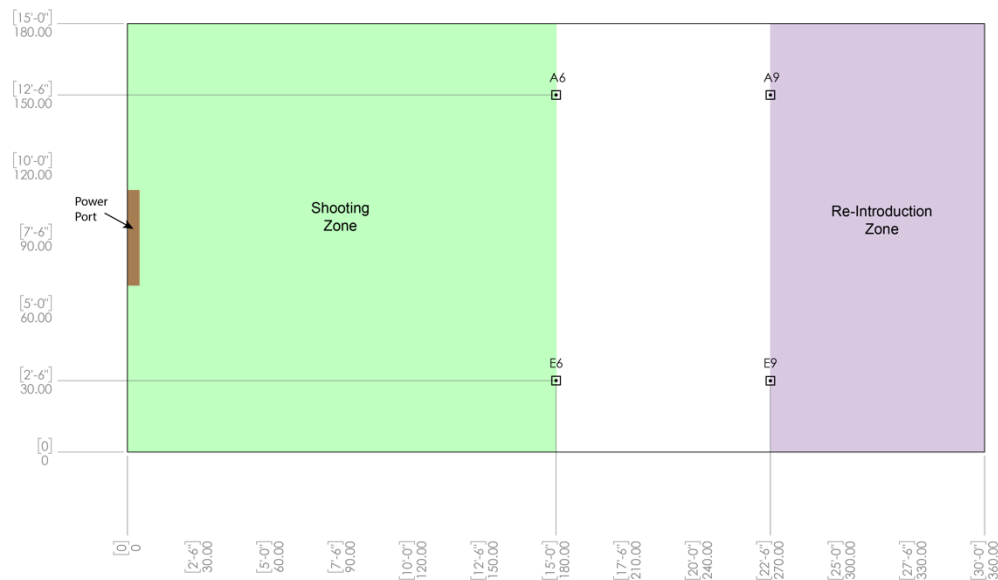


Figure 2-12 POWER PORT Challenge Layout no field element

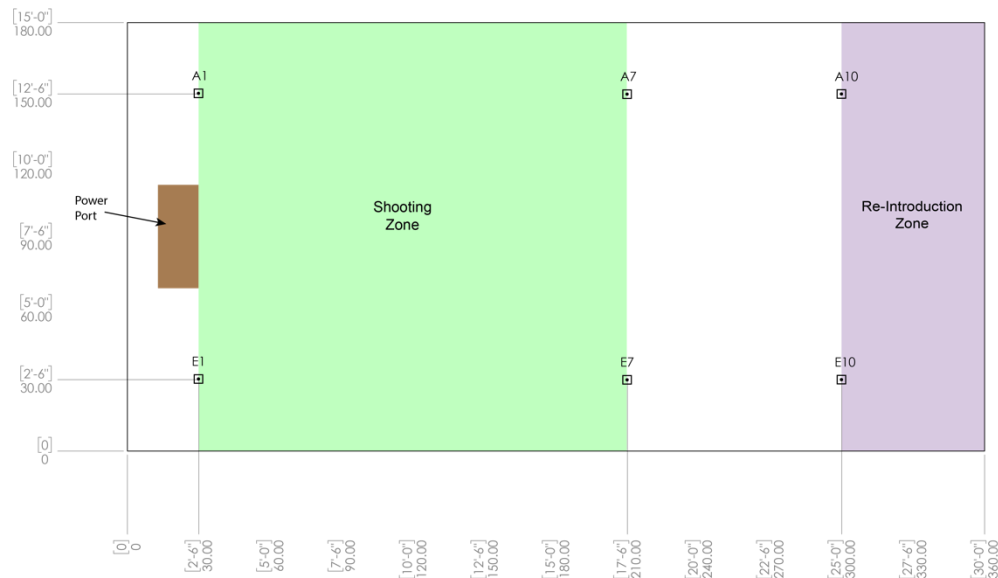


Figure 2-13 POWER PORT Challenge Layout with field element

#### 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 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.

- 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.

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

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.

### 2.4.10.3 Scoring

The raw score is the total number of points scored with the fifteen (15) POWER CELLS. Teams must record a raw score greater than 0 to have the challenge count towards calculation of Overall Scores. Points are awarded for each scored 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 balls 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

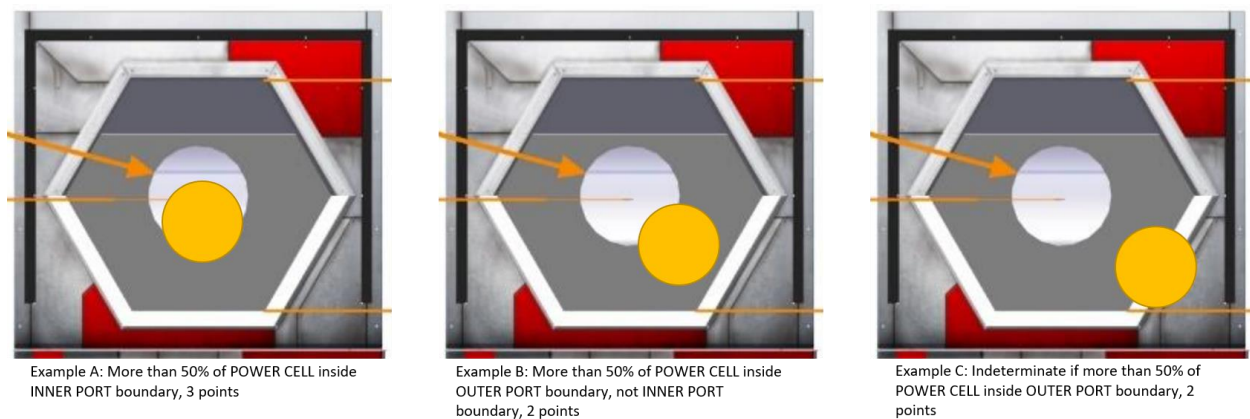


Figure 2-14 Examples of shots on two-dimensional INNER and OUTER PORTS

### 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  $Q_1$  and  $Q_3$  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.  $Q_1$  is the median of the first half, 2.  $Q_3$  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  $R_{Lower}$ .

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

**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.

**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

<b>Raw Score</b>	10.0	25.0	37.1	38.2	49.3	53.0	56.1	59.5	70.5	120.5
<b>Bounded Score</b>	14.7	25.0	37.1	38.2	49.3	53.0	56.1	59.5	70.5	81.9
<b>Computed Score</b>	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
1 <sup>st</sup>	Overall Score
2 <sup>nd</sup>	Highest Computed Score
3 <sup>rd</sup>	Second highest Computed Score
4 <sup>th</sup>	Fourth highest Computed Score
5 <sup>th</sup>	Fifth highest Computed Score
6 <sup>th</sup>	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.

## 3 GAME DESIGN CHALLENGE

---

### 3.1 Overview

The Game Design Challenge is an opportunity for teams to design a *FIRST* Robotics Competition game and compete against other teams for a chance to pitch their game to the *FIRST* Robotics Competition Game Design Team. Teams may include a specified Game Design Challenge ELEMENT (see Game Design Challenge ELEMENT for more details) that was included in each Kickoff Kit.

In addition to developing a game, each team that participates in the Game Design Challenge answers specific questions in their submission to be considered for awards and possible advancement. Teams may also include supplementary information with their submission and have the opportunity to elaborate on their game during an interview with *FIRST* Robotics Competition judges. Teams are expected to develop as complete a game as possible, at the same time creating a succinct presentation for judges to evaluate.

Winning game(s), or their elements, may inspire or be used as a future official *FIRST* Robotics Competition game! Although *FIRST* is likely to make modifications to any submitted concept, credit will be given to the associated team when the game/element is released.

### 3.2 Submission Information

See How to Submit and Deadlines for additional details on how to submit. For the Game Design Challenge, teams are asked to provide the following information when they submit:

- two (2) contact emails (must be mentors)
- time zone
- game name (text only, not a logo)
- image of the field
  - can be a sketch, a photo of a physical model, a CAD image, etc.
  - accepted formats include gif, jpg, jpeg, png
  - files must be no larger than 10 MB.
- game overview (500-word limit)
- description of notable field elements. (300-word limit)
- description of expected robot actions (300-word limit)
- if ELEMENT used, a description of how? (300-word limit)

Although use of the Game Design Challenge ELEMENT is required for a team to be considered for the Concept Award, teams who choose not to use the ELEMENT will not be judged at a disadvantage to teams who choose to use it for any other award.

- Optional - a video providing additional information about the game.
  - Videos may not exceed two (2) 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/codecs pairs [Supported Input Codecs and Containers](#).

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.

- Optional – Supplementary information.
  - up to four (4) pages no larger than 8.5 in. x 14 in. (~21cm x 35cm) (may be in either portrait or landscape orientations)
  - Should be 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 size requirements.

- Acknowledge that the game design concept is a unique creation by the team

Most robotics competitions copyright their game materials. Judges are not expected to know every robotics game that exists, but teams should be mindful to not submit a game that is too similar or identical to a copyrighted game.

*FIRST* wants to see creative solutions from teams. Teams shouldn't just take another robotics game, super-size it for *FIRST* Robotics Competition, make it 3 robots versus 3 robots, and call it a day. Show us your creativity!

### 3.3 Design Considerations

Beyond submission requirements, there are no additional requirements for a game; however, top Game Design Concepts will maximize the following criteria:

- safe for teams, field crew, and spectators
- accommodate six (6) ROBOTS on the field simultaneously
- play on a field no larger than 30 ft. (~914 cm) wide x 74 ft. (~2255 cm) long x 20 ft. (~609 cm) tall
  - This includes the space where DRIVE TEAMS and HUMAN PLAYERS stand during matches, but does not include space for technicians, the scoring table, referees, etc.
- matches last between 1 minute 30 seconds (1:30) and 3 minutes (3:00)
- play with Robots that follow *FIRST* Robotics Competition Robot rules per the [2021 Game Manual](#) (legal motors, battery, pneumatics, etc.) with the following exceptions:
  - R2, R3, and R4 are game specific and may be omitted or defined appropriately for your game. If they are defined, they do not have to take the exact same form as the 2021 rules.
    - ROBOT weight restrictions should not be less than 70 lbs. (~32 kg) or more than 125 lbs. (~56kg) (not including battery and BUMPERS)
    - ROBOT size requirements, should not require robots to be less than 18 in. (~ 46 cm) in any dimension
    - ROBOT maximum starting size, if specified, should consider robot transport to and from the field and robot shipping in crates, i.e. dimensions should be less than 47 in. (~119 cm) x 47 in. (~119 cm) x 54 in. (~137 cm). While starting robot size may exceed crate size, it should be backed by sound reasoning as to why it's important to the game and how teams are likely to meet the challenge of transporting the larger robot.
  - Bumpers may be omitted if robots aren't able to contact their opponents.

For tips on what the *FIRST* Robotics Game Design Team thinks makes a good game, teams should look at the What Makes a Game “Good” activity in the [Game Design Challenge Activities](#).

### 3.3.1 Game Design Challenge ELEMENT

Teams may choose to include the Game Design Challenge ELEMENT in their submission. It is generally not a requirement to use the ELEMENT, but it must be used in order to be considered for the Concept Award.

The ELEMENT is a chain. For the purposes of this challenge, the definition of chain is “a series of links or rings connected to or fitted into one another and used for various purposes (such as support, restraint, transmission of mechanical power, or measurement).”

Teams that chose to use the ELEMENT will be asked how they implemented it in their submission. Teams may choose to be creative when using the ELEMENT, so long as they can provide a solid logic as to how their “chain” fits the provided definition.

A sample of chain is included in each 2021 Kickoff Kit. The sample is zinc plated straight link coil chain from Fehr Bros Industries, Inc. Each sample is 3 ft. (~91 cm) long, is trade size 2/0, and is product code EGSLC2-0. Please note that the provided chain is an *example* of the ELEMENT. The exact specifications of chain (size, length, material, etc.) are not defined.



Figure 3-1 Game Design Challenge ELEMENT – Sample Chain. Photo courtesy: Fehr Bros Industries, Inc.

## 3.4 Awards & Judging Logistics

### 3.4.1 Awards

Teams are required to submit their Game Design Concept and participate in an interview with FIRST Robotics Competition judges to be eligible for awards. The official award guidelines can be found on the [At Home Challenges Award Guidelines](#) webpage. Interviews are virtual and held on a remote platform. The awards for this challenge are as follows:

- **Designer’s Award** – Celebrates a team’s outstanding success with the Game Design Challenge. The winner of this award should be a strong candidate for some other awards in this challenge.
  - To be eligible for this award a team is not required to use the Game Design Challenge ELEMENT.
- **Concept Award** – Celebrates a team that creates an interesting, realistic game concept.
  - To be eligible for this award a team is required to use the Game Design Challenge ELEMENT.
- **Imagery Award in honor of Jack Kamen** – In honor of Jack Kamen, Dean’s father, for his dedication to art and illustration and his devotion to FIRST. This award celebrates attractiveness in visual aesthetic integration.
- **Creativity Award sponsored by Rockwell Automation** – Celebrates creativity that enhances the overall game design concept.
- **Engineering Design Award** – Celebrates the team that demonstrates sound engineering in the design process.
- **Rookie Design Award (optional)** - Celebrates the rookie team’s outstanding success in the Game Design Challenge.

### 3.4.2 Judging GROUPS

For the Game Design Challenge, 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). All teams in a GROUP will compete against each other for judged awards. 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 a team is placed in for the Game Design Challenge.

Teams are assigned to a GROUP by FIRST Headquarters. Once assignments are 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 Game Design Challenge by the deadline, divided by 30, and rounded up.
2. Rookie teams (2020 and 2021 Rookies) 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.
4. If any groups contain less than the minimum of 25 teams, a GROUP is dissolved, and the teams are redistributed into the remaining. This is repeated until all groups contain the minimum threshold of teams.

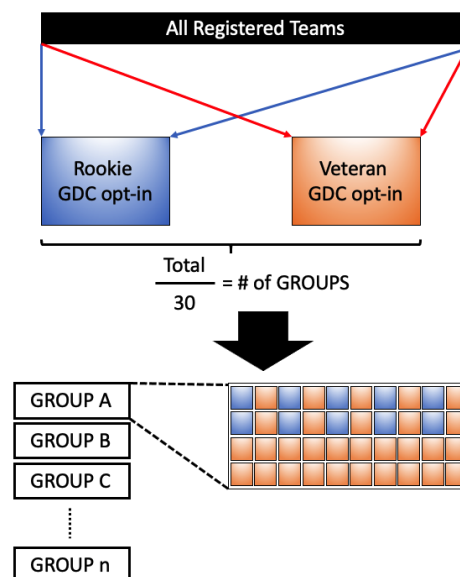


Figure 3-2 Game Design Challenge GROUPS

### 3.4.3 Judging Process

- Teams must submit all content described in Submission Information by the deadline as described in Deadlines.
- Judge Advisors contact teams (via the email they supplied when submitting) to set up an interview with a panel of judges.
- Judges 'spread the wealth' within this challenge so no team wins more than 1 (one) judged award for this challenge

### 3.4.4 Interview Process

Teams that complete the Game Design Challenge submission receive a remote 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.

- 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.
  - The interview time begins after a one (1) minute buffer to allow all team members to be on the call
  - Please remember that judges review the team's submission prior to this interview. We encourage teams to present new information to the judges, rather than reiterating what was already submitted.
- Teams are allowed to share their screens and use video as part of their presentation
- 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 5 team members.

We encourage all teams to be prepared to adapt to any technical difficulties by having multiple team members prepared to present all materials.

Remember to put safety first with social distancing guidelines and compliance with local regulations if your students are in the same physical location.

- At least one (1) adult team mentor **must** attend the interview.
- 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.
  - **Exception:** If necessary, the mentor may provide translation services for students needing foreign language or sign language translation.
- 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.

## 3.5 Advancement

All submissions from teams who received either the Designer's Award or the Concept Award will advance to a second round of judging. In the second round, judges (including members of the *FIRST* Robotics Competition Game Design Team) will review the submissions and select up to 20 entries to move into the final round. There are no interviews in the second round.

The teams selected to advance from the second round will present remotely to members of the *FIRST* Robotics Competition Game Design Team. These Finalists participate in an interview scheduled with HQ Game Designers between June 7<sup>th</sup> and June 18<sup>th</sup>, 2021.

The Game Design Team selects up to three (3) teams as winners of the competition from the group of Finalists. All submissions that advance to the final round are made public by *FIRST* and could have elements of their games be incorporated into a future *FIRST* Robotics Competition season!



Any student who was considered a pre-college team member at the time of the original submission (no later than March 4<sup>th</sup>) will be considered a pre-college student if a team becomes a Finalist regardless of actual academic standing.

### 3.6 Activities

Developing a *FIRST* Robotics Competition game is a new challenge for teams. To help educate teams about the process, get started, and get over roadblocks, members from the Game Design Team put together Activities for teams. These Activities are entirely optional and do not act as a step-by-step process, they do not have to be completed in any particular order. Completion of the Activities is not part of the judging process.

Activities vary, and information ranges from helpful vocabulary, to norm setting, to how to process sets of great ideas and more. Please reference [Game Design Activities](#) for full details and content.

## 4 *FIRST*® INNOVATION CHALLENGE PRESENTED BY QUALCOMM

---

### 4.1 Overview



In the *FIRST*® Innovation Challenge presented by Qualcomm, registered teams identify a real-world problem related to this season's theme *FIRST*® GAME CHANGERS<sup>SM</sup>, powered by *Star Wars: Force for Change*, design a solution, build a business model, and deliver a pitch to compete with other *FIRST* Robotics Competition teams for judged awards and a chance to be one (1) of twenty (20) Finalist teams invited to the *FIRST* Global Innovation Awards powered by *Star Wars: Force for Change*, a multi-day experience where students showcase their innovations, participate in workshops, and receive mentorship from experts.

Science, technology, engineering, and math (STEM) have always been the catalyst for innovation that moves our world forward. As our societies continue to evolve and become more inclusive and connected, our sports - and the activities that make us physically and mentally strong - must change along with us. This means redefining where and how we move and play. We actively play and move for ourselves, but also with and as a community to attain optimum health. This means inventing and innovating places, ways, sports, tools, and concepts so people of all abilities and skill levels can thrive through active play and movement.

#### Think about it:

- In 2006, the Nintendo® slogan 'Experience a new way to play' took the world by storm as it introduced the Nintendo Wii. Game developers and engineers developed a revolutionary new game controller that worked in three dimensions and allowed users of all ages to be active while playing a video game. This solution won the Game Critics Awards for Best Hardware. When coupled with the new software and accessories, it had people off their couches engaging in everything from bowling and dance competitions to tennis and go-kart driving.
- For tracking athletic performance, the stopwatch was one of the few pieces of measuring technology available. Now, companies are refining wearable tech, but athletes have a rapidly growing number of sophisticated options from smart clothing to advanced wearable tech. These have ushered in a new age of performance tracking with metrics such as position, distance, velocity, and acceleration. Heads-Up Display (HUD) cycling glasses are an example of one piece of sports tracking equipment that helps cyclists make mid-ride adjustments when competing, not to mention enhances overall safety.
- In 2019, a *FIRST*® LEGO® League team invented a community sports field that used LED lights to light up fields in different patterns, allowing for the instant and seamless changing of demarcation lines for different types of sports play.

## 4.2 Challenge

Identify a problem or opportunity and design a solution to help people (or a community of people) keep, regain, or achieve optimum physical and/or mental health and fitness through active play or movement.

### 4.2.1 Criteria

Teams who participate in the *FIRST* Innovation Challenge:

- identify and define a problem or opportunity.
- brainstorm and design an innovation to seize the opportunity or solve the problem
  - i. The innovation can be entirely new and novel or may significantly improve an existing invention
- create a business model
- show and be evaluated on the soundness of the design
- develop and present a pitch for the innovation
  - i. Each team develops a two (2) minute business pitch, to be presented live
- use technology in either the solution development process and/or design
  - i. The use of technology in either the solution itself or the development of the solution will fulfill this requirement.

## 4.3 Submission Information

We encourage teams to let *FIRST* know if they are planning to participate as soon as possible by starting their application, but teams have until the deadline to submit their entry.

See How to Submit and Deadlines for additional details on how to submit. For the *FIRST* Innovation Challenge, teams are asked the following questions when they submit:

- two (2) contact emails (must be mentors)
- time zone
- project title
- project described in brief phrase (10-word limit)
- executive summary
  - i. Please describe the problem/opportunity the team is focusing on (200-word limit).
  - ii. Please describe how the team proposes to solve the problem/opportunity (200-word limit).
  - iii. What technology the team used (or planning to use) in the design or solution development? (This does not have to be a comprehensive list but will help align any specific technical expertise a judge may have to the judging GROUP) (100-word limit).

Think of the executive summary as a very brief overview; it does not mean the team needs to have all of the *FIRST* Innovation Challenge figured out! On the contrary, because the information in the executive summary is only reviewed, it is expected that teams expand and iterate upon the solution between the submission deadline and interview.

### 4.3.1 Additional Requirements for Semi-Finalists

The following requirements are *only* for advancing Semi-Finalist teams. Teams will be contacted by *FIRST* with instructions on how to submit and are due April 21, 2021. These are in addition to the previously submitted requirements above:

- public project description (150-word limit)
- team logo
  - accepted formats include gif, jpg, jpeg, png
  - files must be no larger than 10 MB.
- A video of the team's business pitch

- Videos may not exceed two (2) 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/codecs pairs [Supported Input Codecs and Containers](#).

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.

- a description of the innovation impact (500-word limit)
- a description of the design (500-word limit)
- a description of the business model (500-word limit)
- team description (150-word limit)

The following items are optional:

- the team can update or refine any answers to the three questions they made in the Executive Summary submitted earlier; word counts are expanded to 350 for the problem and solution descriptions.
- up to 1 page (8.5 x 11 or A4) of supplemental documentation; we recommend this is used to illustrate any data, drawings, photographs to help show the design.
- an image of the innovation
  - can be a sketch, a photo of a physical model, a CAD image, etc.
  - accepted formats include gif, jpg, jpeg, png
  - files must be no larger than 10 MB.
- a video to show the design, for example CAD animation or prototype in action
  - Videos may not exceed 0:30 seconds.
  - 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/codecs pairs [Supported Input Codecs and Containers](#).

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.

## 4.4 Awards & Judging Logistics

### 4.4.1 Semi-Finalist 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 the award and advancement. Teams who advance to become a Semi-Finalist in the Innovation Challenge receive both a physical award and designation as a:

- ***FIRST* Innovation Challenge Semi-Finalist**– Semi-Finalists are teams that achieve excellence across all above required criteria as described in the guidelines within a GROUP.

Multiple Semi-Finalists advance from each GROUP. See Advancement for more details

#### 4.4.2 Judging GROUPS

For the *FIRST* Innovation Challenge, teams are placed 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). All teams in a GROUP compete against each other for judged awards and advancement. 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 a team is placed in for the Game Design Challenge.

Teams are assigned to a GROUP by *FIRST* Headquarters. Once assignments are made, the GROUP is shown on the [FRC Events webpage](#). Each GROUP has between 20-30 teams (with a target of ~25 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 *FIRST* Innovation Challenge by the deadline, divided by 25, and rounded up.
2. Rookie teams (2020 and 2021 rookies) 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.
4. If any groups contain fewer than the minimum of 20 teams, a GROUP is dissolved, and the teams are redistributed into the remaining. This is repeated until all groups contain the minimum threshold of teams.

#### 4.4.3 Judging Guidelines

The below guidelines are used by judges evaluating the submission for the *FIRST* Innovation Challenge for advancement and for awards at the *FIRST* Global Innovation Awards powered by *Star Wars Force for Change*. Working in a team is a core tenet of *FIRST* and critical for successful innovation, the *FIRST* Innovation Challenge is not designed for individual participants. In each of the criteria, Judges specifically look for:

##### 4.4.3.1 *Problem or Opportunity*

The submission has a clearly outlined problem or opportunity with supporting evidence.

- Evidence could include consultations with experts, data, applicable studies/theories, and /or team conducted user surveys.
- Teams should have a *fully* clear problem or opportunity.
- We recommend evidence be sourced from multiple, reputable sources.

##### 4.4.3.2 *Business Model*

The business model includes a distinct value proposition, the feasibility of the model, and a description of factors/resources for implementation.

- Teams should demonstrate the validation of their value proposition with experts, potential users, or both.
- A specific tool or method to present their business model, such as the business model canvas, is not required.
- Teams should consider a wide variety of factors for implementation and we recommend the consideration of factors be from multiple perspectives.
- Teams may consider creating a full cost and revenue structure.

#### 4.4.3.3 Innovation Impact

Each submission must show, the innovation impact, a deep understanding of how it creates impact by making life better.

- Teams tangibly demonstrate the expected impact of their innovation and how it adds value, either by volume, degree of impact, or both.
- Impact may be demonstrated through surveying, modeling, prototyping, or other methods.
- The impact will be sound and compelling.
- Teams may consider how their impact can be measured initially and/or over time.

#### 4.4.3.4 Design

- The design has effective functionality and is overall comprehensive.
- The design accounts for reliability and user experience
- Teams can explain all underlying science, math, and/or theory in their design.
- Use of technology in the design and/or development process is sound and creative. Teams should use technology in the design process, the development, or throughout the project.
  - The design must be shown to the judges, but how it is shown is at the team's discretion. Teams may draw or use software to show a 2D or 3D representation of their design. A physical model is not required. If built, a photograph or video of it in use will fulfill the showing of the design.
  - Teams may consider building a prototype or have plans on how a prototype would be used to test and refine their design if one cannot be built.
  - Teams may consider incorporating an inclusive, universally accessible design.

#### 4.4.3.5 Business Pitch

The team must present a two (2) minute live business pitch.

- Use of visuals is recommended. We recommend no more than eight (8) slides.
- A video may be a part of your pitch (such as a CAD animation or video of a prototype) but it should not include pre-recorded audio.
- See The Business Pitch (2 min) for recommendations.

#### 4.4.3.6 FIRST Innovation Challenge Emphasis

Team(s) who perform strongly *in each* of the above criteria areas are most likely to advance in the *FIRST* Innovation Challenge. Because learning the innovation process is essential to develop the critical thinking skills and creative problem-solving competencies of our future workforce, judges only look for elements described in Judging Guidelines. Judges are not looking for the next big idea or disruptive innovation, i.e. they are not judging based on their predictive outcomes of your innovation. Although given a GAME CHANGERS<sup>SM</sup> mindset, it's likely that teams develop an idea just as competent as today's top innovators. Whether or not a team's solution is likely to go to market is not considered. What is important is concisely articulating all the outlined requirements.

#### 4.4.4 Judging Process

- Teams must submit all content described in Submission Information by the deadline as described in Deadlines
- Judge Advisors contact teams (via the email they supplied when submitting) to set up an interview with a panel of judges.

#### 4.4.5 Interview Process

Teams who complete the *FIRST* Innovation Challenge submission receive a remote interview with a panel of Judges. We prefer team members presenting information to judging have access to a web

camera and be on screen. The default format is a video conference, but a call-in number can be provided if needed.

- Interviews are limited to fifteen (15) minutes total; two (2) minutes for a pitch, three (3) minutes presentation by the team and the remaining time (at least ten (10) minutes) is used for questions and answers led by the Judges.
  - The interview time begins after a one (1) minute buffer to allow all team members to be on the call
  - See Interview Details for details on what to prepare
- Teams are allowed and encouraged to share their screens and use video as part of their presentation.
- 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 encourage all teams to be prepared to adapt to any technical difficulties by having multiple team members prepared to present all materials.

Remember to put safety first with social distancing guidelines and compliance with local regulations if team members are in the same physical location.

- At least one (1) adult team mentor **must** attend the interview.
  - 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 improve their solution and skills. If the mentor provides any assistance during the interview, the Judges will respectfully remind the mentor of the rule.
  - **Exception:** If necessary, the mentor may provide translation services for students needing foreign language or sign language translation.
- 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.

## 4.5 Interview Details

### 4.5.1 The Business Pitch (2 min)

Participating teams receive educational webinars full of advice on the business pitch; participation is highly encouraged. Please see Content Series – Innovation, Inspiration & Education for more details.

At the Finalist level, *FIRST* Innovation Challenge teams who advance to the *FIRST* Global Innovation Awards receive expert 1:1 pitch coaching from real-world entrepreneurs before their final judging.

The pitch communicates the business model and is designed for an external stakeholder audience. Even though teams are delivering it to judges, it should have a compelling tone as if it were being delivered to an external audience, not just a judging panel.

The elements of a strong business pitch typically consist of an introduction of the problem and solution, an explanation of how it works, an overview of any competition for the business (if applicable), progress to date, validation (from experts/partners/data), an ask, and a closing.

We recommend the use of visuals in the pitch, especially if teams are communicating complex ideas or data; however, they are not required. If teams use a slide show, teams should not use more than eight (8) slides. A video may be a part of the pitch (such as a CAD animation or video of a prototype), however because the pitch is live, the video should not have pre-recorded explanatory audio.



It is not appropriate to ask any *FIRST* judges to fund your solution or participate in any online fundraising campaigns. Interested judges may be directed to your team's website or social media account for further information.

#### 4.5.2 Uninterrupted Presentation (3 min)

The presentation is designed to communicate information to the judges on how the innovation matches the criteria. It can be given in any style (i.e. this can be creative and less formal than the pitch), and it should not be pre-recorded. Whereas the pitch focuses on the business model, this presentation should focus on articulating the impact and design of your innovation, as well as how the team used technology in its development and/or design. Teams may use drawings, photographs, CAD animations, model/prototype, or video to assist in this presentation. If teams use a video, it should not take more than 90 seconds and should not have pre-recorded explanative audio.

#### 4.5.3 Judge's Question & Answers (Q&A, 10 min)

Judges use this time to ask questions they may have based on the pitch or presentation. Judges finish each live judging session with the question: Is there anything else you'd like us to know?

### 4.6 Advancement

The table below shows how many Semi-Finalists are chosen per GROUP depending on the number of teams that applied. Please note if there are fewer than 100 teams who submit for the *FIRST* Innovation Challenge, advancement to the Finalist level occurs directly. Semi-Finalists vie for 20 Finalist spots. Semi-Finalist teams are placed into new GROUPS of approximately 25 teams using the process described in Judging GROUPS. A panel of different judges review these teams' innovation solution submissions; there is no live remote judging at the Semi-Finalist level.

Total Number of Teams	# of Semi-Finalists per GROUP
<b>0 – 150</b>	4 teams receive the <i>FIRST</i> Innovation Challenge Semi-Finalist Award and become Finalists
<b>151 - 1000</b>	4
<b>1,001 - 1900</b>	3
<b>1901 - 3000</b>	2

Twenty (20) *FIRST* Robotics Teams are chosen as Finalists and move on to compete at The *FIRST*® Global Innovation Awards powered by *Star Wars: Force for Change*. Finalist teams are expected to continue to iterate and refine their work. The top twenty (20) Finalists are eligible for the Awards described in the *FIRST* Global Innovation Awards section.

### 4.7 The *FIRST*® Global Innovation Awards powered by *Star Wars: Force for Change*

Advancing *FIRST*® LEGO® League Challenge, *FIRST*® Tech Challenge, and *FIRST*® Robotics Competition teams showcase and celebrate their innovative solutions at the 2021 *FIRST*® Global Innovation Awards held June 28-30, 2021 at a remote event in front of *FIRST* Strategic Partners and a global audience of peers and industry leaders. Teams participate in judging, workshops, expert mentoring, and fun during a 3-day event that culminates in a live Awards Broadcast featuring the work of all Finalist teams. Teams vie for Awards within their own program only, not against teams in other programs.

Past *FIRST* Global Innovation Awards teams have received patents, brought products to market, won pitch competitions, received funding grants and university partnerships, and national press coverage.



Teams who participate are expected to have availability on June 28-30 for the majority of team members to be judged and participate in the remote event should they become one of the 20 Finalist teams. A stable internet connection and device are required for all Finalist team members who advance to the *FIRST* Global Innovation Awards.

#### 4.7.1 Preparing for the *FIRST* Global Innovation Awards

The twenty (20) Finalist *FIRST* Robotics Competition Teams are provided with a separate judging guide to prepare for the *FIRST* Global Innovation Awards; however, the remote judging format follows the same format as the initial judging. Finalist teams should plan on being seen multiple times by judges for a longer duration to allow for longer Q&A.

Finalist teams may have additional non-judged requirements for the *FIRST* Global Innovation Awards, such as submitting materials for remote pits, updating their submission with additional written information and/or an Engineering Change notice to help judges understand the work in advance, and submitting answers to questions in the form of videos or images for use in our social media campaign, etc. A full calendar of due dates for these addition elements is provided to coaches of Finalist teams the third week in May.

Each program recognizes a *FIRST* Global Innovation Awards winner, two (2) runners-up, and one (1) award each for Business Model Design, Innovation Design, and Innovation Impact. The overall winner and the two (2) runners-up for each program are teams that achieve excellence across all criteria as described in the Judging Guidelines.

Awards for Business Model Design, Innovation Design, and Innovation Impact look for particular excellence *just* in those respective criteria described in Judging Guidelines. The overall *FIRST* Global Innovation Award winner and runners-up are determined by judges first and are not eligible for these Awards.

Finalist teams are asked to create a brief (30 second) public pitch for their *FIRST* Innovation Challenge. These pitches are made publicly available and family, fans, and the *FIRST* community can vote on their favorite. Three (3) Community Choice winners are recognized, one (1) from each *FIRST* program. Because this Award is based on a public vote, a team may win the Community Choice Award in addition to another Award at the *FIRST* Global Innovation Awards.

#### 4.7.2 Timeline

- **April 21, 2021:** Deadline for Semi-Finalist teams to submit further requirements. (See Submission Information)
- **May 7, 2021:** The 20 Finalists from each program for the *FIRST* Global Innovation Awards are chosen on or around this date. Teams should anticipate receiving an e-mail from *FIRST* at this time. In May and June, Finalists continue to iterate and refine their work.
- **June 28-30, 2021:** The 20 Finalist teams should be available for judging, workshops, and mentoring on these days to participate in the *FIRST* Global Innovation Awards remote event. Please note this event typically has a commitment of ~5 hours a day, with plenty of breaks and time of day dependent on time zone. Via our closed App platform, open just to coaches, team members and sponsors, teams also engage in a real-time activity feed and with each other. On June 25<sup>th</sup> and (the Friday before the event) and throughout, teams are given the opportunity to meet 1:1 or in small groups with other Finalist teams.

## 4.8 Intellectual Property Protection

*FIRST* cannot give legal advice. We work in collaboration with the USPTO in order to provide intellectual property education to all students, which is a critical part of innovation. Protecting the idea is an important part of any invention or innovation process. For the 20 teams that reach the Finalist level and advance to

the *FIRST* Global Innovation Awards, *FIRST* encourages teams to file a United States provisional patent. Teams can learn more on the patent resource page of the [FIRST Innovation Challenge](#) webpage.

## 4.9 Content Series – Innovation, Inspiration & Education

As part of the *FIRST* Innovation Challenge presented by Qualcomm, *FIRST* will host a content series featuring conversations with innovators and essential tips teams can apply to succeed in the challenge.

Topics may include pitch advice, business model education, intellectual property, careers in innovation, product development, using CAD to show design, and more. The series will be a combination of informative webinars and live panel discussions featuring dynamic *FIRST* alumni and experts from our sponsors, allowing teams exclusive access to engage with real-world innovators and entrepreneurs.

Teams may access the content series and additional resources at the [Innovation Content Series](#) webpage.

## 5 TRADITIONAL SUBMITTED AWARDS

### 5.1 Overview

Teams may compete for the following traditional Submitted Awards:

- [Chairman's Award](#)
- [FIRST Dean's List Award](#)
- [Woodie Flowers Finalists Award](#)

To be eligible, teams must submit for these awards through the [FIRST Dashboard](#). The Chairman's Award and Woodie Flower's Finalist Award submissions must be entered by a designated [Award Submitter](#). The FIRST Dean's List Award must be submitted by Lead Mentor 1 or 2 or a designated Dean's List Award Submitter. See the exact details for these awards on the [Submitted Awards](#) webpage.

### 5.2 Awards & Judging Logistics

For the Traditional Submitted Awards, teams are grouped into regions based on their geographic location. Each region awards a specific number of Chairman's, Dean's List, and Woodie Flowers Finalist Awards based on the number of teams participating in that region during the 2021 season.

Table 5-1 Regions for Submitted Awards

Region Name	States/Countries included in the Region
<b>Caribbean + South American Region</b>	Brazil, Colombia, Dominican Republic, and Panama
<b>Central Asia, Africa, and Europe Region</b>	Afghanistan, Croatia, Germany, France, India, Libya, Lesotho, Netherlands, Norway, Poland, South Africa, Ukraine, and United Kingdoms
<b>China Region</b>	China
<b>FIRST Chesapeake District</b>	D.C., Maryland, and Virginia
<b>FIRST Indiana District</b>	Indiana
<b>FIRST Israel District</b>	Israel
<b>FIRST in Michigan District</b>	Michigan
<b>FIRST in Texas District</b>	Texas and New Mexico
<b>FIRST Mid-Atlantic District</b>	Delaware, New Jersey, and Eastern Pennsylvania
<b>FIRST North Carolina District</b>	North Carolina
<b>Florida Region</b>	Florida
<b>Greater Central Valley Region</b>	California - Central Valley/Northern Central California
<b>Greater Los Angeles Region</b>	California - Orange/Los Angeles/Inland Empire
<b>Greater San Diego Region</b>	California - San Diego
<b>Greater San Francisco Bay Region</b>	California - Greater San Francisco Bay Area/Northern CA Coast
<b>Illinois Region</b>	Illinois
<b>Mexico Region</b>	Mexico
<b>Midwestern Plains Region</b>	Iowa, Nebraska, and Oklahoma
<b>MoKan Region</b>	Kansas and Missouri
<b>NE FIRST District</b>	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont
<b>New York &amp; Quebec Region</b>	New York and Quebec

<b>Ontario District</b>	Canada - Ontario
<b>Pacific Northwest District</b>	Alaska, Oregon, and Washington
<b>Pacific Region</b>	Australia, Chinese Taipei, Hawaii, Indonesia, Japan, New Zealand, Singapore, and Vietnam
<b>Peachtree District</b>	Georgia
<b>Rocky Mountain Region</b>	Colorado, Idaho, Montana, Utah, Western Canada, and Wyoming
<b>Southeastern Region</b>	Alabama, Arkansas, Louisiana, and Mississippi
<b>Southern Appalachian Region</b>	Kentucky, South Carolina, and Tennessee
<b>Southwestern Region</b>	Arizona and Nevada
<b>Turkish Region</b>	Turkey
<b>Upper Midwest Region</b>	Minnesota, North Dakota, and South Dakota
<b>Upper Ohio River Region</b>	Ohio, West Virginia, and Western PA
<b>Wisconsin Region</b>	Wisconsin

Table 5-2 # of Awards per Region

<b>Region</b>	<b># of Chairman's Award Winners</b>	<b># of Dean's List Finalists</b>	<b># of Woodie Flower Finalists</b>
<b>Caribbean + South American Region</b>	1	2	1
<b>Central Asia, Africa, and Europe Region</b>	1	2	1
<b>China Region</b>	2	4	1
<b>Florida Region</b>	3	6	1
<b>Greater Central Valley Region</b>	1	2	1
<b>Greater Los Angeles Region</b>	4	8	1
<b>Greater San Diego Region</b>	2	4	1
<b>Greater San Francisco Bay Region</b>	3	6	1
<b>Illinois Region</b>	2	4	1
<b>Mexico Region</b>	3	6	1
<b>Midwestern Plains Region</b>	2	4	1
<b>MoKan Region</b>	3	6	1
<b>New York &amp; Quebec Region</b>	4	8	1
<b>Pacific Region</b>	3	6	1
<b>Rocky Mountain Region</b>	4	8	1
<b>Southeastern Region</b>	2	4	1
<b>Southern Appalachian Region</b>	2	4	1
<b>Southwestern Region</b>	2	4	1
<b>Turkish Region</b>	3	6	1
<b>Upper Midwest Region</b>	6	12	1
<b>Upper Ohio River Region</b>	3	6	1
<b>Wisconsin Region</b>	2	4	1

Table 5-3 # of Awards per District

Region	District Level Chairman's Awards	Max # of District Championship level Dean's List Semi-Finalists	District Championship level Chairman's Awards	District Championship level Dean's List Finalists	# of Woodie Flower Finalists
<b>FIRST Chesapeake District</b>	6	12	2	3	1
<b>FIRST Indiana District</b>	4	8	1	2	1
<b>FIRST Israel District</b>	4	8	1	2	1
<b>FIRST in Michigan District</b>	25	48	7	12	1
<b>FIRST in Texas District</b>	9	18	3	5	1
<b>FIRST Mid-Atlantic District</b>	7	14	2	4	1
<b>FIRST North Carolina District</b>	4	8	1	2	1
<b>NE FIRST District</b>	10	20	3	5	1
<b>Ontario District</b>	5	10	2	3	1
<b>Pacific Northwest District</b>	7	14	2	4	1
<b>Peachtree District</b>	4	8	1	2	1

### 5.2.1 Interview Process

Teams who have submitted for the Chairman's Award and/or the *FIRST* Dean's List Award receive a remote 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 for team members. Additional details are described on the [submitted awards](#) webpage.

## 6 GLOSSARY

Term	Definition
<b>BOTTOM PORT</b>	a 10 in. (~25 cm) tall, 2 ft. 10 in. (~86 cm) wide rectangle. The bottom edge is 1 ft. 6 in. (~46 cm) above the carpet.
<b>BUMPER</b>	A required assembly which attaches to the ROBOT frame
<b>CONTROL</b>	A ROBOT is in CONTROL of a POWER CELL if: A. the POWER CELL is fully supported by the ROBOT, B. the POWER CELL travels across the FIELD such that when the ROBOT changes direction, the POWER CELL travels with the ROBOT, or C. the ROBOT is holding a POWER CELL against a FIELD element in attempt to guard or shield it.
<b>DRIVE TEAM</b>	a set of up to five (5) people from the same FIRST Robotics Competition team responsible for team performance for a specific MATCH.
<b>ELEMENT GROUP</b>	is the collection of teams that compete against each other for awards in a specific 2021 At Home Challenge.
<b>HUMAN PLAYER</b>	a pre-college student DRIVE TEAM member who acts as a POWER CELL manager
<b>INNER PORT</b>	a 1 ft. 1 in. (~33 cm) diameter circle concentric with and 2 ft. 5¼ in. (~74 cm) behind (i.e. on the ALLIANCE STATION side of) the OUTER PORT. The center is 8 ft. 2¼ in. (~249 cm) above the carpet.
<b>MARKER</b>	physical objects with a minimal cross-section of 2.5 in (~63 mm) wide by 2.5 in (~63 mm) deep and at least 6 in (~152 mm) tall used to mark specific locations relevant to each challenge.
<b>NAV POINT</b>	specific locations marked on the Skills Competition General Layout Diagram and used to locate MARKERS or zones for specific challenges
<b>OPERATOR CONSOLE</b>	a pre-college student DRIVE TEAM member who acts as a POWER CELL manager
<b>OUTER PORT</b>	a regular hexagon that measures 2 ft. 6 in. (~76 cm) in height. The center of the OUTER PORT is 8 ft. 2¼ in. (~249 cm) above the carpet.
<b>POWER CELL</b>	A yellow 7 in. (~18 cm) diameter Medium Bounce Dino-Skin foam ball. The FIRST logo may be printed on each ball in black ink. The ball is made by Flaghouse (PN 1892 YEL) and sold by AndyMark (PN AM-4200)
<b>POWER PORT</b>	a 10 ft. 2¼ in. (~310 cm) tall by 4 ft. (~122 cm) wide (excluding backboards) structure and is located between PLAYER STATIONS 1 and 2.
<b>ROBOT</b>	An electromechanical assembly built by the FIRST Robotics Competition team to play the current season's game and includes all the basic systems required to be an active participant in the game –power, communications, control, BUMPERS, and movement about the FIELD.