



FIRST® DIVESM
presented by Qualcomm

firstinspires.org/robotics/ftc



2024-2025 FIRST® Tech Challenge
INTO THE DEEP
Competition Manual

INTO THE DEEP

Competition Manual

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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 Pre-K-8, ages 4-16
- FIRST® LEGO® League Challenge for grades 4-8 (ages 9-16, ages vary by country)
- FIRST® LEGO® League Explore for grades 2-4 (ages 6-10)
- FIRST® LEGO® League Discover for grades Pre-K-1 (ages 4-6)

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

1.2 FIRST® Tech Challenge

FIRST® Tech Challenge is a student-centered program that focuses on giving young people a unique and stimulating experience. Each year, small teams of students with the help of mentors engage in a new dynamic challenge where they design, build, test, and program ROBOTS that must perform a series of game tasks autonomously and under driver control. Participants and alumni of FIRST programs gain access to education and career discovery opportunities, connections to exclusive scholarships and employers, and a place in the FIRST community for life. To learn more about FIRST® Tech Challenge and other FIRST® Programs, visit www.firstinspires.org.

Gracious Professionalism®, a FIRST Credo

Gracious Professionalism® 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, and
- 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 and
- 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.

Figure 1-1 Dr. Woodie Flowers, *Gracious Professionalism* advocate and exemplar



“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.

1.3 *Coopertition*[®]

At *FIRST*, *Coopertition*[®] 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.

1.4 Spirit of Volunteering

FIRST can only hope to achieve our mission of providing life-changing robotics programs that give young people the skills, confidence, and resilience to build a better world with your help.

There are two phrases which drive and motivate the individuals that volunteer their time for FIRST: “Giving Back” and “Pay It Forward.” Each year, you have the extraordinary opportunity to help create the best-ever experience for our fellow volunteers, mentors, COACHES, and students by becoming a FIRST volunteer

To our team members and mentors: remember that the volunteers you interact with are dedicating their most precious asset - their time - to ensure that all teams have a fulfilling, fun, and memorable competition. Volunteers are the lifeblood of FIRST, and without them, FIRST would not be where it is today. We urge you to remember that *Gracious Professionalism* 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. We strive to train each volunteer to always exhibit Gracious Professionalism - we hope we can work together to create an environment where all feel safe and welcome.

Please consider volunteering at local events near you but know that not all applicates can be placed in all roles at any given event. Please work with your volunteer coordinator and local program delivery partner to help identify the most meaningful way you can help in your region. A complete set of all role-specific volunteer materials can be found on our [Volunteer Resources Page](#).

1.5 Accessibility and Inclusion

FIRST is committed to Equity, Diversity, and Inclusion and as such, FIRST makes reasonable accommodations for persons with disabilities that request accommodation. If a participant needs an accommodation for an event, please [contact your local leadership](#) before the event so they can help ensure the accommodation is provided. Local leadership may make exceptions to event rules to allow for reasonable accommodations given the exceptions do not create an undue hardship or cause safety concerns.

1.6 This Document & Its Conventions

The 2024 Competition Manual is a resource for all FIRST Tech Challenge teams for information specific to the 2024 season and the INTO THE DEEP game. Its audience will find the following detail:

- a general overview of the INTO THE DEEP game (to be released 9/7/2024),
- detail about the INTO THE DEEP playing FIELD (to be released 9/7/2024),
- a description of how to play the INTO THE DEEP game (to be released 9/7/2024),
- rules (related to safety, conduct, game play, inspection, event, etc.),
- ROBOT construction rules, and
- a description of how teams advance at 2024-25 tournaments and throughout the season (to be released 9/7/2024),

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 manual to highlight warnings, cautions, key words, and phrases. These conventions are used to alert the reader to important information and are intended help teams in constructing a ROBOT that complies with the rules in a safe manner.

Links to other section headings and rule references within this manual appear in [blue underlined text with a grey background](#). Links to external resources appear [blue underlined text](#).

For linked references not included in a preview release of this document, the links will appear with the section letter and ### for the rules number within square brackets. For example, a cross link to a game rule before a game rule is released will appear as [\[G###\]](#) and will be replaced with the current linked rule when that section of the manual is released.

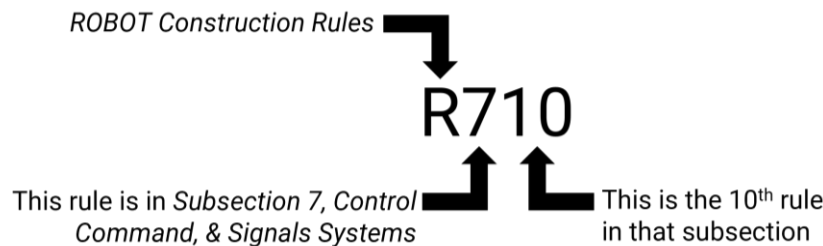
Key words that have a particular meaning within the context of the FIRST Tech Challenge and INTO THE DEEP are defined in section [16 Glossary](#) and indicated in ALL CAPS throughout this document.

The rule numbering method indicates the section, subsection, and position of the rule within that subsection. The letter indicates the section in which the rule is published.

- I for Section [3 Competition Eligibility and Inspection \(I\)](#)
- E for Section [5 Event Rules \(E\)](#)
- G for Section [11 Game Rules \(G\)](#)
- R for Section [12 ROBOT Construction Rules \(R\)](#)
- T for Section [13 Tournament \(T\)](#)
- L for Section [14 League Play Tournaments \(L\)](#)
- C for Section [15 FIRST Championship Tournament \(C\)](#)

The following digit(s) represents the subsection in which the rule can be found. The final digits indicate the rule’s position within that subsection.

Figure 1-1 Rule numbering method



Warnings, cautions, and notes appear in orange 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 orange 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 orange box, the rule supersedes the language in the orange box).

Imperial dimensions are followed by comparable metric dimensions in parentheses to provide metric users with the approximate size, mass, etc. Metric conversions for non-rules (e.g. 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 official drawings (i.e. dimensions and rules will always defer to measurements using imperial units).

Rules include colloquial language, also called headlines, in an effort to convey an abbreviated version of the rule or rule set. There are two versions of headline formatting. Evergreen rules, rules which are expected to go relatively unchanged from season to season, are indicated with their headline presented in ***bold green text** with a leading asterisk. “Relatively unchanged” means that the overall intent and presence of the rule from season to season is constant, but game specific terms may be updated as needed (e.g. changing Cones to Pixels in a rule about what COACHES may not contact during a MATCH). These rules also start their respective section, so their rule number is less likely to change from season to season. All other rule headlines use **bold orange text**. Any disagreement between the specific language used in the rules and the colloquial language is an error, and the specific rule language is the ultimate authority. If you discover a disparity, please let us know at firsttechchallenge@firstinspires.org.

Team resources that aren’t generally season specific (for example, what to expect at an event, communication resources, team organization recommendations, and award descriptions) can be found on the FIRST Tech Challenge website.

1.7 Translations & Other Versions

The *FIRST* Tech Challenge manual is originally and officially written in English and is occasionally translated into other languages for the benefit of *FIRST* Tech Challenge teams whose native language may not be English. These assets are posted on the Translated Manuals page.

A text-based English version can be provided only for use with assistive devices and not for redistribution. For more information, please contact the *FIRST* Tech Challenge at firsttechchallenge@firstinspires.org.

In the event that a rule or description is modified in an alternate version of this manual, the English pdf version as published on the Game and Season web page is the authoritative version.

1.8 Team Updates

Team Updates are used to notify the *FIRST* Tech Challenge community of revisions to the official season documentation (for example, the manual, drawings, etc.) or important season news. Team Update posts are scheduled as follows:

- Every other Thursday beginning on kickoff day and ending two weeks prior to the *FIRST* Championship.

Team Updates are posted on the Game and Season web page and are generally posted at 1pm Eastern.

Team Updates are indicated using the following formatting:

- Additions are highlighted in yellow. **This is an example.**
- Deletions are indicated with a strikethrough. ~~This is an example.~~

1.9 Question and Answer System

The [Question and Answer System \(Q&A\)](#) is a resource for teams to ask questions about gameplay, competition rules, judging and advancement, ROBOT build rules, and FIELD setup. 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 September 16th, 2024, 12:00 PM Eastern. Access to the Game Q&A forum is through the Lead COACH 1 and/or Lead COACH 2's account through the www.firstinspires.org/ dashboard. Follow the instructions on [how to create an official Q&A account](#). Teams may still create a separate view -only account to read the forum.

The Q&A may result in revisions to the text in the official manuals (which are communicated using the process described in section [1.8 Team Updates](#)).

The responses in the Q&A do not supersede the text in the manual, although every effort will be made to eliminate inconsistencies between the two. While responses provided in the Q&A may be used to aid discussion at each event, REFEREES and INSPECTORS are the ultimate authority on rules. If you have concerns about enforcement trends by volunteer authorities, please notify *FIRST* at firsttechchallenge@firstinspires.org.

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

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

Questions that are overly broad, vague, and/or include no rule references. Some examples of questions that may not be answered in the Q&A are:

- How should the REFEREE have ruled when this specific game play happened?
- Duplicate questions
- Questions clearly defined/addressed in this manual

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 "FTC 1000" represent content asked by key volunteers (e.g., REFEREES, INSPECTORS, etc.), answered by *FIRST*, and are considered relevant to teams.



2 FIRST Season Overview



Explore the Future

The ocean is more than what you can see on the horizon. Beneath the surface lies our planet’s most complex ecosystems, full of life and potential for exploration and learning, where each inhabitant has a role to play in building a thriving environment.

During the 2024-2025 FIRST season, FIRST® DIVESM presented by Qualcomm, teams will use their STEM and collaboration skills to explore life beneath the surface of the ocean. Along the way, we’ll uncover the potential in each of us to strengthen our community and innovate for a better world with healthy oceans. Join us as we explore the future.



PRESENTED BY RTX

PRESENTED BY HMS
Green House Foundation

Children can join any of our three programs based on age or grade level. Ages may vary by region.



AGES
4-16



AGES
12-18



AGES
14-18

LEARN MORE: firstinspires.org/dive

3 Competition Eligibility and Inspection (I)

This section will be updated with the Kickoff Competition Manual release on September 7th, 2024



4 Advancement

This section will be updated with the Kickoff Competition Manual release on September 7th, 2024



5 Event Rules (E)

This section of event rules are general rules which apply from the beginning of the public schedule when teams arrive through the end of the event with departure from the venue. They are high level rules intended to promote an orderly and safe experience for all participants. The event director may specify additional restrictions beyond those listed here based on local venue requirements.

Safety is always paramount, and many rules are intended to establish norms at each event that will mitigate injury risk to all participants.

The event director has the final decision authority for all safety-related issues within a venue.

5.1 General Rules

The rules below apply throughout an event, i.e. from when Load-In begins to when Load-Out is complete.

Universal Violation Note: A violation of any [Event Rules \(E\)](#) will result in a verbal warning. Egregious or subsequent violations will be addressed by the Head REFEREE, the Lead ROBOT INSPECTOR (LRI) and/or event director. Teams should note that egregious and/or frequent violations may be shared with the Judge Advisor which could lead to disqualification from awards. Criminal behavior will not be tolerated and may be met with immediate disqualification for the team from the game and judging.

Additional rule specific violations, if applicable, are listed with their corresponding rule.

E101 *Personal safety comes first. All team members must observe the following safety practices throughout the event:

- A. wear safety glasses (only ANSI-approved, UL Listed, CE EN166 rated, AS/NZS certified, or CSA rated non-shaded) while in and around the playing FIELD and in the pit area. Clear or lightly tinted safety glasses are preferred. Shaded glasses are allowed for those who need them and do not require a specific accommodation request. The only instances where teams are not required to wear safety glasses are in their first 10 minutes of their event load in, and for the first 10 minutes pits are open each day of the event as long as they're not working on the ROBOT or setting up their pit.
- B. wear closed toed/heeled shoes.
- C. control entanglement risks by tying back long hair and removing other dangling decorations including lanyards, spirit wear and rings as needed while working on or around a ROBOT or ROBOT related materials or tools.
- D. wear appropriate clothing.
- E. walk in the venue.
- F. comply with government and venue-specific health and safety requirements in place for that event (e.g. mask wearing).

For more information about safety at *FIRST* events, please reference the [FIRST Safety Manual](#).

- E102 *Be a Gracious Professional.** All participants must be gracious and professional at all times while attending a FIRST Tech Challenge event. Uncivil behavior toward any participants is not tolerated.

Examples of inappropriate behavior include, but are not limited to

- A. use of offensive language or other uncivil conduct towards someone,
- B. intentionally blocking the view of other participants or spectators for an extended period (team members momentarily holding up team signs while directly supporting their team is not considered a violation of this rule.), and
- C. jamming or interfering with the remote sensing capabilities of a ROBOT or the FIELD while in open-access spectator seating areas.

Examples of remote sensing capabilities include, but are not limited to, vision systems, acoustic range finders, sonars, and infrared proximity sensors.

Use of imagery that, to a reasonably astute observer, mimics the AprilTags employed on the FIELD is a violation of this rule.

Examples of particularly contemptible behavior that may result in ejection from the event include, but are not limited to, the following:

- A. assault, e.g. throwing something that hits another person (even if unintended),
- B. threat, e.g. saying something like “if you don’t reverse that call, I’ll make you regret it,”
- C. harassment, e.g. badgering someone with no new information after a decision’s been made or a question’s been answered,
- D. bullying, e.g. using body or verbal language to cause another person to feel inadequate or unsafe,
- E. insulting, e.g. telling someone they don’t deserve to be on a team,
- F. swearing at another person (versus swearing under one’s breath or at oneself), and
- G. yelling at another person(s) in anger or frustration.

- E103 *Children with adults, please.** Children under 12 must be accompanied in the pits by an adult at all times.
- E104 *Respect the venue.** Teams may not damage the venue, including but not limited to bleachers, floors, walls, railings, etc., in any way. This includes littering with team giveaways including candies, flyers and stickers.
- E105 *Teams must check in.** An adult team member must check in at the Pit Administration station, or the designated check in location, no later than 45 minutes before Qualification MATCHES are scheduled to start unless otherwise specified or approved by the event director.

Violation: Failure to check in may result in a team not participating in the event.

- E106 *Event resources are for competing teams only.** Only teams registered for an event may use that event's competition FIELD, practice FIELD, and inspection. Host teams supplying practice FIELD elements and/or machine shop resources may use them, however teams registered for that event must be granted priority.
- E107 *Practice only when/where permitted.** Teams may only practice with their ROBOT in their pit space, in the designated event practice areas, or while in a practice MATCH.
- Teams may not set up their own practice equipment outside their pit in other areas of the event venue. When practicing in their pit, safety must remain the top priority. If the event director determines a pit practice setup is unsafe or interferes with activity in adjacent pits or aisles, the team must discontinue the activity.
- E108 *Work in designated areas only.** At the event venue, teams may only produce FABRICATED ITEMS as follows:
- A. in their pit area,
 - B. in another team's pit area with permission from that team,
 - C. while queued for a MATCH or practice FIELD (given space constraints, extra scrutiny regarding safety is required),
 - D. any area designated by event staff (e.g. playoff pit area, etc.), or
 - E. as permitted at provided machine shops that are available to all teams.
- E109 *Some things don't belong at events.** Do not bring or use the following:
- A. skateboards
 - B. 'hoverboards'
 - C. drones
 - D. bottled gas tanks (e.g. helium)
 - E. noisy devices or noisemakers, such as floor stompers, whistles and/or air horns
 - F. walkie-talkies
 - G. scooters, except for those used for accommodations
- E110 *Don't arrange for additional utilities.** Do not arrange for power, internet access, or phone lines from venue service providers or attempt to use venue internet connections reserved for event purposes (e.g. *FIRST* event management software or web casting).
- E111 *Don't sell stuff.** Teams may not conduct sales at an event. This includes, but is not limited to, raffle tickets, food, hats, shirts, candy, water, soft drinks, fruit, or any promotional products unless specifically allowed by the event director.
- E112 *Make FIRST loud, but with restrictions.** Do not invite or bring live bands to play in the audience. Do not play loud music.
- E113 *Hang banners with care.** Be respectful when hanging your banners.
- A. Do not cover or move other team or sponsor signs already in place.
 - B. Share the available space fairly with other teams.
 - C. Do not obstruct the view of spectators.
 - D. Get permission from the event director before hanging banners outside of your pit.

- E. Hang signs and banners in a safe manner.
- F. Banners hung outside team pits must not be larger than 25 ft.² (2.3 m²).

We encourage teams to bring team flags and/or signs for display in their pits and/or the playing FIELD area.

To find your event director, inquire at the pit administration desk.

Respect venue-specific rules regarding sign location and hanging methods. At the end of the event, safely remove all signs and anything used to hang the signs (tape, string, etc.).

- E114 *Limit flag and flagpole size if used on the FIELD.** Flags and flagpoles may not be of unreasonable size and weight if they are going to be used on or around the FIELD.

As a guideline, reasonable flags are less than 3 ft. by 5 ft. (~91 cm by 152 cm) in size and weigh less than 2 lbs. (~907g). Reasonable flagpoles may not be more than 8 ft. (~243 cm) long and weigh less than 3 lbs. (~1360g).

- E115 *No firearms or other weapons.** Firearms or other weapons are prohibited at all *FIRST* events for all *FIRST* programs, including without limitation, [all official *FIRST* Events posted here](#). This rule includes prop or simulated weapons which appear to be real. This policy does not apply to law enforcement or venue security personnel.
- E116 *Inspection required for practice FIELD access.** A team may only use a practice FIELD with a ROBOT that has passed an initial, complete inspection. This rule only applies to events not using scheduled inspection times.
- E117 *Don't record *FIRST* staff or volunteers at the event without their consent.** Do not record your interactions with *FIRST* event staff, or anyone at an event, without the person's consent and do not challenge the decision to decline consent to be recorded. *FIRST* event staff are empowered to excuse themselves from an interaction in which they are being recorded after declining consent.

Laws regarding recording of conversations vary state-to-state and country-to-country, and, in some cases, recording without consent may be criminal. Introducing the idea of recording a conversation with an implied reason of proving someone's error can escalate a discussion and is likely to increase its adversarial nature.

5.2 Machine Shops and Host Team Build Spaces

Rarely, some events host a machine shop or open their team's build space, during specific hours (see the event public agenda), to help teams with repair and fabrication of their ROBOT. Machine shops are typically sponsored by the local host organization. In most cases, the machine shop is on site and readily accessible to all teams.

5.3 Wireless Rules

E301 *No wireless communication. Teams may not set up their own Wi-Fi (802.11a/b/g/n/ac/ax/be) wireless communication (e.g. access points or ad-hoc networks) in the venue.

A wireless hot spot created by a cellular device, camera, smart TV, etc. is considered an access point.

Some smart TVs have access points enabled by factory default. Please make sure that functionality is disabled for any TVs brought to the event.

E302 *Don't interfere with wireless networks. Participants may not interfere, attempt to interfere, or attempt to connect with any other team or *FIRST* wireless network without expressed permission.

Teams are encouraged to report suspected wireless security vulnerabilities to the *FIRST* Technical Advisor (FTA) or event director if at the event or to *FIRST* via ftctech@firstinspires.org to report a suspected issue after the event.

Violation: Subsequent violations may lead to dismissal from the event and/or legal action based on applicable laws.

5.4 Load-In

Some large events (often multi-day events) may set specific time frames, published on the event public schedule, in which teams are invited to load their ROBOT and equipment into their pit areas before pits officially open.

Load-in can be stressful for teams and volunteers, which can be mitigated by preparation and planning. Unanticipated factors, like traffic or weather, can change a team's scheduled arrival time, making the process difficult. The most important things a team should remember are to be safe, gracious, and professional. Teams who experience smooth and easy load-ins are encouraged to check with others to see if they can help and make their experience as positive as possible.

5.5 Pits

A team pit is the designated space, typically a 10 ft. by 10 ft. by 10 ft. (~3 m x 3 m x 3 m) area, where a team may work on their ROBOT. Each team is assigned a pit space marked with their team number. This helps team members, judges, and visitors find teams easily. Pit spaces may vary based on competition venue size limits.

The pit area refers to the general area where team pits are located which encompasses the aisles between the pits, pit admin, ROBOT inspection, practice FIELD, or other areas where ROBOTS may be active or worked on. All pit rules apply to the full pit area.

Additional limitations beyond those listed below may be imposed by the event director but they should be clearly communicated at least 48 hours before the event start time and applied to all teams fairly. Team pits may or may not have a table and power outlet. If individual team outlets are not provided, the venue must provide access to team-useable outlets in the pit area for charging batteries.

Teams, volunteers, *FIRST* staff, and guests spend a lot of time in the pits. Get to know other teams and help each other when you can. Time is short and help is very often right "next door" in the adjacent team pits.

Small, bench-top machinery, with appropriate guards, is permitted in team pits. 'Small' machinery is machinery that can be easily lifted by one person and examples include, but are not limited to, 3D printers, small band saws, small drill presses, desktop CNC mills, and sanders.

E501 *Pits are unavailable if closed. Teams may not be in their team pit outside the designated pit hours.

E502 *Stay in your pit. Teams may neither allow their materials to expand beyond their team pit (including running power or internet lines from their team pit to any other area), swap team pits with other teams, nor move themselves to empty team pits.

E503 *Keep aisles clear. Aisles must be kept clear.

E504 *No sparks. Tools that throw sparks or produce open flames are prohibited.

Examples of tools that violate this rule include, but are not limited to, welders, bench and angle grinders, gas torches, etc.

E505 *Nothing too big. Floor standing power tools are prohibited.

Examples include but are not limited to full-size drill presses, band saws, and table saws.

Violation: Teams will be asked to remove or not bring in floor standing power tools. Any items that are deemed unsafe or outside specifications by FIRST personnel and/or event director must be removed.

E506 *No brazing or welding. Brazing/welding is prohibited.

Violation: Teams will be asked to remove or not bring in brazing/welding tools. Any items that are deemed unsafe or outside specifications by FIRST personnel, and/or event director must be removed.

E507 *Solder with specific tools only. Soldering may be done using an electric iron/gun only.

Violation: Any items that are deemed unsafe or outside specifications by FIRST personnel and/or the event director must be removed.

E508 *Structures must be safe. Teams may not build any structure that supports the weight of people or stores items overhead. Structures may not block or inhibit fire sprinkler systems or otherwise be unsafe.

Violation: Any pit structures that are deemed unsafe or outside specifications by FIRST personnel and/or the event director must be removed.

E509 *Secure team identification assets. Team signs, flags, and displays must be securely mounted to the pit structure.

Violation: Any pit structures that are deemed unsafe or outside specifications by FIRST personnel and/or the event director must be removed.

E510 *Only use aerosol or other chemicals with noxious fumes in approved areas. Any aerosol or chemical that produces noxious fumes or spray particulates should only be used in approved areas. Not all venues will allow the use of these products anywhere on site.

Violation: Any items that are deemed unsafe or outside specifications by FIRST personnel and/or the event director must be removed.

5.6 ROBOT Carts

Most teams use carts to transport their ROBOT throughout an event. Carts are not required but are strongly recommended (to minimize risk of muscle strains, dropped ROBOTS, and other hazards). In addition to the rules listed below, teams are strongly encouraged to put the team's number on the cart, refer to the [FIRST Safety Manual](#) for ROBOT lifting techniques, and practice putting the ROBOT on and off the cart to develop a safe, quick, fluid routine.

E601 *Carts must be safe and easy to use. Carts must be easy to control, maneuver, and pose no risk to bystanders.

E602 *Carts shouldn't be too big. Carts must fit through a standard 30-inch door.

E603 *Carts can't park anywhere. Carts must remain in the team pit (or cart staging area during a MATCH) when not in use.

E604 *No noisy carts. Carts may not be equipped with music or other sound-generating devices.

E605 *No motor driven carts. ROBOT carts may not use powered propulsion.

5.7 Ceremonies

At every event, there are opening and closing ceremonies to show honor and respect for represented countries, sponsors, teams, mentors, volunteers, and award winners. Ceremonies provide everyone with the opportunity to collectively applaud the successes of all participants. They also give teams a chance to "meet" the volunteers and other people and sponsors involved with the event. Closing ceremony elements at the end of the event are integrated into and presented between playoff MATCHES.

At the awards ceremony, *FIRST* presents trophies and medallions to outstanding teams. All team members are encouraged to attend the ceremonies, be punctual, and show appreciation to volunteers that staffed the event.

- E701** ***Quiet in the pits during ceremonies.** During ceremonies outside of playoff MATCHES, team members may not:
- A. use power tools
 - B. use loud hand tools (hammers, saws, etc.)
 - C. shout, yell, or use loud voices, unless as a demonstration of approval during a ceremonial activity.

- E702** ***Pit person limit during Ceremonies is 5.** No more than 5 team members may be in the pits during Ceremonies outside of Playoff MATCHES.

All teams are encouraged to have as many people in the stands for ceremonies as possible. This is important both to celebrate all who are recognized during ceremonies, but also to listen for important day-of information from event organizers which might be critical for your team.

- E703** ***Be respectful during anthems.** Team members, including any remaining in the pits, should exhibit peaceful behavior during the presentation of all national anthems. Traditionally, team members stand to face the flag, remove hats, and either sing along or maintain a respectful silence during the anthems of all nations present at the event. If team members wish to abstain, they have a right to do so, as long as they remain silent and non-disruptive.

5.8 In the Stands

- E801** ***No saving seats.** Teams are not permitted to save or designate seats for team members that are not present.

Teams may not hang banners or ribbons or otherwise designate seating. (Event staff will remove and discard any banners, roping, etc., used to designate seating.) Please take turns sitting in the bleachers/stands if seating is limited. If there is a crowding problem, we ask that you kindly leave after your team's MATCH and return later, if possible.

The event director may reserve seats for attendees who require accessible seating or to ensure teams in the playoffs have seats to watch their teams play.

- E802** ***Don't throw items from the stands.** Items may not be thrown from audience seating.



6 Judged Awards

This section will be updated with the Kickoff Competition Manual release on September 7th, 2024



7 Game Sponsor Recognition



**FIRST
TECH
CHALLENGE**



8 Game Overview

This section will be updated with the Kickoff Competition Manual release on September 7th, 2024



9 ARENA

This section will be updated with the Kickoff Competition Manual release on September 7th, 2024



10 Game Details

This section will be updated with the Kickoff Competition Manual release on September 7th, 2024



11 Game Rules (G)

This section will be updated with the Kickoff Competition Manual release on September 7th, 2024



12 ROBOT Construction Rules (R)

The rules listed below explicitly address legal parts and materials and how those parts and materials may be used on a ROBOT. A ROBOT is an electromechanical assembly built by the FIRST Tech Challenge 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, and movement about the FIELD.

There are many reasons for the structure of the rules, including safety, reliability, parity, creation of a reasonable design challenge, adherence to professional standards, and impact on the competition.

Another intent of these rules is to have all energy sources and active actuation systems on the ROBOT (e.g. batteries, motors, servos, and their controllers) drawn from a well-defined set of options. This is to ensure that all teams have access to the same actuation resources and that the INSPECTORS can accurately and efficiently assess the legality of a given part.

ROBOT construction rules in this section only apply to the construction of your ROBOT as it might be inspected. MATCH play rules and consequences for violating rules during MATCH play are outlined in section [11 Game Rules \(G\)](#).

ROBOTS are made up of COMPONENTS and MECHANISMS. A COMPONENT is any part in its most basic configuration, which cannot be disassembled without damaging or destroying the part or altering its fundamental function. A MECHANISM is an assembly of COMPONENTS that provide specific functionality on the ROBOT. A MECHANISM can be disassembled (and then reassembled) into individual COMPONENTS without damage to the parts.

Many rules in this section reference Commercial-Off-The-Shelf (COTS) items. A COTS item must be a standard (i.e. not custom order) part commonly available from a VENDOR for all teams for purchase. To be a COTS item, the COMPONENT or MECHANISM must be in an unaltered, unmodified state (with the exception of installation or modification of any software). Items that are no longer commercially available but are functionally equivalent to the original condition as delivered from the VENDOR are considered COTS and may be used.

Example 1: A team orders 2 ROBOT panels from RoboPanels Corp. and receives both items. They put 1 in their storeroom and plan to use it later. Into the other, they drill "lightening holes" to reduce weight. The first panel is still classified as a COTS item, but the second panel is now a FABRICATED ITEM, as it has been modified.

Example 2: A team obtains openly available blueprints of a drive module commonly available from Wheels-R-Us Inc. and has local machine shop "We-Make-It, Inc." manufacture a copy of the part for them. The produced part is not a COTS item, because it is not commonly carried as part of the standard stock of We-Make-It, Inc.

Example 3: A team obtains openly available design drawings from a professional publication and uses them to fabricate a gearbox for their ROBOT. The design drawings are considered a COTS item and may be

used as “raw material” to fabricate the gearbox. The finished gearbox itself would be a FABRICATED ITEM, and not a COTS item.

Example 4: A COTS part that has non-functional label markings added would still be considered a COTS part, but a COTS part that has device-specific mounting holes added is a FABRICATED ITEM.

Example 5: A team has a COTS gearbox which has been discontinued. If the COTS gearbox is functionally equivalent to its original condition, it may be used.

A **VENDOR** is a legitimate business source for COTS items that satisfies all the following criteria:

- A. has a Federal Tax Identification number. In cases where the **VENDOR** is outside of the United States, they must possess an equivalent form of registration or license with the government of their home nation that establishes and validates their status as a legitimate business licensed to operate within that country.
- B. is not a “wholly owned subsidiary” of a *FIRST* team or collection of teams. While there may be some individuals affiliated with both a team and the **VENDOR**, the business and activities of the team and **VENDOR** must be completely separable.
- C. should maintain sufficient stock or production capability so they are able to ship any general (i.e., non-*FIRST* unique) product within a timely manner. It is recognized that certain unusual circumstances (such as a global supply chain disruption and/or 1,000 *FIRST* teams all ordering the same part at once from the same **VENDOR**) may cause atypical delays in shipping due to backorders for even the largest **VENDORS**. Such delays due to higher-than-normal order rates are excused. This criterion may not apply to custom-built items from a source that is both a **VENDOR** and a fabricator.

For example, a **VENDOR** may sell flexible belting that the team wishes to procure to use as treads on their drive system. The **VENDOR** cuts the belting to a custom length from standard shelf stock that is typically available, welds it into a loop to make a tread, and ships it to a team. The fabrication of the tread takes the **VENDOR** 2 weeks. This would be considered a FABRICATED ITEM, and the 2-week ship time is acceptable. Alternately, the team may decide to fabricate the treads themselves. To satisfy this criterion, the **VENDOR** would just have to ship a length of belting from shelf stock (i.e. a COTS item) to the team within 5 business days and leave the welding of the cuts to the team.

- D. makes their products available to all *FIRST* Tech Challenge teams. A **VENDOR** must not limit supply or make a product available to just a limited number of *FIRST* Tech Challenge teams.

The intent of this definition is to be as inclusive as possible to permit access to all legitimate sources, while preventing ad hoc organizations from providing special-purpose products to a limited subset of teams in an attempt to circumvent any applicable cost accounting rules.

FIRST desires to permit teams to have the broadest choice of legitimate sources possible, and to obtain COTS items from the sources that provide them with the best prices and level of service available. Teams also need to protect against long delays in availability of parts that will impact their ability to complete their ROBOT. The build season is brief, so the VENDOR must be able to get their product, particularly *FIRST* unique items, to a team in a timely manner.

Ideally, chosen VENDORS should have effective distribution channels. Remember, *FIRST* Tech Challenge events are not always near home – when parts fail, local access to replacement materials is often critical.

A FABRICATED ITEM is any COMPONENT or MECHANISM that has been altered, built, cast, constructed, concocted, created, cut, heat treated, machined, manufactured, modified, painted, produced, surface coated, or conjured partially or completely into the final form in which it will be used on the ROBOT.

Note that it is possible for an item (typically raw materials) to be neither COTS nor a FABRICATED ITEM. For example, a 20 ft. (~610 cm) length of aluminum which has been cut into 5 ft. (~152 cm) pieces by the team for storage or transport is neither COTS (it's not in the state received from the VENDOR), nor a FABRICATED ITEM (the cuts were not made to advance the part towards its final form on the ROBOT).

Teams may be asked to provide documentation (i.e. reference the relevant rule in this manual) proving the legality of items during inspection where a rule specifies limits for a legal part (e.g. motors, servos, current limits, COTS electronics, etc.).

Some of these rules make use of English unit requirements for parts. If your team has a question about a metric-equivalent part's legality, please e-mail your question to the *FIRST* Tech Challenge at firsttechchallenge@firstinspires.org for an official ruling. To seek approval for alternate parts/devices for inclusion in future *FIRST* Tech Challenge seasons, please use the [Part Suggestion Form](#).

FIRST Tech Challenge can be a high-contact competition and may include rigorous game play. While the rules aim to limit severe damage to ROBOTS, teams should design their ROBOTS to be robust.

12.1 General ROBOT Design

R101 ***STARTING CONFIGURATION is limited to an 18-inch Cube.** In the STARTING CONFIGURATION (the physical configuration in which a ROBOT starts a MATCH), the ROBOT must be fully self-contained within an 18-inch wide, by 18 inch long, by 18-inch-high volume. The only exceptions are:

- A. preloaded game elements may extend outside the starting size constraint.
- B. minor protrusions (0.25 inches) by flexible materials (i.e., zip tie, surgical tube, string, etc.) may extend beyond the 18-inch (45.72 cm) size constraint

If a ROBOT uses interchangeable MECHANISMS per [I###], teams should be prepared to show compliance with this rule and [R104](#) in all configurations.

- R102** ***ROBOTS may assist in holding the STARTING CONFIGURATION.** In the STARTING CONFIGURATION, ROBOTS must be fully self-supported (i.e., does not exert force on the sides or top of a sizing tool). ROBOTS may accomplish this using any combination of:
- mechanical means while powered-off, and/or
 - initializing an OpMode that pre-positions servos and motors to a desired stationary position. The OpMode may control motors and servos to hold their position to maintain the STARTING CONFIGURATION.

ROBOTS holding STARTING CONFIGURATION during inspection or waiting for a MATCH to start may have to do so for several minutes and should limit the possibility of thermal failure (e.g. not having motors stalled against a hard stop). Teams must also be especially cautious when operating a running ROBOT during inspection, notifying the INSPECTOR that the ROBOT is live and taking every precaution to ensure the process is carried out safely.

- R103** ***There is no ROBOT weight limit.** There is no explicit weight limit for *FIRST* Tech Challenge ROBOTS

While there is no official weight limit, teams should still consider the impact of a ROBOT's weight on various factors, including but not limited to:

- FIELD TILE damage
- battery consumption
- ROBOT transportation
- total ROBOT performance

- R104** **There is a horizontal expansion limit.** After the MATCH has started, ROBOTS may expand beyond the STARTING CONFIGURATION but must stay within an overall working ARENA TILE footprint. The overall working footprint has the following constraints:

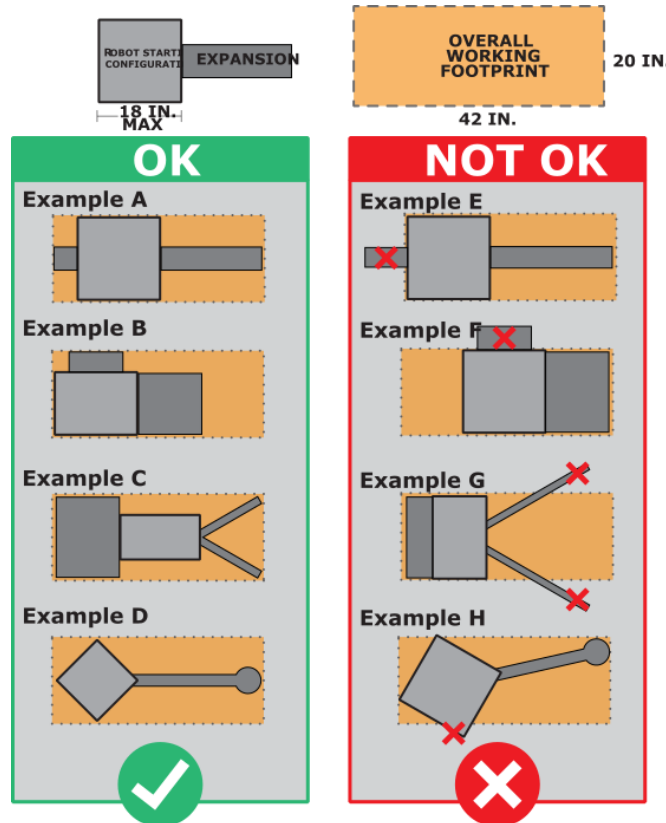
- has no vertical height limit
- is a 20" x 42" (50.8cm x 116.8cm) rectangle measured parallel (coplanar) to the TILE floor
- is always a vertical projection relative to the TILES, so robots which change orientation (drive, tip, spin, etc.) during the match are still subject to the horizontal expansion limit measured parallel (coplanar) to the TILES.
- [game specific exception may be added at kickoff on 9/7/2024]

This rule is intended to limit the amount of floor area each robot can cover with the maximum mechanical range of motion of all extensions.

Teams should be prepared to show compliance with this rule and demonstrate their robot expansions during the inspection process. During inspection each ROBOT will need to demonstrate that the full mechanical range of motion of all extensions outside of STARTING CONFIGURATION will be contained within a fixed 20 in by 42 in working area.

Teams are subject to penalties listed in [\[G###\]](#) for any violations during the MATCH.

Figure 12-1: Expansion Limits



12.2 ROBOT Safety & Damage Prevention

- R201** ***Don't damage the TILE floor.** Traction devices must not have surface features which could damage the TILE floor. Traction devices are all parts of the ROBOT that are designed to transmit any propulsive and/or braking forces between the ROBOT and the FIELD.

Examples of traction devices known to cause damage when used directly on TILE floors are high traction wheels (for example, AndyMark am-2256) and high grip tread (for example, Roughtop, AndyMark am-3309). While these (and other) COMPONENTS are not outright prohibited, e.g. used as part of an intake, MECHANISMS that involve these COMPONENTS contacting the TILE floor are not allowed.

- R202** ***No exposed sharp edges.** Protrusions from the ROBOT and exposed surfaces on the ROBOT shall not pose hazards to the ARENA elements (including SCORING ELEMENTS) or people.

R203 *Design ROBOTS for safety. ROBOT parts shall not be made from hazardous materials, be unsafe, cause an unsafe condition, or interfere with the operations of other ROBOTS. Examples of items that will violate this rule include (but are not limited to):

- A. shields, curtains, or any other devices or materials designed or used to obstruct or limit the vision of any DRIVE TEAM members and/or interfere with their ability to safely control their ROBOT,
- B. speakers, sirens, air horns, or other audio devices that generate sound at a level sufficient to be a distraction,
- C. any devices or decorations specifically intended to jam or interfere with the remote sensing capabilities of another ROBOT, including vision systems, acoustic range finders, sonars, infrared proximity detectors, etc. (e.g. including imagery on your ROBOT that utilizes or closely mimics 36h11 AprilTags),
- D. flammable gasses,
- E. any device intended to produce flames or pyrotechnics,
- F. hydraulic fluids or hydraulic items,
- G. switches or contacts containing liquid mercury,
- H. exposed, untreated hazardous materials (e.g. lead weights) used on the ROBOT. These materials may be permitted if painted, encapsulated, or otherwise sealed to prevent contact. These materials may not be machined in any way at an event.
- I. high intensity light sources used on the ROBOT may only be illuminated for a brief time while targeting and may need to be shrouded to prevent any exposure to participants. Complaints about the use of such light sources will be followed by re-inspection and possible disablement of the device,
- J. animal based materials,
- K. any device designed to damage or flip competing ROBOTS,
- L. devices or conditions that pose an unnecessary risk of entanglement

Flashing lights can be particularly distracting and can cause harm to some individuals. Decorative or functional lighting which flashes at greater than 2Hz will invite additional scrutiny and teams may be asked to disable or modify their lighting at the discretion of the Head REFEREE and/or LRI.

R204 *SCORING ELEMENTS stay with the FIELD. ROBOTS must allow removal of SCORING ELEMENTS from the ROBOT and the ROBOT from FIELD elements while powered off.

Teams must make sure that SCORING ELEMENTS and ROBOTS can be quickly, simply, and safely removed per [G###] and [G###].

Teams are encouraged to consider [G###] when developing their ROBOTS.

- R205** ***Don't Contaminate the FIELD.** ROBOTS may not contain any materials which if unintentionally released would damage the FIELD, other ROBOTS or delay the start of a MATCH due to required decontamination. Lubricants may be used only to reduce friction within the ROBOT. Lubricants must not contaminate the FIELD or other ROBOTS.

Lubricants used on the ROBOT must not be excessively applied such that they spin off or drip off during normal ROBOT operations on the FIELD.

Additional examples of items that will violate this rule include (but are not limited to):

- any ballast not secured sufficiently, including loose ballast e.g. sand, ball bearings etc., such that it may be released on the FIELD during a MATCH
- liquid or gel materials
- tire sealant, and
- Other lubricants

- R206** ***Don't damage SCORING ELEMENTS.** ROBOT elements likely to contact SCORING ELEMENTS shall not pose a significant hazard to the SCORING ELEMENT.

SCORING ELEMENTS are expected to undergo a reasonable amount of wear and tear as they are handled by ROBOTS, such as scratching or marking. Gouging, tearing off pieces, or routinely marking SCORING ELEMENTS are violations of this rule.

- R207** ***No Air Power on the ROBOT.** ROBOTS may not use any closed air devices such as but not limited to: pneumatic solenoids or cylinders, gas storage vessels, gas springs, compressors, or vacuum generating devices. Air-filled (pneumatic) wheels are exempt from this rule.

12.3 Fabrication

- R301** ***Legal COTS Parts and Raw materials can be modified.** Allowed raw materials and Legal COTS parts can be modified (drilled, cut, painted, etc.) as long as no other rules are violated.

Raw materials refers to unfinished building stock such as but not limited to:

- sheet stock
- extruded shapes
- metals, plastic, rubber, and wood
- magnets

- R302** ***Custom parts can be reused year to year.** FABRICATED ITEMS created before Kickoff are permitted.

- R303** ***Custom designs and software can be reused year to year.** ROBOT software and designs created before Kickoff are permitted.

R304 *SCORING ELEMENTS are not allowed for ROBOT Construction. Current season SCORING ELEMENTS or replicas of SCORING ELEMENTS are not allowed to be used as part of ROBOT construction or for any other team supplied SCORING ELEMENTS.

R305 *During an event, work can occur outside of pit hours. During an event a team is attending (regardless of whether the team is physically at the event location), the team may work on or practice with their ROBOT or ROBOT elements outside of the hours that pits are open.

For teams who chose to work offsite during an event please work smart and safely. Ensure team members get adequate rest and have sufficient adult supervision during afterhours and off-site work.

Note that [E107](#) and [E108](#) impose additional restrictions on work done on the ROBOT or ROBOT materials while attending an event.

R306 *COTS MECHANISMS have limits. COTS MAJOR MECHANISMS (as defined in [I###](#)) purposefully designed to complete a game task are prohibited.

Allowed exceptions to this rule are:

- A. COTS drive chassis, provided none of the individual parts violate any other rules

COTS parts are intended to help teams design and build ROBOT MECHANISMS to complete game tasks and solve challenges but are not intended to be purpose-built complete bolt-on out-of-the-box solution to complete game objectives.

R307 *COTS should be single DoF. COTS COMPONENTS and MECHANISMS must not exceed a single degree of mechanical freedom (DoF). Examples of allowed COTS single degree of freedom MECHANISMS and COMPONENTS are as follows:

- A. linear slide kit,
- B. linear actuator kit,
- C. single speed (non-shifting) gearboxes,
- D. pulley,
- E. turntable, and
- F. lead screw
- G. single DoF grippers

Allowed exceptions to this rule are:

- H. ratcheting devices (wrenches, bearings, etc.),
- I. Holonomic wheels (omni or mecanum), and
- J. dead-wheel odometry kits

The general test for a single degree of freedom MECHANISM is whether the orientation and position of each COMPONENT in the MECHANISM can be generally predicted based on the orientation and position of a single COMPONENT (such as the input) of the system.

12.4 ROBOT SIGN Rules

A ROBOT SIGN is a required assembly which attaches to the ROBOT. A ROBOT SIGN simultaneously identifies a ROBOT's team number as well as its ALLIANCE affiliation for FIELD STAFF. Criteria used in writing these rules include the following:

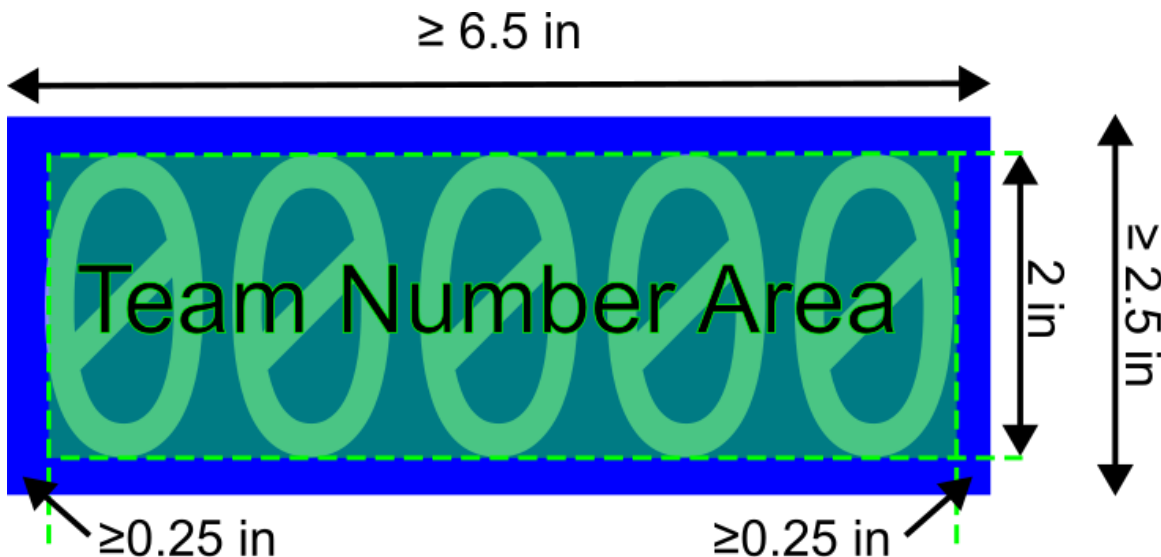
- Maximize FIELD STAFF's ability to determine team number and ALLIANCE of a ROBOT,
- Minimize the amount of design challenge in creating ROBOT SIGNS, and
- Increase consistency in displaying ROBOT identification.

R401 *Two ROBOT SIGNS per ROBOT. ROBOT SIGNS must be placed in at least two separate locations on the ROBOT. These locations must be on opposite or adjacent surfaces of the ROBOT, ≥ 90 degrees apart. All ROBOT surfaces visible to FIELD STAFF can be used for placing ROBOT SIGNS including the top of the ROBOT. The intent of this rule is for FIELD STAFF to easily view ROBOT SIGNS from at least 12 feet (3.66 meters) away before, during, and after the MATCH. ROBOT SIGNS must meet the following criteria:

- A. be made of a robust material,
- B. minimally be 6.5 inches (16.51 cm) wide (Figure 12-2),
- C. minimally be 2.5 inches (6.35 cm) tall (Figure 12-2), and
- D. be supported by the structure/frame of the ROBOT

Examples of robust materials that satisfy this rule include, but are not limited to, acrylic, plastic laminated paper, wood, and metal. ROBOT SIGNS must be designed to withstand vigorous game play.

Figure 12-2: Team Number ROBOT SIGN Sizing



R402 *ROBOT SIGNS indicate your ALLIANCE. Each ROBOT SIGN must contain a red or blue opaque background to indicate their ALLIANCE color, as assigned in the MATCH schedule at the event. Visible markings on ROBOT SIGNS when installed on the ROBOT, other than the following, are prohibited:

- A. those required per [R403](#),
- B. solid white *FIRST* logos no larger than 1.5 in. (3.81 cm) in height (Figure 12-3),
- C. small amounts of hook-and-loop tape, hard fasteners, or functional equivalents, and
- D. narrow areas of differing colors exposed at corners, folds, or cutouts.

ROBOT SIGNS that are reversible or configurable must not allow the opposite ALLIANCE color to be visible to FIELD STAFF, except where permitted by this rule.

Figure 12-3: Legal team number display for team 117 playing on the red ALLIANCE



R403 *Team number on ROBOT SIGNS. Team numbers must be displayed and positioned on the ROBOT SIGN as shown in Figure 12-2, Figure 12-3 and Figure 12-4, and meet the following additional criteria:

- A. consist of solid opaque white Arabic numbers (e.g. 1,2,3,4) 2 inches (5.08 cm) tall,
- B. there must be a minimum of 1/4" inches (6.35 mm) of background surrounding the numbers,
- C. numbers may not be vertically stacked (Figure 12-5)
- D. be made of robust materials
- E. cannot be powered or rely on power from any sources to illuminate/reveal numbers

Figure 12-4: Legal number for team 21001 playing on the blue ALLIANCE



Figure 12-5: Team number orientation examples for team 1355 playing on the blue ALLIANCE



If a team at an event does not have completely legal ROBOT SIGNS, and there is no color printer or other means available at the event to create a legal ROBOT SIGN, the head REFEREE may approve an alternate substitute for use at the event.

Team numbers must be robust enough to withstand the rigors of MATCH play. Example robust materials include:

- self-adhesive numbers (mailbox or vinyl numbers)
- ink jet or laser printed numbers on paper and laminated or protected from ROBOT-to-ROBOT interaction.

Examples of prohibited team numbers on ROBOT SIGNS include but are not limited to:

- Edge lit engraved plastic
- LED Display numbers

12.5 Motors & Actuators

R501 *Allowable motors. The only allowed motor actuators are:

Table 12-1 Motor allowances

Motor Name	Part Numbers Available	Notes
AndyMark NeveRest 12V DC	am-3104	
AndyMark NeveRest Hex 12V DC	am-3104c	
goBILDA Yellow Jacket 520x Series 12V DC	5201-0002-0026, etc	5201, 5202, 5203, and 5204 series
Modern Robotics / MATRIX 12V DC	5000-0002-0001	
REV Robotics HD Hex 12V DC	REV-41-1291	
REV Robotics Core Hex 12V DC	REV-41-1300	
Studica Robotics Maverick 12V DC	75001	
TETRIX MAX 12V DC	739530	Discontinued
TETRIX MAX TorqueNADO 12V DC	W44260	
VEX EDR 393	276-2177	Counts as a servo for R503
Factory installed vibration and autofocus motors resident in COTS computing devices (e.g. rumble motor in a smartphone). Can only be used as part of the device, cannot be removed and/or repurposed. These motors do not count toward the limit in R503 .		
Motors integral to a COTS sensor (e.g. LIDAR, scanning sonar, etc.), provided the device is not modified except to facilitate mounting. These motors do not count toward the limit in R503 .		

Many legal gearmotors are sold with labeling based on the entire assembly. These motors may be used with or without the provided gearbox.

R502 *Allowable servos. Servo actuators must meet the requirements below. Servos must be compatible with the power regulation devices they are ultimately used with (per [R505](#)) and may include additional servo position output interfaces (e.g. 4th Wire Position Feedback).

Table 12-2 Servo Requirements at 6V

Actuator Class	Mechanical Output Power	Stall Current	Example Servos (including, but not limited to) NOT COMPLETE LIST
Servo	≤ 8 watts @6V	≤ 4 amps @6V	AndyMark High-Torque Servos (am-4954)
			Axon MAX+ Servo (Axon MAX+)
			DSSERVO 35KG Coreless (DS3235MG)
			FEETECH Digital Servo (FT5335M-FB)
			goBILDA Dual Mode Servo (2000-0025-0003)
			REV Robotics Smart Servo (REV-41-1097)
			Studica Multi-Mode Smart Servo (75002)
Linear Servo	N/A	≤ 1 amps @6V	Actuonix Micro Linear Servo (P8-100-252-12-R)
			Hitec Linear Servo (HLS12-3050-6V)
			Studica Linear Servo RC Actuator (75014)

[Servo mechanical output power](#) is approximated by the following formula (using 6V data reported by manufacturer):

- Mechanical Output Power = 0.25 x (Stall Torque in N-m) x (No Load Speed in rad/s)**

Servos must meet both requirements to be legal for use. Refer to the Legal and Illegal Parts List for a list of servos that are pre-approved, otherwise teams must be able to provide documentation verifying servo specifications. Use the [online calculator](#) to verify output power compliance.

If a manufacturer does not provide 6V specs, any specs for voltages that exceed 6V are allowed to be used.

Stall current is the maximum stall current possible for the device at the specified voltage, regardless of any programmable software limits that may be available within the servo.

It is important to ensure the voltage provided by the intended power regulation device is within the operating voltage range of the desired servo. The REV Control Hub and REV Expansion Hub provide 5V to servos, and the REV Servo Power Module and Studica Servo Power Block provide 6V to servos. While virtually all servos are compatible with 6V, servos with an operating voltage range of 6-8.4 DCV, for example, may not work properly when only provided 5V.

R503 ***ROBOTS are limited to a total of 8 motors and 12 servos.** A ROBOT may not have more than 8 motors and 12 servos from the allowable actuator lists per [R501](#) and [R502](#) for all MECHANISMS used in all configurations, with the following exceptions:

- A. The VEX EDR 393 (276-2177) motor is counted as a servo instead of a motor.

If a ROBOT has multiple configurations used at a single event which use different MECHANISMS the sum total of all motors and servos must be less than or equal to the limit set in this rule.

For servos, note that each REV Expansion Hub and REV Control Hub provide 5V and are limited to a max current output of 5A total shared across all servo ports and the +5V auxiliary power port, with a 2A maximum limit across paired servo ports (10W of maximum electrical output power per port pair, 25W total). Teams should make sure that their total servo power usage always remains below this limit.

Given the extensive number of motors and servos allowed on the ROBOT, teams are encouraged to consider the total power available from the ROBOT battery during the design and build of the ROBOT. Drawing large amounts of current from many motors and/or servos at the same time could lead to drops in ROBOT battery voltage that may result in exceeding the battery fuse limits or browning out the control system leading to power loss or communications loss.

R504 ***Don't modify actuators unless explicitly allowed.** The integral mechanical and electrical system of any motor or servo must not be modified. Motors and servos used on the ROBOT shall not be modified in any way, except as follows:

- A. the mounting brackets and/or output shaft/interface may be modified to facilitate the physical connection of the motor to the ROBOT and actuated part,
- B. the electrical leads may be trimmed to length as necessary and connectors or splices to additional wiring may be added,
- C. servos may be modified as specified by the manufacturer (e.g. re-programming or modification for continuous rotation),
- D. minimal labeling may be applied to indicate device purpose, connectivity, functional performance, etc. as long as the team applied label doesn't obstruct the markings used to identify the device,
- E. insulation may be applied to electrical terminals,
- F. repairs, provided the original performance and specifications are unchanged, and
- G. maintenance recommended by the manufacturer.

R505 *All actuators must be powered from approved devices. With the exception of servos, fans, or motors integral to sensors of COTS computing devices permitted in [R501](#), each actuator must be controlled by a power regulating device. The only power regulating devices for actuators permitted on the ROBOT are:

Table 12-3 Power Regulators and Limits

Power Regulating Device	Part Number	Load Limit per Device
REV Control Hub or Expansion Hub Motor Ports	REV-31-1153 / REV-31-1595	2 Motors per Port
REV Control Hub or Expansion Hub Servo Ports	REV-31-1153 / REV-31-1595	2 Servos per Port
REV Servo Power Module	REV-11-1144	2 Servos per Port OR 2 VEX Motor Controller 29 (one per port)
REV SPARKmini	REV-31-1230	2 Motors per Device
Studica Servo Power Block	75005	2 Servos per Port
VEX Motor Controller 29	276-2193	1 VEX EDR 323 Motor (Counts as a Servo per R503)

R506 *No relays or alternative electrical actuation. The application of electromechanical actuation through the use of additional relays, electromagnets, electrical solenoid actuators, or related systems is prohibited. In addition, the use of relays and electromagnets is also prohibited.

12.6 Power Distribution

In order to maintain safety, the rules in this section apply at all times while at the event, not just while the ROBOT is on the FIELD for MATCHES.

R601 *Battery limit – everyone has the same main ROBOT power. The only legal source of electrical energy for the ROBOT control system and actuation during the competition, the ROBOT battery, must be 1 and only 1 approved 12V NiMH main battery. The ROBOT main battery must have a COTS equivalent in-line 20A ATM mini blade fuse installed. Installed connectors may be replaced with other popular connectors such as Anderson Powerpole, XT30, or any connector with a comparable power rating. The only allowed ROBOT main power battery packs are:

Table 12-4 Legal ROBOT Main Power Battery Packs

Battery Pack	Part Number	Notes
AndyMark Flat Pack Battery DC 12V	am-5290	
goBILDA 12V NiMH Nested Battery	3100-0012-0020	
Matrix 12V 3000mAh NiMH	14-0014	
REV 12V Slim Battery	REV-31-1302	

Battery Pack	Part Number	Notes
Studica 12V 3000mAh NiMH	70025	
TETRIX MAX 12V 3000mAh NiMH	W39057	Formerly 739023

There are many other similar style batteries available from multiple VENDORS but only the listed manufactures and part numbers are legal for use at FIRST Tech Challenge Events.

Batteries should be charged in accordance with manufacturer's specification. (Please see the [FIRST Safety Manual](#) for additional information.)

R602 *Other batteries are only allowed for peripheral devices and LEDs only. COTS USB battery packs with a capacity of 100Wh or less (27000mAh at 3.7V), with 5V/5A max output or 12V/5A max output using USB-PD per port, and batteries integral to a self-contained camera (e.g. GoPro style camera) may be used provided they are:

- A. connected only using unmodified COTS cables,
- B. charged according to manufacturer recommendations,
- C. securely fastened to the ROBOT,
- D. not supplement power to any of the ROBOT actuators, and
- E. not used by any devices receiving control signals from the ROBOT control system (i.e. COTS USB battery packs must remain electrically isolated from the ROBOT power systems.)

Exceptions to part E of this rule are:

1. powered USB Hubs, and
2. ROBOT CONTROLLER smartphones

For example, a REV Blinkin powered by a COTS USB battery pack cannot be controlled by signals from a REV Control or Expansion Hub. Any device receiving signals from a REV Control or Expansion Hub must be powered by the main ROBOT battery.

R603 *Charge batteries with safe connectors. Any battery charger used to charge a ROBOT battery must have a corresponding polarized connector installed.

Batteries must never be charged using alligator clips or similar.

R604 *Charge batteries at a safe rate. Any battery charger used to charge a ROBOT battery may not be used such that it exceeds a 3-amp average charge current. Follow all manufacturer recommendations when charging batteries.

R605 *Batteries are not ballast. No batteries other than those allowed per [R601](#) and [R602](#) are allowed on the ROBOT, whether or not they are being used to supply power.

For example, teams may not use additional batteries as extra weight on their ROBOTS.

R606 *Batteries should be securely mounted. The ROBOT battery must be secured such that it will not dislodge during vigorous ROBOT interaction including if the ROBOT is turned over or placed in any arbitrary orientation. Batteries must be mounted such that they are protected from direct contact with other ROBOTS or any sharp edges.

R607 *Electrical connections should be robust and must be insulated. All electrical paths may include intermediate elements such as COTS connectors (Anderson Powerpole, XT30, and similar crimp or quick-connect style connectors), splices, COTS flexible/rolling/sliding contacts, and COTS slip rings, as long as the entire electrical pathway is via appropriately gauged/rated elements and all connections are protected from accidental electrical shorts

Teams are strongly encouraged to insulate all exposed electrical terminations or provide physical barricades to protect from accidental electrical shorts.

R608 *Limit non-battery energy. Non-electrical sources of energy used by the ROBOT (i.e., stored at the start of a MATCH) shall come only from the following sources:

- A. a change in the altitude of the ROBOT center of gravity, or
- B. storage achieved by deformation of ROBOT parts including, but not limited to, springs, rubber bands, surgical tubing, etc.

R609 *Connect the ROBOT battery safely though the Main Power Switch. Exactly one main power switch must control all power provided by the ROBOT battery pack to all power regulating devices on the ROBOT such that all the following conditions are met:

- A. must be one of the following approved power switches:

Table 12-5 Legal Power Switches

Power Switch	Part Number
AndyMark FTC Power Switch w/ Bracket	am-4969
REV Switch Cable and Bracket	REV-31-1387
TETRIX R/C Switch Kit	W39129

- B. must be mounted or located where it's accessible to the team and FIELD STAFF
- C. a "Main Power Switch" label no smaller than 1" x 2.5" must be placed near the switch on a flat surface.
- D. secondary power switches can be used on the 12V line downstream of the main power switch provided they are clearly labeled as "secondary switch" and must still be one of the approved switches.

There are no specific location requirements for the main power switch, but it should be located clear of any moving parts and other obstructions that would block its access during normal ROBOT operations.

Examples considered not "quickly and safely accessible" include main power switches covered by an access panel or door, or mounted on, underneath or immediately adjacent to moving COMPONENTS.

The main power switch should be mounted on the ROBOT so it is protected from ROBOT-to-ROBOT contact to avoid inadvertent actuation or damage.

- R610** *Fuse ratings should not be altered. Fuses must not be replaced with fuses of higher rating than originally installed or according to manufacturer's specifications; fuses may not be shorted out. Fuses must not exceed the rating of those closer to the battery. If necessary, a fuse may be replaced with a smaller rating. Replaceable fuses must be single use only; self-resetting fuses (breakers) are not allowed.
- R611** *The ROBOT frame is not a wire. All wiring and electrical devices shall be electrically isolated from the ROBOT frame. The ROBOT frame must not be used to carry electrical current. Electrically grounding the control system electronics to the frame of the ROBOT is only permitted such that all of the following conditions are met

- A. must use one of the following approved parts:

Table 12-6: Legal ROBOT Grounding Straps

Grounding Strap	Part Number
AndyMark Resistive Grounding Strap	am-4648
REV Resistive Grounding Strap	REV-31-1269

- B. the strap must directly connect to a fully COTS COMPONENT with an XT30 connector, and also must connect directly to the frame of the ROBOT.
- C. no ROBOT COMPONENTS or MECHANISMS are designed to electrically ground the ROBOT frame to the FIELD

Compliance with this rule can be checked by observing a $>120\Omega$ resistance between both the (+) or (-) terminal of the ROBOT main power switch in the "ON" position and any point on the ROBOT. Most aluminum has a clear anodizing layer or oxidation layer on it that acts as an insulator. In order to make a good electrical connection with the grounding strap to the frame, it may be necessary to scratch/file/remove the anodize/oxidation layer from the area of contact with the metal first.

Note that some cameras, decorative lights, and sensors (e.g. some encoders, some IR sensors, etc.) have grounded enclosures or are manufactured with conductive plastics. These devices must be electrically isolated from the ROBOT frame to ensure compliance with this rule.

Examples of devices with COTS XT30 connectors include but are not limited to the REV Control Hub (REV-31-1595), a COTS XT30 power distribution block (such as a REV-31-1293), or a COTS Anderson Powerpole to XT30 Adapter (such as REV-31-1385). For additional details on installation of the grounding strap, please see the [ROBOT Wiring Guide](#).

R612 *Electrical system must be inspectable. All power regulating devices (per [R505](#)), associated wiring, and all fuses must be visible for inspection.

“Visible for inspection” does not require that the items be visible when the ROBOT is in STARTING CONFIGURATION, provided the team can make the items viewable during the inspection process.

R613 *No high voltage allowed. Any active electrical item that is not an actuator (specified in [R501](#)) or power regulation device (specified in [R505](#)) is considered a CUSTOM CIRCUIT. CUSTOM CIRCUITS shall not provide regulated output voltages exceeding 5V, but may pass through unregulated battery voltage.

R614 *Energize Power Regulating Devices as specified. All power regulating devices ([R505](#)) must be powered per the manufacturer’s instructions and the following table must be true:

Table 12-7 Power Regulation Device Power Requirements

Power Regulating Device	Part Number	Method of Powering
REV Control Hub / REV Expansion Hub	REV-31-1153 / REV-31-1595	Only powered using one of the XT30 connectors on the device by the ROBOT main battery
REV Servo Power Module	REV-11-1144	Only powered using the screw terminals and must always be powered by the ROBOT main battery
REV SPARKmini	REV-31-1230	Only powered by the Power input and must always be powered by the ROBOT main battery
Studica Servo Power Block	75005	Only powered by JST-VH power connector, and must always be powered by the ROBOT main battery
VEX Motor Controller 29	276-2193	Only powered via servo connector

R615 *Use appropriately sized wire. All circuits shall be wired with appropriately sized insulated copper wire (SIGNAL LEVEL cables don't have to be copper):

Table 12-8 Wire sizing requirements

Application	Minimum Wire Size
12V Main Battery Power	18 AWG (19 SWG or 1 mm ²)
Motor Power (unless otherwise listed)	
11-20A fuse protected circuit	
Motor Power - TETRIX MAX 12V DC Motors, REV Robotics Core Hex (REV-14-1300)	22 AWG (22 SWG or 0.5 mm ²)
PWM / Servo	
LEDs (5V / 12V)	
≤10A fuse protected circuit	
SIGNAL LEVEL circuits (i.e. circuits which draw ≤1A continuous and have a source incapable of delivering >1A, including but not limited to I2C, DIO, Analog, encoder and RS485 connections)	28 AWG (29 SWG or .08 mm ²)

Integrated wires originally attached to legal COTS devices are considered part of the device and by default legal. Such wires are exempt from this rule.

In order to show compliance with these rules, teams should use wire with clearly labeled sizes if possible. If unlabeled wiring is used, teams should be prepared to demonstrate that the wire used meets the requirements of this rule (e.g. wire samples and evidence that they are the required size).

R616 *Use specified wire colors. All non-SIGNAL LEVEL wiring with a constant polarity (i.e., except for outputs of motor controllers, or sensors) must use consistent color-coding with different colors used for the positive (red, yellow, white, brown, or black with white stripe) and negative/common (black, blue) wires.

R617 *Powered USB Hubs must draw energy from approved sources. Powered USB hubs used on the ROBOT can only be powered through one of the following ways:

- A. an approved COTS USB battery Pack per [R602](#), or
- B. the 5V auxiliary power port on the REV Expansion Hub or REV Control Hub

R618 *Don't modify critical power paths. CUSTOM CIRCUITS shall not directly alter the power pathways between:

- A. the ROBOT battery and main power switch,
- B. the main power switch and a power regulating device (per [R609](#)),
- C. any two power regulating devices (per [R613](#)), or
- D. power regulating devices and actuators.

Custom high impedance voltage monitoring or low impedance current monitoring circuitry connected to the ROBOT'S electrical system is acceptable if the effect on power pathways is inconsequential.

Altering a power pathway includes, but is not limited to, altering the voltage of the power pathway using a boost (DC voltage step-up) or buck (DC voltage step-down) converter or otherwise altering the natural variable DC voltage provided by the ROBOT battery to create a constant DC voltage.

R619 *Don't mix and match power on or between power regulation devices. The following rules must be adhered to when using power on any power regulation device (per [R505](#)):

- A. other than power used to energize the power regulation device (per [R614](#)) no power originating outside the power regulation device may be used on or with devices connected to the power regulation device. The only exceptions are connections intended for communication between devices (RS485/USB/PWM/etc).

Example 1: The +5V port on a REV Expansion Hub cannot be used to power devices connected to a REV Control Hub's I2C ports.

Example 2: A regulated 5V output provided by a CUSTOM CIRCUIT cannot be used to power an I2C device connected to a REV Control Hub.

- B. power originating from ports/connectors on power regulation devices may only be used for devices directly connected to that port/connector. The only exception to this is +5V power from the +5V power port on the REV Control Hub or REV Expansion Hub may be used in conjunction with any Analog, Digital, or I2C port on that device. In addition the +5V power port may be used to power external devices.

Example 1: The power provided by Digital Port 0-1 on a REV Control Hub should not be used to power devices connected to I2C Port 0. However, power provided by Digital Port 0-1 can be used to power devices connected to both signal channels N and N+1 on Digital Port 0-1.

Example 2: The +5V power can be used to power external devices such as externally powered USB hubs (per [R617](#)).

- C. 6V power provided by the REV Servo Power Module or Studica Servo Power Block may only be used for powering servos.

12.7 Control, Command & Signals System

R701 *Control the ROBOT with a single ROBOT CONTROLLER. ROBOTS must be controlled via 1 programmable ROBOT CONTROLLER. The ROBOT CONTROLLER is the only source of control for the ROBOT actuators and must be comprised of:

- A. REV Control Hub (REV-31-1595), or
B. an allowed smartphone Android device connected to a REV Expansion Hub (REV-31-1153)

In addition to A and B, a ROBOT may also contain:

C. no more than one additional REV Expansion Hub (REV-31-1153)

R702 *No general purpose co-processors. General purpose co-processors, such as Raspberry Pi, Arduino boards, or similar are prohibited, including devices containing such co-processors unless explicitly permitted in this rule or rule [R703](#). Permitted devices may not be user-programmed but firmware provided by the manufacturers may be updated. Permitted devices are:

Table 12-9: Allowed exceptions containing general-purpose co-processors

Device	Part Number
REV Robotics Blinkin LED Driver	REV-11-1105
Digital Chicken Labs OctoQuad	DCL-OQF1

R703 *Programming vision is okay. Supported vision co-processors are allowed to be programmed. Current vision co-processors that are allowed are:

Table 12-10 - Supported Vision co-processors

Device	Part Number
Limelight Vision Limelight 3A	LL_3A

R704 *Use only legal Android smartphone devices. Android smartphone devices, if used, must minimally be running the Android 7 (Nougat) operating system. The following table lists the legal Android smartphones:

Table 12-11: Legal Android Smartphones

Phone	Notes
Motorola Moto G4 Play	Sometimes noted as “4th Generation”
Motorola Moto G5	
Motorola Moto G5 Plus	
Motorola Moto E4	USA versions only, includes SKUs XT1765, XT1765PP, XT1766, and XT1767
Motorola Moto E5	XT1920
Motorola Moto E5 Play	XT1921

Some supported models still using Android 6.x (Marshmallow) might be updatable by the [Motorola Rescue and Smart Assistance Tool](#).

Teams outside North America with extenuating circumstances (such as international purchasing limitations) are allowed to use alternate Android

smartphones if necessary. Teams doing so are required to fill out [this alternate Android Smartphone survey](#).

- R705** ***Smartphone android devices used as a ROBOT CONTROLLER must connect to the REV Expansion Hub using USB.** If used as a ROBOT CONTROLLER, the smartphone android device must be connected via its integrated micro USB port to a REV Expansion Hub either:
- A. a mini USB to OTG Micro Cable, or
 - B. any combination of Mini USB Cable, a USB Hub (powered or unpowered) and an OTG Micro adaptor (the hub can be integrated into the USB Hub).
- R706** ***Bandwidth is restricted.** Communication between the ROBOT and the DRIVER STATION is limited to ROBOT command data from the DRIVER STATION app, debugging data and telemetry from the ROBOT to the DRIVER STATION app, and single frame images used during ROBOT set-up pre-MATCH. No streamed video or audio may be sent.
- R707** ***Configure devices for your team number.** The ROBOT CONTROLLER, DRIVER STATION, and any spares used must be configured/named to correspond to the correct team number as follows:
- A. ROBOT CONTROLLER should be named <team number>-RC (e.g. 12345-RC)
 - B. DRIVER STATION should be named <team number>-DS (e.g. 12345-DS)
 - C. If a spare ROBOT CONTROLLER or DRIVER STATION is configured, a letter designator may be added <team number>-<letter>-RC/DS (e.g. 12345-A-DS, 12345-B-DS)

See the [DRIVER STATION Instructions](#) and [ROBOT CONTROLLER Instructions](#) for a detailed procedure for updating DRIVER STATION and ROBOT CONTROLLER “names.”

- R708** ***Don't interfere with the ROBOT networks.** During a MATCH, all communications signals must originate from only the ROBOT CONTROLLER device or the DRIVER STATION device using the ROBOT CONTROLLER Wi-Fi network. No other devices may attempt to connect to, interfere with, or alter the ROBOT CONTROLLER Wi-Fi network.

Teams are allowed to connect programming laptops and other devices to the ROBOT CONTROLLER Wi-Fi network outside of a MATCH. These devices must be disconnected from the ROBOT CONTROLLER Wi-Fi network prior to and during a MATCH.

- R709** ***No other wireless allowed.** No form of wireless communication shall be used to communicate to, from, or within the ROBOT, except those specified per [R706](#) and [R708](#).

Devices that employ signals in the visual spectrum (e.g. cameras) and non-RF sensors that don't receive human-originated commands (e.g. “beam break” sensors or IR sensors on the ROBOT used to detect FIELD elements) are not wireless communication devices and thus this rule doesn't apply.

- R710** ***ROBOT CONTROLLER must be visible for inspection.** The ROBOT CONTROLLER device must be mounted on the ROBOT such that the diagnostic lights, or device screen if applicable, can be visible for inspection.

“Visible for inspection” does not require that the items be visible when the ROBOT is in STARTING CONFIGURATION or normally during a MATCH, provided the team can make the items viewable during the inspection process if necessary.

Teams are strongly encouraged to make the diagnostic lights visible during normal match play ROBOT configurations. If diagnostic LEDs are not visible during a MATCH, FIELD STAFF may not be able to provide comprehensive support to the team.

Teams are encouraged to mount the ROBOT CONTROLLER device away from noise generating devices such as motors and EMF shielding materials like sheets of metal.

R711 ***Only specified modifications to core control system devices permitted.** The DRIVER STATION device and software, Android-based ROBOT CONTROLLER device, main and secondary power switch(es), power regulation devices, fuses, and batteries shall not be tampered with, modified, or adjusted in any way (tampering includes drilling, cutting, machining, rewiring, disassembling, painting, removing enclosures and replacing with custom enclosures, etc.), with the following exceptions:

- A. wires, cables, and signal lines may be connected via the standard connection points provided on the devices,
- B. fasteners (including adhesives) may be used to attach devices to the OPERATOR CONSOLE or ROBOT or to secure cables to the device,
- C. thermal interface material may be used to improve heat conduction,
- D. labeling may be applied to indicate device identification, purpose, connectivity, functional performance, etc. as long as they do not cover labels or markings used to identify the product,
- E. jumpers may be changed from their default location,
- F. jumpers or switches may be moved to configure devices per the manufacturer’s manual,
- G. device firmware may be updated with manufacturer supplied firmware,
- H. integral wires on motor controllers may be cut, stripped, and/or connectorized,
- I. devices may be repaired, provided the performance and specifications of the device after the repair are identical to those before the repair,
- J. add insulating material to exposed conductors, and
- K. tape may be applied for debris protection.

Please note that while repairs are permitted, the allowance is independent of any manufacturer’s warranty. Teams make repairs at their own risk and should assume that any warranty or return options are forfeited. Repairs must be functionally equivalent to original device condition.

Be aware that diagnosing and repairing COMPONENTS such as these can be difficult.

For example, “repairs” that change connector types, include device footprint modifications, or provide mechanical enhancements, are prohibited.

R712 ***Always keep control system device software up to date.** The following table lists the recommended software versions for each core control electronics module, and a link on how to update this software. Note that some devices have multiple pieces of software that may need to be updated each season, and not all software is available prior to kickoff each season. Check the [FIRST Tech Challenge Blog](#) for release announcements.

Regardless of the versions selected, it is highly recommended that the installed ROBOT CONTROLLER App and DRIVER STATION App versions match major and minor values to ensure compatibility as not all software versions are compatible with each other.

Table 12-12 - Recommended Software for Control System Devices

Device	Software and Recommended Versions	How to Update
REV Control Hub (REV-31-1595)	Control Hub OS Recommended: 1.1.2	Updating the Control Hub OS
REV Control Hub (REV-31-1595)	Hub Firmware Recommended: 1.8.2	Updating the Hub Firmware
REV Control Hub (REV-31-1595)	ROBOT CONTROLLER App Recommended: 10.0	Updating the ROBOT CONTROLLER App
REV Expansion Hub (REV-31-1153)	Hub Firmware Recommended: 1.8.2	Updating the Hub Firmware
Android Smartphone (ROBOT CONTROLLER device)	ROBOT CONTROLLER App Recommended: 10.0	Updating the ROBOT CONTROLLER App
Android Smartphone (DRIVER STATION device)	DRIVER STATION App Recommended: 10.0	Updating the DRIVER STATION App
REV Driver Hub (REV-31-1596)	Driver Hub OS Recommended: 1.2.0	Updating the Driver Hub OS
REV Driver Hub (REV-31-1596)	DRIVER STATION App Recommended: 10.0	Updating the DRIVER STATION App

Software at or above the recommended versions have the latest bugfixes and updates. Teams are highly encouraged to update their software minimally to the recommended version. FIELD STAFF will not be able to provide comprehensive support to teams with software older than the recommended version.

Teams may choose to run older versions without affecting their ROBOT inspection status.

- R713** ***USB is for vision.** Only the following devices may be connected to the ROBOT control system using USB:
- webcams and optical vision sensors per [R714](#),
 - USB hub, and
 - a REV Expansion Hub (if using a smartphone per [R704](#) as the ROBOT CONTROLLER)
- R714** ***Use only supported Vision.** Only single image sensor vision devices that are natively supported by the ROBOT CONTROLLER App are allowed (stereoscopic cameras are not allowed). This includes the following:
- all UVC compatible USB webcams (Logitech C270, and related),
 - DFRobot HuskyLens (SKU: SEN0305, SEN0305-S), and
 - Limelight Vision Limelight 3A (SKU: LL_3A)
- To request support (or to provide sample drivers) for alternate vision devices for inclusion in future *FIRST* Tech Challenge seasons, please use the [Part Suggestion Form](#).

UVC compatible USB webcams may only use the UVC provided stream / data. No other interfaces or data provided by the webcam may be used.
- R715** ***Recording devices are okay.** Self-contained video recording devices (GoPro or similar) are allowed providing they are used only for non-functional post-MATCH viewing and the wireless capability is turned off.
- R716** ***Lasers must be safe.** Lasers are not allowed unless they meet all of the following criteria:
- must be part of a sensor,
 - must be rated as IEC/EN 60825-1 "Class I" or IEC/EN 62471 "Exempt"
 - non-visible spectrum

12.8 Pneumatic Systems

In order to maintain safety, the rules in this section apply at all times while at the event, not just while the ROBOT is on the FIELD for MATCHES.

- R801** ***No Pneumatics.** No closed air systems are allowed on *FIRST* Tech Challenge ROBOTS except for those explicitly listed in [R207](#).

12.9 OPERATOR CONSOLE

- R901** ***Use only a specified DRIVER STATION device.** The OPERATOR CONSOLE may only have one approved android-based DRIVER STATION device connected and powered on. The OPERATOR CONSOLE must have at least one of the following:
- REV Driver Hub (REV-31-1596) or
 - Approved Android Device from rule [R704](#) with one OTG cable and COTS USB cable to connect the required gamepad controller(s).

Teams who wish to have a spare DRIVER STATION device as part of their OPERATOR CONSOLE may do so as long as only one DRIVER STATION device is connected and powered on at a time.

- R902** *The OPERATOR CONSOLE must make the touch screen accessible. The OPERATOR CONSOLE, the set of COMPONENTS and MECHANISMS used by the DRIVE TEAM to relay commands to the ROBOT, must make the touch screen of the DRIVER STATION device accessible. The DRIVER STATION device must be positioned within the OPERATOR CONSOLE so that the screen display can be clearly seen during inspection and in a MATCH.
- R903** *Options for portable power to the DRIVER STATION device are limited. The DRIVER STATION device can be charged using one (1) COTS USB external battery as long as the following requirements are met:
- A. COTS USB battery is limited by [R602-A](#) and [R602-A](#)
 - B. Controller is charged through the built-in USB-C port on the REV Driver Hub or through a USB Hub connected to the smartphone Android Device.
- R904** *Only limited gamepads are supported. The OPERATOR CONSOLE may have no more than two (2) electrically unmodified gamepads in any combination from the following list connected to the DRIVER STATION at any time:

Table 12-13 - Allowed Gamepads on OPERATOR CONSOLE

Gamepad	Part Number	Notes
Logitech F310 gamepad	940-00010	
Xbox 360 Controller for Windows	52A-00004	
Sony DualShock 4 Wireless Controller for PS4	N/A	Operating in wired mode only (i.e., connected through USB cable without being Bluetooth paired to any device)
Sony DualSense Wireless Controller for PS5	N/A	This DOES NOT include the Sony DualSense Edge Wireless Controller in any configuration
Etpark Wired Controller for PS4	REV-39-1865	
REV Robotics USB PS4 Compatible Gamepad	REV-31-2983	
Quadstick game controller in Xbox 360 Emulation Mode	any model	

Enhancements to the gamepad that do not modify the electronics are legal. Different color gamepads are allowed provided they are the same model as the allowed gamepad.

Teams are strongly encouraged to use short USB cable extenders with the USB ports on the DRIVER STATION device. These extenders are used to reduce the wear and tear on the DRIVER STATION device ports from frequent plugging and unplugging – instead of plugging/unplugging

directly into the DRIVER STATION device, gamepads are plugged and/or unplugged from the cable extenders. The extenders are intended to remain forever plugged into the DRIVER STATION device and, with proper strain relief employed, can protect the port from accidental damage.

Teams who wish to have spare gamepad(s) available as part of their OPERATOR CONSOLE may do so as long as no more than two gamepads are connected at any time.

R905 *OPERATOR CONSOLE physical requirements. The OPERATOR CONSOLE must not

- C. include more than one (1) connected external USB hub,
- D. contain any non-decorative electronics not otherwise required,
- E. exceed a volume of 3ft wide, 1ft deep and 2 ft tall (excluding any items that are held or worn by the DRIVERS during the MATCH)

Please note that while there is no hard weight limit, OPERATOR CONSOLES that weigh more than 20 lbs. (~9 kg.) will invite extra scrutiny as they are likely to present unsafe circumstances.

Teams who wish to have a spare external USB hub as part of the OPERATOR CONSOLE may do so as long as only one USB hub is connected at any time.

R906 *ROBOT application wireless communication only. Other than the connection controlled by the ROBOT CONTROLLER app running on the ROBOT and the DRIVER STATION app running on the DRIVER STATION device, no other form of wireless communications shall be used to communicate to, from, or within the OPERATOR CONSOLE during a MATCH.

Examples of prohibited wireless systems include, but are not limited to, active wireless network cards and Bluetooth devices.

Because this system uses a built-in wireless radio teams are strongly encouraged to ensure there is no metal material blocking the line-of-sight between the DRIVER STATION device and the ROBOT CONTROLLER device which could impede the signal quality.

R907 *No unsafe OPERATOR CONSOLES. OPERATOR CONSOLES shall not be made using hazardous materials, be unsafe, cause damage, cause an unsafe condition, distract, or interfere with other DRIVE TEAMS or the operation of other ROBOTS.

DRIVER STATION sounds which are distracting or which mimic MATCH sounds are examples of disallowed OPERATOR CONSOLE features.

Sounds which are frequent or continuous which serve no apparent value to the MATCH play would likely be considered distracting.

The intent of this rule is to allow teams to use a container to store, organize, and transport the DRIVER STATION device and supporting electronics. The OPERATOR CONSOLE rules are not intended to allow

systems that function as a ROBOT cart or replace a competition-provided OPERATOR CONSOLE stand, table, etc.



13 Tournament (T)

This section will be updated with the Kickoff Competition Manual release on September 7th, 2024



14 League Play Tournaments (L)

This section will be updated with the Kickoff Competition Manual release on September 7th, 2024



15 *FIRST* Championship Tournament (C)

This section will be updated with the Kickoff Competition Manual release on September 7th, 2024



16 Glossary

The following definitions and terms are used for a *FIRST* Tech Challenge game INTO THE DEEP. Defined terms are in ALL CAPITAL LETTERS throughout the manual (for example, ALLIANCE). Competition rules mean exactly and only what it plainly says. If a word isn't given a game definition, then you should use its common conversational meaning.

Term	Definition
ALLIANCE	a cooperative of two <i>FIRST</i> Tech Challenge teams
ARENA	includes all elements of the game infrastructure that are required to play this season's FTC game including: the FIELD, SCORING ELEMENTS, queue area, team media area, and all equipment needed for FIELD control, ROBOT control, and scorekeeping
COACH	a guide or advisor
COMPONENT	any part in its most basic configuration, which cannot be disassembled without damaging or destroying the part or altering its fundamental function
COTS	a standard (i.e. not custom order) part commonly available from a VENDOR for all teams for purchase
CUSTOM CIRCUIT	Any active electrical item that is not an actuator (specified in R501 or R502) or core control system item (specified in R711)
DRIVE TEAM	a set of up to 4 people from the same <i>FIRST</i> Tech Challenge team responsible for team performance for a specific MATCH
DRIVER STATION	Android device (smartphone or REV Driver Hub) that runs the DRIVER STATION App software to communicate with a ROBOT.
FABRICATED ITEM	any COMPONENT or MECHANISM that has been altered, built, cast, constructed, concocted, created, cut, heat treated, machined, manufactured, modified, painted, produced, surface coated, or conjured partially or completely into the final form in which it will be used on the ROBOT
FIELD	an approximately 12 ft by 12 ft foam TILE covered area bounded by the outside edge of the extrusion of the FIELD perimeter walls.
FIELD STAFF	the collective group of people working on or near the FIELD responsible for making sure the MATCHES are cycled through efficiently, fairly, safely, and with a spirit of cooperation, Gracious Professionalism, and generosity of spirit
FTA	<i>FIRST</i> Technical Advisor

Term	Definition
INSPECTOR	a person determined by <i>FIRST</i> to accurately and efficiently assess the legality of a given part of a ROBOT
LRI	the Lead ROBOT INSPECTOR
MAJOR MECHANISM	a group of COMPONENTS and/or MECHANISMS assembled together to address at least 1 game challenge: ROBOT movement, SCORING ELEMENT manipulation, FIELD element manipulation, or performance of a scorable task without the assistance of another ROBOT.
MATCH	the 2-minute and 30-second in which a ROBOT is enabled to play the current seasons game
MECHANISM	an assembly of COMPONENTS that provide specific functionality on the ROBOT. A MECHANISM can be disassembled (and then reassembled) into individual COMPONENTS without damage to the parts.
OPERATOR CONSOLE	the set of COMPONENTS and MECHANISMS used by the DRIVERS and/or HUMAN PLAYERS to relay commands to the ROBOT
REFEREE	an official who is certified by <i>FIRST</i> to enforce the rules of the current season's game.
ROBOT	an electromechanical assembly built by the <i>FIRST</i> Tech Challenge 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, and movement about the FIELD
ROBOT CONTROLLER	Android device (smartphone or REV Control Hub) that runs the ROBOT CONTROLLER App to control the ROBOT as defined in R701 and R704
ROBOT SIGN	A regulated way for a team to display their team number and ALLIANCE color on their ROBOT for FIELD STAFF, other volunteers, and teams to identify their ROBOT during competition as defined in section 12.4 ROBOT SIGN Rules
SCORING ELEMENT	Objects that ROBOTS manipulate to earn points for their ALLIANCE.
SIGNAL LEVEL	a term used to characterize circuits which draw $\leq 1A$ continuous and have a source incapable of delivering $>1A$, including but not limited to REV Control and Expansion Hub sensor input/output signals (DIO, analog, I2C, encoder, 485)
STARTING CONFIGURATION	the physical configuration in which a ROBOT starts a MATCH
TILE	An approximate 24-inch x 24-inch (61 cm x 61 cm) foam rubber interlocking mat. The FIELD floor has thirty-six (36) TILES.
VENDOR	a legitimate business source for COTS items that satisfies criteria defined in section 12 ROBOT Construction Rules (R)

