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2020-2021 *FIRST®* Tech Challenge

Game Manual Part 1
Remote Events

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Revision History		
Revision	**Date**	**Description**
1	7/16/2020	Initial Release

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1.0 Introduction

1.1 What is FIRST® Tech Challenge?
FIRST® Tech Challenge is a student-centered program that focuses on giving students a unique and stimulating experience. Each year, teams engage in a new game where they design, build, test, and program autonomous and driver operated robots that must perform a series of tasks. To learn more about *FIRST*® Tech Challenge and other *FIRST*® Programs, visit www.firstinspires.org.

1.2 FIRST Core Values
We express the *FIRST*® philosophies of *Gracious Professionalism*® and *Coopertition*® through our Core Values:

- **Discovery:** *We explore new skills and ideas.*
- **Innovation:** *We use creativity and persistence to solve problems.*
- **Impact:** *We apply what we learn to improve our world.*
- **Inclusion:** *We respect each other and embrace our differences.*
- **Teamwork:** *We are stronger when we work together.*
- **Fun:** *We enjoy and celebrate what we do!*

2.0 *Gracious Professionalism*®

FIRST® uses this term to describe our programs' intent.

Gracious Professionalism® is a way of doing things that encourages high-quality work, emphasizes the value of others, and respects individuals and the community.

Watch Dr. Woodie Flowers explain *Gracious Professionalism* in this short video.

3.0 The Competition – Definitions and Rules

3.1 Overview
Students that engage in the *FIRST* Tech Challenge program develop Science, Technology, Engineering, and Math (STEM) skills and practice engineering principles while realizing the value of hard work, innovation, and sharing ideas.

There are two types of competition formats a *Team* might experience this season; Traditional events and remote events. This manual describes remote events; however, some *Teams* may switch between formats depending on social distancing rules within their state/region. Below are descriptions of both formats.

3.1.1 Traditional Events
A traditional *FIRST* Tech Challenge event is typically held in a school or college gymnasium, where *Teams* use *Robots* to compete in the current seasons game challenge. *Teams* participating in traditional events compete with alliance partners in a head to head style of competition on the official *FIRST* Tech Challenge *Playing Field*. *Teams* compete in a series of *Matches* that determine their ranking at a traditional tournament. The size of a traditional event can range anywhere from 8 *Teams* to over 50 *Teams* competing in one place. Traditional events are generally scheduled by the local program delivery partner, and are run by many volunteers including referees, judges, scorekeepers, queuers, and other key volunteers. Traditional events consist of *Robot* inspections, *Robot* competitions, judging interviews (for most competitions), and an overall celebration of *Teams* and their accomplishments. To learn more about traditional events, please read the Game Manual Part 1 – Traditional Events manual.

3.1.2 Remote Events
Remote events were developed to mimic traditional *FIRST* Tech Challenge events, while practicing social distancing guidelines. Since *Teams* are not able to gather and compete in the traditional head-to-head competition format, the season's official full *Playing Field* has been adapted to allow *Teams* to play as a single *Team*. Remote *Teams* may order an official half version of this seasons field, or compete using a modified version of the field, which will be released at kickoff on 9/12/2020. *Teams* will still sign up for events and will be provided a window to submit their own *Match* scores, which will determine their rankings. Unlike traditional events, the scoring of the official *Matches* is done by the *Team*, rather than an event volunteer. *Teams* will participate in judging interviews via video conference.

3.2 Eligibility to Compete in Official FIRST Tech Challenge Competitions:

3.2.1 North America Teams
To compete in an official *FIRST* Tech Challenge competition at any level, a *Team* must be registered and in good standing with *FIRST*.

1. The *Team* must complete the registration process through the Team Registration System.
2. The *Team* registration fee must be paid.
3. Two adults must pass the Youth Protection screening process.

3.2.2 Outside North America
Teams outside of North America are required to register through the Team Registration System. The registration ensures that *Teams* competing remotely will have access to the necessary software application to compete in the current season. Fees will not be due to *FIRST* for the registration. *Teams* outside of North America should consult the program delivery partner in their region for program fees and product purchase.

3.3 Competition Types
There are several types of competitions that *Teams* and other organizers hold throughout the *FIRST* Tech Challenge season and off-season. Competition types are listed in the following section.

3.3.1 Scrimmage

A scrimmage is an unofficial *FIRST* Tech Challenge competition where *Teams* do not advance. *Teams* compete at a scrimmage solely to prepare for an official *Tournament*. A scrimmage can be done in person or via the Internet as a way for *Teams* to practice, learn the rules, and mentor one another during the *Robot* build process.

Anyone can host a scrimmage to prepare for an official competition. *Teams* hosting a scrimmage are encouraged to tell their local [Program Delivery Partner](#) that such an event is taking place. *Teams* that choose to create and host a local meet are responsible for finding a location, organizing the format for the day, and inviting other *Teams* to participate. *Teams* may also have to secure the field elements, computers, and other items.

3.3.2 League Meets

A league meet is a competition in which *Teams* compete in *Qualification Matches* only. Rankings from one meet to the next accumulate as outlined in section 5.2. The number of meets a *Team* can play in may vary by region. Whenever possible, it is highly encouraged that *Teams* participate in as many meets as they can*.* Some standard competition guidelines may be adapted for those regions that participate in the league format. *Teams* should contact their [program delivery partner](#) for more information about the scheduling, structure, advancement, and processes that are unique to the league/meet in their region.

3.3.3 Qualifying Tournaments and League Tournaments

Hosted and managed by *FIRST* Tech Challenge program delivery partner or program delivery partner-appointed host. *Qualifying Tournaments* follow the format outlined in section 4.0. *Qualifying Tournaments* are held before *Championship Tournaments*. The number of *Teams* advancing to the state/regional championship tournament depends on the capacity of the state/regional championship tournament, the number of qualifying tournaments, and the number of *Teams* attending the qualifying tournament. The advancement criteria for moving up to the next tournament level is detailed in section 6.0.

3.3.4 Super Qualifying Tournaments

These tournaments are held in regions with a large number of *Teams* and/or leagues. In these regions, *Teams* advance from either a league tournament or qualifying tournament to a super-qualifying tournament, and then to the state/regional championship.

3.3.5 Championship Tournaments

Hosted and managed by a *FIRST* Tech Challenge program delivery partner, championship tournaments uphold certain standards in format, judging, awards, and overall quality. Some championship tournaments require that *Teams* advance from a qualifying tournament or league tournament to advance to the state/regional championship. Championship tournaments may include *Teams* from a geographic region, province, state, country, or several countries. *Teams* should expect a higher level of competition, both on the field and in the judging room at championship tournaments.

3.3.6 World Championship

Hosted and managed by *FIRST,* the world championships, held in Houston, Texas and Detroit, Michigan, are the culminating events for all *FIRST* programs. *FIRST* Tech Challenge *Teams* advance to the world championship through their state/region championship tournament. The world championship includes *Teams* from several countries, and *Teams* should expect a higher level of competition, both on the field and in the judging room.

3.4 Competition Definitions

Alliance Station –The designated *Alliance* area next to the *Playing Field* where the *Drivers* and *Coach* stand or move within during a *Match*.

Competition Area – The *Area* where the *Playing Field is* located.

Drive Team - Up to four representatives two (2) drivers, one (1) coach, and one (1) *Human Player* from the same *Team*.

Human Player – A student *Team* member that supplies *Scoring Elements* during a *Match*.

Playing Field –The area where the game elements are located and where *Robots* play *Matches*.

Qualification Match – A *Match* used to earn *Ranking Points* and *TieBreaker Points.*

Ranking Points/Total Ranking Points – The first basis for ranking *Teams*. For a single *Team* competing remotely, the *Team's* final score for a *Match* is used as their *Ranking Points*. For *Teams* that compete at a traditional tournament, each *Team* receives their *Alliance's* final score for a *Match* as *Ranking Points*. *Total Ranking Points* is the sum of the *Ranking Points* of all non-*Surrogate Matches* that a *Team* plays in a tournament. Please see section 5.0 for further explanation for how this is used to determine a *Team's* ranking.

Robot - Any mechanism that has been built to compete in the game challenge and complies with the *Robot* rules outlined in Section 7 of this manual.

Sports Start – A model of competition where *Teams* start their *Robot* after the 3-2-1 countdown.

Team – An official *FIRST* Tech Challenge *Team* consists of no more than 15 student *Team* members. A *Team* is made up of pre-college students and is designed for students in grades 7-12. Students cannot be older than high school-aged if they are participating *Team* members. All *Teams* in North America are required to register through the Team Registration System. *Teams* must have a minimum of two Lead Coaches or Mentors that have registered through the *Team* Registration System and have passed the Youth Protection Program screening. The *Team* must be in good standing through the registration system to compete in *FIRST* Tech Challenge official tournaments.

Teams outside of North America are required to register through the Team Registration System. *Teams* registered will receive the regular *Team* email blasts, receive access to the Game Q&A system, receive permanent *FIRST* team numbers, and can access nominations for the Dean's List Award.

TieBreaker Points/Total TieBreaker Points – *TieBreaker Points* are used as the tiebreakers when *Teams* have equal *Total Ranking Points.* There are two types of *TieBreaker Points*, *TBP1* and *TBP2.*

> *TBP1*: For a single *Team* competing remotely, the *Team's Autonomous Period* score for a Qualification *Match* is used as their *TBP1*. For *Teams* that compete at a traditional tournament, each *Team* receives their *Alliance's Autonomous Period* score for a *Qualification Match* as *TBP1*. *Total TBP1* is the sum of the *TBP1s* of all non-S*urrogate Qualification Matches* that a *Team* plays in a *Tournament*.

> *TBP2*: For a single *Team* competing remotely, the *Team's End Game* specific task score for a *Qualification Match* is used as their *TBP2*. For *Teams* that compete at a traditional tournament, each *Team* receives their *Alliance's End Game* specific task score for a *Qualification Match* as *TBP2*. *Total TBP2* is the sum of the *TBP2s* of all non-*Surrogate Qualification Matches* that a *Team* plays in a *Tournament*.

Please see section 5.0 for further explanation for how this is used to determine a *Team's* ranking.

Tournament – A Tournament is an event that advances *Teams* to the next level of competition within a state/region, or to the world championship. For many *Teams*, a *Tournament* is their culminating event.

3.5 Competition Rules

There are competition rules in the Game Manual Part 1 – Traditional Events, that do not apply to *Teams* competing remotely. Those rules have been removed from this manual; however, the numbering of the rules has been kept the same for consistency between both manuals.

<C01> Egregious behavior by any *Team*, *Team* member, or other representative of the *Team* is not tolerated at a *FIRST* Tech Challenge *Competition*.

<C05> Each registered *Team* may enter only one *Robot* (a *Robot* built to play the current season's game challenge) into the *FIRST* Tech Challenge competition. It is expected that *Teams* will make changes to their *Robot* throughout the season and at competitions.

    a. It is against this rule to compete with one *Robot* while a second is being adjusted or assembled at a competition.

    b. It is against this rule to switch back and forth between multiple *Robots* at a competition.

    c. It is against this rule to register and attend concurrent competitions with a second *Robot*.

    d. It is against this rule to use a *Robot* built by another *Team* at a competition.

Violations of this rule will immediately be considered deliberate and egregious.

<C07> *Teams* competing in a meet, league *Tournament*, qualifying *Tournament*, and championship Tournament will compete in no fewer than five (5) *Qualification Matches*, and no more than six (6) *Qualification Matches. Teams* competing remotely will have a total of six (6) *Qualification Matches*.

<C15> All *Team* members, coaches, and their guests must wear ANSI Z87.1 certified safety glasses while in the *Pit* or *Competition Area*. Prescription glasses with ANSI Z87.1 approved Commercial Off-The-Shelf side shields are also allowed.

<C16> Batteries must be charged in an open, well-ventilated area.

<C17> Open-toed or open-backed shoes are not allowed in the *Competition Area*.

<C18> There is no running, skateboarding, roller skating, 'hover boards', and/or flying drones are not allowed at any competition. These can create safety hazards to the *Teams*, spectators, or volunteers attending the competition.

4.0 Remote Competition Overview

Remote competitions are a way for *Teams* to compete while practicing social distancing. *Teams* are required to register with *FIRST* in order to access the cloud-based scoring system where their official *Matches* are submitted. This section of the manual outlines what *Teams* should expect while competing in remote competitions.

4.1 Consent and Release Forms and Team Roster

Each student competing at a *FIRST* Tech Challenge competition must have a signed consent and release form completed by a parent or legal guardian. **Students cannot compete without a signed consent and release form**. These forms can be filled out electronically or by hard copy.

- Electronically – A parent or legal guardian of the student can create a youth team member registration through the [*FIRST* website](#) and complete the consent and release form online.
- Hard copy – A hard copy of the form may be printed from the *Team* registration system and filled out be signed by a parent or legal guardian. Either the printed original, or a photocopy of the printed original of the form must be provided to the tournament director or program delivery partner.

The roster, printed from the team registration system must be handed in at event registration. The roster will show that each student's parent or guardian has electronically filled out the consent and release form online with a green checkmark. If the roster from the team registration system is blank or missing *Team* members' names, the coach should write in the names of each student competing. The hard copies of those consent and release forms must be turned in along with the roster.

4.2 Remote Competition Registration

Once a *Team* registers with *FIRST*, they must also register for their competition. For event information such as dates, competition registration, and competition format, *Teams* should contact their local program delivery partner.

4.3 Judging Interviews

Teams that compete in a remote *Tournament* (except for league meets, where judging interviews do not take place) are eligible for judged awards. Judging interviews are held via video conference and will be set up by either the local program delivery partner, a judge advisor, or tournament director.

Further details about judging interviews will be released at a later date.

4.4 Qualification Matches

Qualification Matches are the official *Matches* used to determine a *Teams* ranking. *Teams* will have up to a 7 day* window for the specific remote event(s) they are registered for to submit their six (6) official *Qualification Match* scores to *FIRST*. *Teams* are not required to play *Matches* on a specific date, however any unplayed/unscored *Qualification Matches* not submitted within the allotted timeframe will receive a zero score. *Teams* are ranked using their individual *Team* performance after their remote event ends.

*Please be sure to check with your local program delivery partner for details about the *Match* scoring window.

4.5 FTC Live Cloud Software

The FTC Live Cloud software is a Cloud-based application that allows *Teams* to score their *Matches* remotely and provide official scores to *FIRST*. *Teams* receive access to the software once they have registered for the season. Each *Team* can use their firstinspires.org *Team* user account to access the system and submit their *Qualification Match* scores. It is required that official *Qualification Match* scores are submitted via the FTC Live Cloud application within the allotted timeframe to count toward the *Team's* rankings.

The FTC Live Cloud application is similar to the live scoring system used in traditional events. *Teams* can run the FTC Live Cloud software to use the *Match* timers, displays, and score their *Match* as the *Match* is played.

In order to run the software to score a *Match* as it happens, an Internet connection is required. For *Teams* competing in a location that does not have high speed Internet access, the *Team* may use paper scoresheets to record the status of the *Match*. The *Team* must then ensure that the scores recorded on paper are submitted through the FTC Live Cloud software prior to the event deadline.

More detailed information, including scoring guides, will be available to *Teams* at kickoff on 9/12/2020.

5.0 Calculating Ranking

5.1 Competition Ranking Calculation

Each *Team* at a competition is ranked according to the following sort order:

1. *Total Ranking Points*; highest to lowest, then
2. *Total TieBreaker Points* (TBP1); highest to lowest, then
3. *Total TieBreaker Points* (TBP2); highest to lowest, then
4. Random electronic selection

Ranking Points and *TieBreaker Points* are awarded at the end of each *Match.*

5.2 League Tournament Ranking Calculation

League *Tournament* rankings are based on the top ten (10) *Matches* from all previous league meets plus the five (5) *Matches* from the league *Tournament*. The ten (10) league meet *Matches* are selected using the sort order from Section 5.1. *Teams* with fewer than fifteen (15) total *Matches* after the *Qualification Matches* at the League *Tournament* have been played will only be ranked on the *Matches* that they have played.

6.0 Advancement Criteria

6.1 Eligibility for Advancement

Teams are eligible for advancement at any one of the first three tournaments they participate in at any of the following levels, **regardless of the region.** This applies to both *Teams* in North America, and *Teams* outside of North America:

- League Tournament
- Qualifying Tournament
- Super Qualifying Tournament
- Championship Tournament

A *Team* can only earn a spot to one world championship event per season.

Tournament Type	Advances To	Special Considerations
Qualifying Tournament League Tournament Super Qualifying Tournament	State or Regional Championship Tournament	A *Team* is eligible to advance to the next competition tier from one of the first three qualifying, league, or super-qualifying tournaments they attend. A *Team* may participate in more than three tournaments in the same competition tier but are not eligible for consideration for advancement or awards at tournaments beyond their third.
State or Regional Championship Tournament	*FIRST* Tech Challenge World Championship	*Teams* advance from a state or regional championship tournament to **one** of the *FIRST* Tech Challenge World Championships.

6.2 Order of Advancement – Remote Competitions Only

If the *Team* listed has already advanced or there is no *Team* fitting that description (as in Inspire Award 3rd place at events of 20 or fewer *Teams*)

1. Inspire Award Winner
2. Highest Ranked *Team* not previously advanced
3. Inspire Award 2nd place
4. Highest Ranked *Team* not previously advanced
5. Inspire Award 3rd place
6. Highest Ranked *Team* not previously advanced
7. Think Award Winner
8. Highest Ranked *Team* not previously advanced
9. Connect Award Winner
10. Highest Ranked *Team* not previously advanced
11. Collins UTC Innovate Award Winner
12. Highest Ranked *Team* not previously advanced
13. Control Award Sponsored by Arm, Inc. Winner
14. Motivate Award Winner

15. Design Award Winner
16. Highest Ranked *Team* not previously advanced
17. Think Award 2nd Place
18. Highest Ranked *Team* not previously advanced
19. Connect Award 2nd Place
20. Highest Ranked Team not previously advanced
21. Collins UTC Innovate Award 2nd Place
22. Highest Ranked *Team* not previously advanced
23. Control Award Sponsored by Arm, Inc. 2nd Place
24. Highest Ranked *Team* not previously advanced
25. Motivate Award 2nd Place
26. Highest Ranked *Team* not previously advanced
27. Design Award 2nd Place
28. Highest Ranked *Team* not previously advanced
29. Think Award 3rd Place
30. Highest Ranked *Team* not previously advanced
31. Connect Award 3rd Place
32. Highest Ranked *Team* not previously advanced
33. Collins UTC Innovate Award 3rd Place
34. Highest Ranked *Team* not previously advanced
35. Control Award Sponsored by Arm, Inc. 3rd Place
36. Highest Ranked *Team* not previously advanced
37. Motivate Award 3rd Place
38. Highest Ranked *Team* not previously advanced
39. Design Award 3rd Place
40. Highest Ranked *Team* not previously advanced
41. Highest Ranked *Team* not previously advanced
42. Highest Ranked *Team* not previously advanced
43. Highest Ranked *Team* not previously advanced
44. Highest Ranked *Team* not previously advanced
45. Highest Ranked *Team* not previously advanced
46. Highest Ranked *Team* not previously advanced
47. Highest Ranked *Team* not previously advanced
48. Highest Ranked *Team* not previously advanced
49. Highest Ranked *Team* not previously advanced
50. Highest Ranked *Team* not previously advanced
51. Highest Ranked *Team* not previously advanced

7.0 The Robot

7.1 Overview
A *FIRST* Tech Challenge *Robot* is a remotely operated vehicle designed and built by a registered *FIRST* Tech Challenge *Team* to perform specific tasks when competing in the annual game challenge. This section provides rules and requirements for the design and construction of a *Robot*. *Teams* should be familiar with the *Robot* and game rules before beginning *Robot* design.

7.2 Robot Control System
A *FIRST* Tech Challenge *Robot* is controlled by an Android-based platform. *Teams* will use two (2) *Android Devices* to control their *Robot* and compete in a "*Sports Start*" model of competition. One *Android Device* is mounted directly onto the *Robot* and acts as a *Robot Controller*. The other *Android Device* is connected to a pair of gamepads and acts as the *Driver Station*.

For more information, tutorials, and to access our Android Technology forum, please visit:
https://www.firstinspires.org/resource-library/ftc/robot-building-resources

7.2.1 Robot Technology Definitions
Android Device – A smartphone running the Android operating system. See rules <RE06> and <RS03> for a list of allowed smartphones and operating system versions.

Driver Station – Hardware and software used by a *Drive Team* to control their *Robot* during a *Match*.

Java – The recommended programming language for the *Robot Controller*.

Logic Level Converter – An electronic device that allows an encoder or sensor, that operates using 5V logic levels, to work with the *REV Expansion Hub* and/or *REV Control Hub*, which operates using 3.3V logic levels. This device may contain a step-up voltage converter (from 3.3V to 5V) and a dual channel, bidirectional logic level converter. This device may be used directly with a 5V digital sensor or with an I^2C *Sensor Adaptor Cable* to a 5V I^2C sensor.

I^2C Sensor Adapter Cable – An adapter to change the pin orientation of the REV Robotics *Logic Level Converter* to match a Modern Robotics compatible I^2C sensor.

Mini USB to OTG (On-The-Go) Micro Cable – The connection between the *Android Device Robot Controller* and the *REV Expansion Hub*.

Op Mode – An *Op Mode* (short for "operational mode") is software that is used to customize the behavior of a competition *Robot*. The *Robot Controller* executes a selected *Op Mode* to perform certain tasks during a *Match*.

OTG Micro Adapter – Connects a USB hub to Micro USB OTG (On-The-Go) port on the *Driver Station* Android device.

REV Control Hub – An integrated electronic device with four (4) DC motor channels, six (6) servo channels, eight (8) digital I/O channels, four (4) analog input channels, and four (4) independent I2C buses. The *REV Control Hub* also serves as the *Robot Controller* when used in place of an *Android Device* connected to *a REV Control Hub*.

REV Expansion Hub – An integrated electronic device with four (4) DC motor channels, six (6) servo channels, eight (8) digital I/O channels, four (4) analog input channels, and four (4) independent I^2C buses.

REV SPARK Mini Motor Controller - An electronic device that accepts a PWM control signal (from a servo controller) and supplies 12V power to a DC motor.

REV Robotics Sensors – Sensors designed by REV Robotics that connect to a *REV Control* or *Expansion Hub*.

REV Servo Power Module – An electronic device that boosts the power supplied to 3-wire servos. A *REV Servo Power Module* has 6 input servo ports and 6 matching output ports. It draws power from a 12V source and provides 6V power to each output servo port. A *REV Servo Power Module* can provide up to 15A of current across all output servo ports for a total of 90 Watts of power per module.

Robot Controller – An allowed *Android Device* connected to a *REV Expansion Hub* or *REV Control Hub* located on the *Robot* that processes *Team* written software, reads on-board sensors, and receives commands from the *Drive Team* by way of the *Driver Station*. The *Robot Controller* sends instructions to the motor and servo controllers to make the *Robot* move.

UVC Compatible Camera – A USB Video Class *(UVC) Compatible Camera* is a digital camera that conforms to the USB Video Class specification.

7.3 Robot Rules

Anyone that has attended a *FIRST* Tech Challenge *Tournament* knows that *Teams* think outside the kit-of-parts to create unique and creative *Robot*s. The intent of the *Robot* construction rules is to create a level playing field and a framework for *Teams* to build *Robot*s that safely play the annual game challenge. *Teams* should read all the *Robot* rules before building their *Robot*. *Teams* can also reference our Legal and Illegal Parts List on our website for common legal and illegal *Robot* parts. Some suppliers' websites may claim that a part is *FIRST* Tech Challenge approved. The only official references for the legality of parts and materials are the Game Manual Part 1, the Legal and Illegal Parts List, and the Official Game Q&A Forum.

7.3.1 General Robot Rules

It is the intent of *FIRST* to encourage creativity in design as long as it does not present a safety hazard or unfairly affect the opportunities of any *Teams* to compete. Although there is significant creative freedom allowed in the *Robot* design rules, *Teams* should consider the adverse effects of any design decisions that they make. When considering your *Robot* design and your game strategy, ask yourself the following questions. If the answer to any of these questions is yes, the design part is not allowed:

- Could it damage or disable another *Robot*?
- Could it damage the *Playing Field*?
- Could it injure a participant or volunteer?
- Is there already a rule that restricts this?
- If everybody did this, would the gameplay be impossible?

<RG01> Illegal Parts - The following types of mechanisms and parts are not allowed:

a. Those used in a *Robot* drive system that could potentially damage the *Playing Field* and/or Scoring Elements such as high traction wheels (for example, AM-2256) and high grip tread (for example, Rough top).

b. Those that could potentially damage or flip other competing *Robot*s.

c. Those that contain hazardous materials such as mercury switches, lead, or lead containing compounds, or lithium polymer batteries (except for the *Android Devices'* internal batteries).

d. Those that pose an unnecessary risk of entanglement.

e. Those that contain sharp edges or corners.

f. Those that contain animal-based materials (because of health and safety concerns).

g. Those that contain liquid or gel materials.

h. Those that contain materials that would cause a delay of game if released (for example, loose ball bearings, coffee beans, etc.).

i. Those that are designed to electrically ground the *Robot* frame to the *Playing Field*.

j. Closed gas devices (for example, gas storage vessel, gas spring, compressors, etc.).

k. Hydraulic devices.

l. Vacuum based mechanisms.

<RG02> Maximum Starting Size - The maximum size of the *Robot* for starting a *Match* is 18 inches (45.72 cm) wide by 18 inches (45.72 cm) long by 18 inches (45.72 cm) high. A *Robot Sizing Tool* will be used as the official gauge to make sure *Robots* comply with this rule. To pass inspection a *Robot* must fit within the sizing tool while in its *Match* start configuration without exerting force on the sides or top of the sizing tool. *Robots* may expand beyond the starting size constraint after the start of the *Match*. Preloaded game elements may extend outside the starting volume constraint.

The *Robot* must be self-supporting while in the *Robot* Sizing tool by either:

a. A mechanical means with the *Robot* in a power-OFF condition. Any restraints used to maintain starting size (that is, zip ties, rubber bands, string, etc.) must remain attached to the *Robot* for the entire *Match*.

b. A *Robot* Initialization Routine in the Autonomous *Op Mode* that may pre-position the servo motors, with the *Robot* powered on, to the desired stationary position.

If the *Robot* Initialization routine moves the servos when a program is executed, there must be an indication label on the *Robot*. A warning label placed near the *Robot*'s main power switch is required. Attach the image ("WARNING! - *Robot* moves on Initialization") to your *Robot* near the *Robot* main power switch if servos are commanded to move during the initialization routine. To be easily seen by field personnel the label should be at least 1 in x 2.63 in (2.54 cm x 6.68 cm, Avery Label # 5160) and placed on a flat surface (not wrapped around corners or cylinders).:

<RG03> *Robot Controller* **Mount** – It is recommended that the *Robot Controller* be accessible and visible by field personnel. If a *Team's Robot Controller* is not accessible or visible to field personnel, the *Team* may not receive adequate support from the field personnel.

The *Robot Controller Android Device* should be mounted so the display screen is protected from contact with the *Playing Field* elements and other *Robot*s. This and other electrical parts (for example, batteries, motor and servo controllers, switches, sensors, wires) make poor bumpers and are unlikely to survive *Robot*-to-*Robot* contact during gameplay.

Important Note: The *Robot Controller* contains a built-in wireless radio that communicates with the *Android Device* in the *Driver Station*. The *Robot Controller* should not be obscured by metal or other material that could block or absorb the radio signals from the *Robot Controller*.

<RG04> *Team* **Number Display** - *Robot*s must prominently display their *Team* number (numerals only, for example "12345") on two separate signs.

a. The judges, referees, and announcers must be able to easily identify *Robot*s by *Team* number.

b. *Team* number must be visible from at least **two** opposite sides of the *Robot* (180 degrees apart).

c. The numerals must each be at least 2.5 inches (6.35 cm) high and in a contrasting color from their background.

d. *Team* numbers must be robust enough to withstand the rigors of *Match* play. Example robust materials include: 1) self-adhesive numbers (mailbox or vinyl numbers) mounted on polycarbonate sheet, wood panel, metal plate, etc. or 2) Ink jet or laser printed numbers on paper and laminated.

<RG05> Alliance Marker – *Robot*s must include a *Team* supplied, *Alliance* specific marker on two opposite sides of the *Robot* to easily identify which *Alliance* a *Robot* is assigned to. The *Alliance* marker must be displayed on the same side of the *Robot* as the *Team* number, within a 3" distance of the number. The *Alliance* marker must be visible to the referees during a *Match*.

a. The red *Alliance* marker must be a solid red square, 2.5 inches x 2.5 inches (6.35 cm x 6.35 cm) +/- 0.25 inches (0.64 cm).

b. The blue *Alliance* marker must be a solid blue circle, 2.5 inches (6.35 cm) +/- 0.25 inches (0.64 cm) in diameter.

c. Both *Alliance* markers must be removeable in order to swap them between *Matches*.

d. The *Alliance* marker must be robust enough to withstand the rigors of *Match* play. Example robust materials include: 1) *Alliance* marker template printed and laminated; mounted on polycarbonate sheet, wood panel, metal plate, etc.

The intent of this rule is to allow easy identification of the *Robot* and their *Alliance* to field personnel. *Alliance* flags will no longer be provided by *Tournament* directors. A template for *Teams* is located on our [website](#).

<RG06> Allowed Energy Sources - Energy used by *FIRST* Tech Challenge *Robot*s (that is, stored at the start of a *Match*), shall come only from the following sources:

a. Electrical energy drawn from approved batteries.

b. A change in the position of the *Robot* center of gravity.

c. Storage achieved by deformation of *Robot* parts. *Teams* must be careful when incorporating spring-like mechanisms or other items to store energy on their *Robot* by means of part or material deformation.

<RG07> Launching *Robot* Parts - Parts of the *Robot* itself may not be launched (i.e. able to move independently of the *Robot*), even if the part that is *launched* is still connected to the *Robot* by a tether (for example, wire, rope, or cable).

<RG08> Launching Game Scoring Elements – *Robot*s can launch (i.e. able to move independently of the *Robot*) scoring elements through the air unless limited by a game specific rule. *Teams* must only *launch* the elements with enough velocity to score. *Launching* elements with excessive velocity could create a safety hazard for other *Teams* and field personnel. If the referees feel that a *Robot* is *launching* scoring elements with excessive velocity, the *Robot* must be re-inspected. *Robot*s must then show that a *launched* scoring element cannot travel in the air more than a 16 ft. (4.88 m) distance or more than 5 ft. (1.52 m) in elevation.

7.3.2 Robot Mechanical Parts and Materials Rules

<RM01> Allowed Materials - *Teams* may use raw and post-processed materials to build their *Robots*, provided these materials are readily available to all *Teams* (for example, McMaster-Carr, Home Depot, Grainger, AndyMark, TETRIX/PITSCO, MATRIX/Modern Robotics, REV Robotics, etc.).

Examples of allowed raw materials are:

- Sheet goods
- Extruded shapes
- Metals, plastics, wood, rubber, etc.
- Magnets

Examples of allowed post-processed materials are:

- Perforated sheet and diamond plate
- Injection molded parts
- 3D printed parts
- Cable, string, rope, filament, etc.
- Springs of all types: compression, extension, torsion, surgical tubing, etc.

<RM02> Commercial Off-The-Shelf Parts - *Teams* may use Commercial Off-The-Shelf (COTS) mechanical parts that have a single degree of freedom. For the *FIRST* Tech Challenge, a single degree of freedom part uses a single input to create a single output. The following are examples of single degree of freedom parts:

- Linear Actuator: a single rotary input results in a single direction linear output
- Pully: rotates around a single axis
- Single Speed Gearbox: a single rotary input results in a single rotary output

It is the intent of *FIRST* to encourage *Teams* to design their own mechanisms rather than buying pre-designed and pre-manufactured solutions to achieve the game challenge. Purchased mechanism kits (for example, grippers) that violate the single degree of freedom rule, either assembled or requiring assembly, are not allowed. COTS drive chassis (for example, AndyMark TileRunner, REV Robotics Build Kit) are allowed provided none of the individual parts violate any other rules. Holonomic wheels (omni or mechanum) are allowed.

Examples of allowed COTS parts:

- Linear Slide Kit
- Linear Actuator kit
- Single Speed (non-shifting) gearboxes
- Pulley
- Lazy Susan
- Lead screws

Examples of illegal multiple degrees of freedom parts:

- Gripper assemblies or kits
- Ratcheting wrenches

<RM03> Modifying Materials and COTS Parts - Allowed materials and legal COTS parts may be modified (drilled, cut, painted, etc.), as long as no other rules are violated.

<RM04> Allowed Assembly Methods - Welding, brazing, soldering, and fasteners of any type are legal methods for assembling a *Robot*.

<RM05> Lubricant - Any COTS lubricant is allowed, if it doesn't contaminate the *Playing Field*, scoring elements or other *Robot*s.

7.3.3 Robot Electrical Parts and Materials Rules

There are many possible ways to build and wire a *Robot*. These rules provide specific requirements on what is and is not allowed. *Teams* must ensure that electrical and electronic devices are used consistently with manufacturer's requirements and specifications. *Teams* are encouraged to review the *FIRST* Tech Challenge Robot Wiring Guide for suggestions on how to build a *Robot* with safe and reliable wiring.

<RE01> Main Power Switch - The *Robot* Main Power Switch must control all power provided by the *Robot* main battery pack. *FIRST* requires *Teams* to use either the TETRIX (part # W39129), MATRIX (part # 50-0030), or REV (REV-31-1387) power switch. This is the safest method for *Teams* and field personnel to shut down a *Robot*.

The *Robot* main power switch must be mounted or positioned to be readily accessible and visible to field personnel. A Main *Robot* Power label must be placed near the Main Power Switch of the *Robot*. Attach the image ("POWER BUTTON") to your *Robot* near the Main Power Switch. To be easily seen by field personnel the label should be at least 1 in x 2.63 in (2.54 cm x 6.68 cm, Avery Label # 5160) and placed on a flat surface (not wrapped around corners or cylinders).
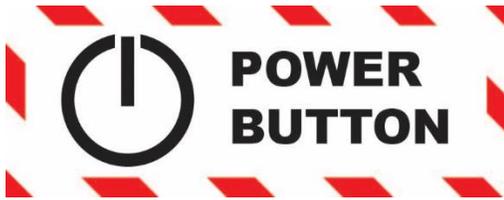
The *Robot* main power switch should be mounted on the *Robot* so it is protected from *Robot*-to-*Robot* contact to avoid inadvertent actuation or damage.

<RE02> Battery Mount - Batteries must be securely attached (for example, VELCRO, zip tie, rubber band) to the *Robot* in a location where they will not make direct contact with other *Robot*s or the *Playing Field*. Batteries should be protected from contact with sharp edges and protrusions (screw heads, screw ends, etc.)

<RE03> *Robot* Main Battery – All *Robot* power is provided by exactly one (1) 12V *Robot* main battery. Only one (1) of the approved battery packs is allowed on the *Robot*.

The only allowed *Robot* main power battery packs are:

   a. TETRIX (W39057, formally 739023) 12V DC battery pack

   b. Modern Robotics/MATRIX (14-0014) 12V DC battery pack

   c. REV Robotics (REV-31-1302) 12V DC Slim Battery pack

Note: There are similar looking batteries available from multiple sources, but the ONLY legal batteries are those listed above.

<RE04> Fuses - 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.

<RE05> *Robot* **Power** - *Robot* power is constrained by the following:

a. Allowed electronic devices may only be powered by power ports on the *REV Expansion Hub* or *REV Control Hub* except as follows:

   i. The *REV Expansion Hub* and *REV Control Hub* are powered by the *Robot* main battery.

   ii. *REV SPARK Mini Motor Controllers* are powered by the *Robot* main battery.

   iii. Allowed sensors connected to the *REV Expansion Hub* or *REV Control Hub.*

   iv. Light sources per <RE12>.

   v. Video cameras per <RE13>.

b. The *Robot Controller Android Device* must be powered by its own internal battery or by the built-in charging feature of the *REV Expansion Hub*; external power is not allowed.

<RE06> Robot Controller – Exactly one (1) *Robot Controller* is required. An optional *REV Expansion Hub* may be also be added.

<RE07> *Android Devices* - The following *Android Devices* are allowed:

a. Motorola Moto G 2nd Generation

b. Motorola Moto G 3rd Generation

c. Motorola Moto G4 Play (4th Generation)/Motorola Moto G4 Play*

d. Motorola Moto G5

e. Motorola Moto G5 Plus

f. Motorola Moto E4 (USA versions only, includes SKUs XT1765, XT1765PP, XT1766, and XT1767)

g. Motorola Moto E5 (XT1920)

h. Motorola Moto E5 Play (XT1921)

No other *Android Devices* may be used as *Robot Controllers* or *Driver Stations.* See Rule <RS03> for the approved list of Android Operating System versions.

An *Android Device Robot Controller* USB interface may only connect to a *REV Expansion Hub*, or a USB hub.

*The Motorola Moto G4 Play may be sold as either Motorola Moto G Play (4th gen)", or "Motorola Moto G4 Play". Either phone is acceptable however *FIRST* Tech Challenge highly recommends that *Teams* purchase either model number XT1607 or XT1609, as these are the US versions and have been tested and are fully compatible with the *FIRST* Tech Challenge software. *Teams* that have purchased phones with model numbers XT1601, XT1602, XT1603, or XT1604 may continue to use these phones as legal, however there is a potential for issues with these phones not being fully compatible with the software.

<RE08> Control Module Quantities - The Control Module consists of one of the following:

a. A *REV Control Hub*; or

b. *An allowed Android Device connected to a REV Expansion Hub*

In addition to "a" or "b" above, you may add:

    c.   No more than one additional REV Expansion Hub

    d.   Any quantity of *REV SPARK Mini Motor Controllers*

    e.   Any quantity of *REV Servo Power Modules*

<RE09> Motor and Servo Controllers – The only allowed Motor and Servo Controllers are: *REV Expansion Hub*, *REV Control Hub*, *REV Servo Power Module*, *REV SPARK Mini Motor Controller,* and VEX Motor Controller 29.

<RE10> DC Motors – A maximum of eight (8) DC motors are allowed in any combination. The only allowed motors are:

    a.   TETRIX 12V DC Motor

    b.   AndyMark NeveRest series 12V DC Motors

    c.   Modern Robotics/MATRIX 12V DC Motors

    d.   REV Robotics HD Hex 12V DC Motor

    e.   REV Robotics Core Hex 12V DC Motor

No other DC motors are allowed.

<RE11> Servos – A maximum of twelve (12) servos are allowed. Any servo that is compatible with the attached servo controller is allowed. Servos may only be controlled and powered by a *REV Expansion Hub, REV Control Hub,* or *REV Servo Power Module*. Servos may be rotary or linear but are limited to 6V or less and must have the three-wire servo connector.

The VEX EDR 393 motor is considered a servo. It must be used in conjunction with a VEX Motor Controller 29 and a *REV Servo Power Module.* A maximum of two (2) VEX EDR 393 Motors per *REV Servo Power Module* is allowed.

<RE12> Sensors - Sensors are subject to the following constraints:

    a.   Compatible sensors from any manufacturer may be connected to the *REV Expansion Hub* or *REV Control Hub.*

    b.   Compatible sensors from any manufacturer may be connected to the *Logic Level Converter and/or the I^2C Sensor Adapter Cable.* Refer to Rule <RE14.k> for details on the use of *Logic Level Converter* and the I^2C *Sensor Adapter Cable.*

    c.   Passive electronics may be used as recommended by sensor manufacturers at the interfaces to the sensors.

    d.   Voltage sensors are allowed; except on an output port of a motor or servo controller.

    e.   Current sensors are allowed; except on an output port of a motor or servo controller.

    f.   Simple I^2C multiplexers are allowed and they may only be connected to and powered from the I^2C connections available on *REV Expansion Hub* or *REV Control Hub.*

g. Voltage and/or current sensors are also allowed to connect between the battery pack and the *REV Expansion Hub* or *REV Control Hub.*

<RE13> Light Sources - Functional and/or decorative light sources (including LEDs) are allowed with the following constraints:

a. Focused or directed light sources (for example: lasers and mirrors) are not allowed except for the REV Robotics 2m Distance sensor (REV-31-1505).

b. Light-source control by compatible ports on the *REV Expansion Hub* or *REV Control Hub* is allowed.

c. Commercial Off the Shelf (COTS) interface modules (without user programmable microprocessors) are allowed between the light source and the components listed in <RE12>b.

d. The only approved power sources for lights are as follows:

   i. Internal (as supplied by the Commercial Off the Shelf manufacturer) battery pack or battery holder.

   ii. *REV Expansion Hub* or *REV Control Hub* Motor-control ports, spare XT30 ports, 5V auxiliary power ports, and I2C sensor ports.

> The common rates to trigger seizures is between 3 and 30 hertz (flashes per second), but varies from person to person. While some people are sensitive to frequencies up to 60 hertz, sensitivity under 3 hertz is not common. Please keep in mind that event attendees could have sensitivities to flashing lights. [1]
>
> *Teams* that choose to install flashing lights should ensure the lights can be turned either completely off or on (not flashing). Tournament directors have the discretion of asking *Teams* to turn their lights to either state if an event attendee or participant has a sensitivity to flashing lights.
>
> *Teams* may still use LED lights to signal events provided the flash rate is approximately 1 hertz or less (e.g. cannot change states more frequently than approximately once a second). For example:
>
>   • *Teams* may signal via LED light that they have a scoring element ready.

<RE14> Video Cameras
a. 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. Approved self-contained video cameras must be powered by an internal battery (as supplied by the manufacturer).

b. *UVC Compatible Cameras* are allowed for computer vision-related tasks. It is recommended that *UVC Compatible Cameras* be connected directly to a *REV Control Hub,* or through a powered USB hub that is in turn connected to an *Android Device Robot Controller* through an OTG adapter.

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[1] See https://www.epilepsysociety.org.uk/photosensitive-epilepsy#.XuJbwy2ZPsE accessed on 7/10/2020

<RE15> *Robot* **Wiring** - *Robot* wiring is constrained as follows:

a. USB surge protectors connected to USB cables are allowed.

b. Ferrite chokes (beads) on wires and cables are allowed.

c. A *Mini USB to OTG (On-The-Go) Micro Cable or any combination of* a *Mini USB cable, a USB hub,* and an *OTG Micro Adapter may be* used to connect the *Robot Controller Android Device* to the *Robot* electronics. Note that the *OTG Micro Adapter* may be integrated into the USB hub. These devices may connect to the *Robot* electronics in the following ways:

   i. Built-in USB input port of the *REV Expansion Hub* or *REV Control Hub, or*

   ii. A USB hub that connects to the built-in USB input port of the *REV Expansion Hub* or *REV Control Hub.* If a powered hub is used, it must draw its energy from either

      i. A commercial USB battery pack, or

      ii. A 5V auxiliary power port on a *REV Expansion Hub* or *REV Control Hub.*

d. Anderson Powerpole, and similar crimp or quick-connect style connectors are recommended for joining electrical wires throughout the *Robot.* Power distribution splitters are recommended where appropriate to reduce wiring congestion. All connectors and distribution splitters should be appropriately insulated.

e. Installed connectors (such as battery-pack connectors, battery charger connectors) may be replaced with Anderson Powerpole or any compatible connector.

f. Power and motor control wires must use consistent color-coding with different colors used for the positive (red, white, brown, or black with a stripe) and negative/common (black or blue) wires.

g. Wire and cable management products of any type are permitted (for example, cable ties, cord clips, sleeving, etc.).

h. Wire insulation materials of any type are permitted when used to insulate electrical wires or secure motor control wires to motors (for example, electrical tape, heat shrink, etc.).

i. Power, motor control, servo, encoder, and sensor wires and their connectors may be extended, modified, custom made, or COTS subject to the following constraints:

   i. Power wires are 18 AWG or larger.

   ii. Motor control wires as follows:

      i. 22 AWG or larger for TETRIX Max 12V DC motors and REV Robotics Core Hex (REV-41-1300) 12V DC motors

      ii. 18 AWG or larger for all other 12V DC motors

   iii. PWM (servo) wires are 22 AWG or larger.

iv. Sensor wires should be the same size or larger than the original wiring.

> *Teams* should be prepared during *Robot* inspection to show documentation confirming the wire gauges used; particularly for multi-conductor cables.

j. *Logic Level Converters* – *Logic Level Converters* that are used to connect a *REV Expansion Hub* or *REV Control Hub* to a 5V-compatible I^{2}C sensor or a 5V-compatible digital sensor are allowed. Exactly one *Logic Level Converter* per I^{2}C device and one *Logic Level Converter* per digital sensor are allowed. A *Logic Level Converter* should only draw power from the *REV Expansion Hub* or *REV Control Hub*.

k. Electrically grounding the Control System electronics to the frame of the *Robot* is recommended and only permitted using a *FIRST*-approved, commercially manufactured Resistive Grounding Strap. The only Resistive Grounding Strap approved for use is the REV Robotics Resistive Grounding Strap (REV-31-1269). *Teams* that have electronics with Powerpole-style connectors may also use the REV Robotics Anderson Powerpole to XT30 Adapter (REV-31-1385) in conjunction with the REV Robotics Resistive Grounding Strap. No other grounding straps or adapters are permitted. For additional details on installation of the grounding strap or adapter, please see the Robot Wiring Guide.

<RE16> Modifying Electronics - Approved electrical and electronic devices may be modified to make them more usable; they may not be modified internally or in any way that affects their safety.

> Examples of modifications that are allowed:
>
> - Shortening or extending wires
> - Replacing or adding connectors on wires
> - Shortening motor shafts
> - Replacing gearboxes and/or changing gears
>
> Examples of modifications that are **not** allowed:
>
> - Replacing an H-Bridge in a motor controller
> - Rewinding a motor
> - Replacing a fuse with a higher value than specified by the manufacturer
> - Shorting out a fuse
> - Changing internal servo components to convert a limited rotation angle servo to a continuous rotation servo or the reverse conversion.

<RE17> *Driver Station* Constraints – *Teams* provide their own *Driver Station* and it must comply with the following constraints:

a. The *Driver's Station* must consist only of:

i. One (1) *Android Device*

ii. One (1) OTG Cable

iii. No more than one (1) USB hub

iv. No more than one (1) COTS USB external battery

v. No more than two (2) gamepads

vi. Any components used to hold the above listed legal devices.

b. The *Driver Station Android Device* USB interface may only connect to either:

    i. A Mini *USB to OTG* (On-The-Go) cable or combination of cables connected to a USB Hub, or

    ii. One (1) gamepad, USB cable, and an *OTG Micro Adapter*.

c. One optional COTS USB external battery connected to the USB Hub to charge the *Android Device* is allowed.

d. The only allowed gamepads are listed below. They may be used in any combination.

    i. Logitech F310 gamepad (Part# 940-00010)

    ii. Xbox 360 Controller for Windows (Part# 52A-00004)

    iii. Sony DualShock 4 Wireless Controller for PS4 (ASIN # B01LWVX2RG) operating in wired mode only (i.e., connected through USB 2.0 Type A to Type B Micro cable with Bluetooth turned off)

    iv. Etpark Wired Controller for PS4 (ASIN # B07NYVK9BT) The touch display screen of the *Driver Station* must be accessible and visible by field personnel.

e. The touch display screen of the *Driver Station* must be accessible and visible by field personnel.

Important Note: The *Driver Station* is a wireless device with a built-in wireless radio. During a *Match*, the *Driver Station* should not be obscured by metal or other material that could block or absorb the radio signals from the *Driver Station*.

<RE18> Additional Electronics – Electronic devices that are not specifically addressed in the preceding rules are not allowed. A partial list of electronics that are not allowed includes: Arduino boards, Raspberry Pi, relays, and custom circuits.

7.3.4 Robot Software Rules

<RS01> Device Names - Each *Team* MUST "name" their *Robot Controller* with their official *FIRST* Tech Challenge *Team* number and –RC (for example, "12345-RC"). Each *Team* MUST "name" their *Driver Station* with their official *Team* number and –DS (for example, 12345-DS). *Teams* with more than one *Driver Station* or *Robot Controller Android Device* must name these devices with the *Team* number followed by a hyphen then a letter designation beginning with "A" (for example, "12345-A-RC", "12345-B-RC").

<RS02> Recommended Programming Tools - The following tools are recommended for use in the *FIRST* Tech Challenge:

a. FTC Blocks Development tool – a visual, blocks-based programming tool hosted by the *Robot Controller*.

b. FTC OnBot Java Programming tool – a text-based integrated development environment hosted by the *Robot Controller*.

c. Android Studio – a text-based integrated development environment.

d. Java Native Interface (JNI) & Android Native Development Kit (NDK) – *Teams* can incorporate native code libraries into their apps using the JNI framework and the Android NDK.

<RS03> Allowed Software System Versions - The following table lists the *Android Devices*, minimum Android versions, minimum operating system and firmware versions, and minimum FTC software versions allowed per device.

Android Phones		
Device	**Minimum Android Version**	**Minimum FTC Software Version**
Motorola Moto G 2nd Generation	6.0 (Marshmallow)	
Motorola Moto G 3rd Generation	6.0 (Marshmallow)	
Motorola Moto G4 Play (4th Generation) / Motorola Moto G4 Play (See <RE06> for details)	7.0 (Nougat)	
Motorola Moto G5	7.0 (Nougat)	
Motorola Moto G5 Plus	7.0 (Nougat)	UltimateGoal 6.0
Motorola Moto E4 (USA versions only, includes SKUs XT1765, XT1765PP, XT1766, and XT1767)	7.0 (Nougat)	
Motorola Moto E5 (XT1920)	7.0 (Nougat)	
Motorola Moto E5 Play (XT1921)	7.0 (Nougat)	

REV Hubs		
Device	**Minimum Software**	**Minimum FTC Software Version**
REV Control Hub	O/S Version 1.1.1	UltimateGoal 6.0
REV Expansion Hub	Firmware version 1.8.2	
Note: The REV PC Hub Interface Software is used to install Firmware and Operating Systems onto the REV Hubs. Its minimum version number is 1.2.0.		

IMPORTANT: Rules <RS02> or <RS03> do not require that *Teams* upgrade to the latest version of the software. A mandatory upgrade (announced by *FIRST*) would only be required if *FIRST* determined there was a critical software fix that must be adopted by *Teams*. *Teams* must install the upgrade before the time of competition. Additionally, beta versions of the software are allowed at official tournaments. Mandatory upgrades will be communicated in the following ways:

- Via *Team* Blast – The mandatory upgrade and version number will be communicated to *Teams* on the *Team* Blast, which will also show the date the required upgrade must be made.
- Online – the minimally required software will be listed on our Technology Resources page, with the date *Teams* are required to make the mandatory software upgrade.
- Forum – The minimally required software will be listed in the Technology Forum page, with the date *Teams* are required to make the mandatory software upgrade.

Templates for all programming choices are available through the links located at http://www.firstinspires.org/node/5181.

<RS04> Autonomous to Driver-Controlled Transition - *Teams* that expect to operate their *Robot* during the Autonomous period must demonstrate during Field Inspection the *Driver Station* switches the *Robot Controller* between Autonomous mode and Driver-Controlled mode.

<RS05> *Robot Controller* App - The *Robot Controller Android Device* (if used) must have a designated "FTC *Robot Controller*" app that is the default application for the *REV Expansion Hub.* The *Robot Controller* App

must not be installed on the *Driver Station Android Device.*

<RS06> *Driver Station* **App –** *Teams* must install the official "FTC *Driver Station"* app onto their *Driver Station Android Device* and use this app to control their *Robot* during a *Match.* The *Driver Station* software version number must match the version number of the *Robot Controller* app. The *Driver Station* App must not be installed on the *Robot Controller Android Device.*

<RS07> *Android Device* **and** *REV Control Hub* **Operating System Settings** - The *Robot Controller* and *Driver Station* must be set to:

   a) Airplane mode must be turned on (does not apply for *Teams* using the *REV Control Hub*).

   b) Bluetooth must be turned off

   c) Wi-Fi must be turned on.

   d) *REV Control Hub* password must be different than the factory default value of "password."

<RS08> Software Modification -
   a) *Teams* are not allowed to modify the *FIRST* Tech Challenge *Driver Station* App in any fashion.

   b) *Teams* are required to use the *FIRST Robot Controller* SDK, and are not allowed to remove, replace, or modify the portions of the SDK which are distributed as binary .AAR files.

> The intent of this rule is for *Teams* to download the official version of the SDK from *FIRST* and make modifications to add *Team* created code*.*
>
> Reengineered, reverse engineered, or modified versions of the official *FIRST* SDK are not allowed.

<RS09> *Driver Station* **Communication** - Communication between the *Robot* and *Driver Station* is only allowed via the *Robot Controller* and *Driver Station* applications.

Communication between the *Robot Controller* and the *Driver Station* is limited to the unmodified mechanisms provided by the official *FIRST* Tech Challenge (FTC) software, which consists of the official FTC Software Development Kit (SDK), the FTC *Robot Controller* app, and the FTC *Driver Station* app. *Teams* are not permitted to stream audio, video or other data using third-party software or modified versions of the FTC software. *Teams* may only use the unmodified telemetry feature included with the FTC software to transfer additional data between the *Robot Controller* and the *Driver Station.* Software that is preinstalled by an approved phone's manufacturer and cannot be disabled is exempt from this constraint.

During a *Match*, a *Team's Robot Controller* and a *Team's Driver Station* are not allowed to be connected wirelessly to any other device besides each other.

8.0 Robot Inspection

8.1 Description
Teams are highly recommended to conduct a *Robot* and Field self-inspection prior to competing. These inspections will ensure that all *Robot* rules and regulations are met. The official "*Robot* & Field Inspection Checklists" are located in Appendices B and C.

9.0 Judging and Award Criteria

Information on judging and award criteria for the 2020-2021 season will be released at a later date.

10.0 Dean's List Award

In an effort to recognize the leadership and dedication of *FIRST's* most outstanding secondary school students, the Kamen family sponsors an award for selected 10th and 11th grade students known as the *FIRST* Robotics Competition and *FIRST* Tech Challenge Dean's List.

Similar to the very prestigious National Merit Scholarship Award winners, there are three (3) "categories" of *FIRST* Dean's List Award students:

1. **FIRST Dean's List Semi-finalists – comprised of the two (2) students in their 10th or 11th grade school year nominated by each** *Team*.
2. **FIRST Dean's List Finalists – comprised of the students (2, 3, or 4, depending on the region) selected at** each State/Regions Championship.
3. **FIRST Dean's List Winners – comprised** of the ten (10) *FIRST* Robotics Competition and ten (10) *FIRST* Tech Challenge students selected from the applicable *FIRST* Dean's List Finalists at the *FIRST* Championship.

The students who earn *FIRST* Dean's List Award status as a Semi-finalists, Finalist or Winner, are great examples of student leaders who have led their *Teams* and communities to increased awareness for *FIRST* and its mission. These students have also achieved personal technical expertise and accomplishment. It is *FIRST's* that these individuals will continue, post-award, as great leaders, student alumni, and advocates of *FIRST*.

Prestigious colleges have expressed great interest in meeting *FIRST* Dean's List's Award winners and *FIRST* hopes that each *Team* will take advantage of the opportunity to nominate the most qualified students as *FIRST* Dean's List Nominees!

For more information on the Dean's List Award, and to see past *FIRST* Tech Challenge winners, please visit our website! http://www.firstinspires.org/Robotics/ftc/deans-list

10.1 Eligibility
Every registered *FIRST* Tech Challenge *Team* can submit up to two (2) students as *FIRST* Dean's List Award Semi-Finalists.

- Students must be a sophomore (grade 10) or junior (grade 11) to be eligible for this award.
    - Note: For regions of the world that do not use grade levels such as this to identify years of schooling: This award is intended for students who are two (2) to three (3) years away from entering college or university. Students that would be attending college or university in the next academic year are not eligible. Mentors will be asked for the year of graduation during the nomination process.
- The coach or mentor nominating the student(s) must submit an essay explaining why the student should receive this award. The essay must be 4,000 characters or less.

10.2 Criteria
Criteria for selection of the *FIRST* Dean's List shall include, but not be limited to a student's:

- Demonstrated leadership and commitment to *FIRST* Core Values
- Effectiveness at increasing awareness of *FIRST* in their school and community
- Interest in and passion for a long-term commitment to *FIRST*
- Overall individual contribution to their *Team*
- Technical expertise and passion

- Entrepreneurship and creativity
- Ability to motivate and lead fellow *Team* members

10.3 Dean's List Nominations

There are specific instructions on how to submit Dean's List Nominations. There are two sets of instructions, The Dean's List Nomination Guide – US, and the Dean's List Nomination Guide – International. Please visit our [website](#) for a copy of the guides, which provides in depth information about the Dean's List, and step by step visual aids to complete the nominations.

Appendix A – Resources

Game Forum Q&A

https://ftcforum.firstinspires.org/
Anyone may view questions and answers within the *FIRST*® Tech Challenge game Q&A forum without a password. To submit a new question, you must have a unique Q&A system username and password for your team.

FIRST Tech Challenge Game Manuals

Part 1 and 2 - https://www.firstinspires.org/resource-library/ftc/game-and-season-info

FIRST Headquarters Pre-Event Support

Phone: 603-666-3906
Mon – Fri
8:30am – 5:00pm
Email: Firsttechchallenge@firstinspires.org

FIRST Websites

FIRST homepage – www.firstinspires.org

FIRST Tech Challenge Page – For everything *FIRST* Tech Challenge.

FIRST Tech Challenge Event Schedule – Find *FIRST* Tech Challenge events in your area.

FIRST Tech Challenge Social Media

FIRST Tech Challenge Twitter Feed - If you are on Twitter, follow the *FIRST* Tech Challenge Twitter feed for news updates.

FIRST Tech Challenge Facebook page - If you are on Facebook, follow the *FIRST* Tech Challenge page for news updates.

FIRST Tech Challenge YouTube Channel – Contains training videos, game animations, news clips, and more.

FIRST Tech Challenge Blog – Weekly articles for the *FIRST* Tech Challenge community, including outstanding volunteer recognition!

FIRST Tech Challenge Team Email Blasts – contain the most recent *FIRST* Tech Challenge news for teams.

Feedback

We strive to create support materials that are the best they can be. If you have feedback about this manual, please email firsttechchallenge@firstinspires.org. Thank you!

Appendix B – Robot Inspection Checklist

Team Number: _____   Robot Inspection Status (circle): **PASS / FAIL**

Team	Insp.	Robot Size Inspection	Rule #
		Robot is presented at inspection with all mechanisms (including all components of each mechanism), configurations, and decorations that will be used on the Robot during the competition.	<I7>
		Separately test the Robot in all of its unique starting (pre-match setup) configurations. The Robot fits within the Sizing Tool without exerting undue force on the Sizing Tool sides and top.	<I7>a RG02>
		Robot Motion Warning Label is attached if servo motors move during the Robot initialization.	<RG02>
✔	✔	**General Robot Rules**	**Rule #**
		Robot does not contain any components that could damage the Playing Field or other Robots.	<RG01>a&b
		Robot does not contain materials that are hazardous.	<RG01>c
		Robot poses no obvious unnecessary risk of entanglement.	<RG01>d
		Robot does not contain sharp edges or corners.	<RG01>e
		Robot does not contain animal-based, liquid, or gel materials.	<RG01>f&g
		Robot does not contain materials that would cause a delay of game if released.	<RG01>h
		Robot does not contain elements that electrically ground the Robot frame to the Playing Field.	<RG01>i
		Robot does not contain closed gas devices.	<RG01>j
		Robot does not contain hydraulic devices.	<RG01>k
		Robot does not contain vacuum based mechanisms.	<RG01>l
		Team number is visible from at least 2 sides and meets requirements.	<RG04>
		Alliance Markers are present and meet requirements.	<RG05>
		Energy used by the Robot, (i.e., stored at the start of a Match), shall come only from approved sources.	<RG06>
		Robot is not capable of launching its own components.	<RG07>
✔	✔	**Robot Mechanical Parts and Materials Rules**	**Rule #**
		All components on the Robot are from allowable raw materials and Commercial Off The Shelf products.	<RM01> <RM02>
✔	✔	**Robot Electrical Parts and Materials Rules**	**Rule #**
		The Main Power Switch is installed properly, labeled, readily accessible, and visible to competition personnel. The TETRIX, REV, and MATRIX switches are the only allowed Main Power Switch.	<RE01>
		All batteries are securely attached to the Robot in a location where they will not make direct contact with other Robots or the Playing Field.	<RE02>
		Exactly one (1) Robot Main Battery Pack of an approved type is on the Robot and it is properly connected to the Main Power Switch and either the REV Expansion Hub or REV Control Hub.	<RE03> <RE05>a(i)
		Where present, fuses must not be replaced with fuses of higher rating than originally installed or according to manufacturer's specifications. Replaceable fuses are single use only.	<RE04>
		Allowed electronic devices are powered by power ports on the REV Expansion Hub or REV Control Hub except as noted in <RE05>a&b, <RE12>, and <RE13>.	<RE05>a
		The REV Expansion Hub and/or REV Control Hub is powered by the Robot main battery.	<RE05>a(i)
		REV SPARK Mini Motor Controllers are powered by the Robot main battery.	<RE05>a(ii)
		Allowed sensors may only receive power from the REV Expansion Hub or REV Control Hub	<RE05>a(iii)
		Light sources (including LEDs) are not focused or directed in any way, except for the REV Robotics 2m Distance Sensor. Light sources are powered by allowed methods.	<RE05>a(iv) <RE13>

		Video recording devices, if used, are powered by an internal battery and their wireless communication capability is turned off.	<RE05>a(v) <RE14>
		The Robot Controller Android device (if used) is powered by its internal battery or by the built-in charging feature of the REV Expansion Hub.	<RE05>b
		Exactly one Robot Controller (a) Android Device + REV Expansion Hub or b) REV Control Hub) is required. One additional REV Expansion Hub is allowed.	<RE06> <RE08>
		The only allowed Motor and Servo Controllers are: REV Expansion Hub, REV Control Hub, REV Servo Power Module, REV Spark Mini Motor Controller, and VEX Motor Controller 29.	<RE09>
		Robot contains no more than eight (8) DC motors of the allowed models.	<RE10>
		Robot contains no more than twelve (12) servos. They must be compatible with the attached REV Expansion Hub, REV Control Hub, REV Servo Power Module, or VEX Motor Controller 29 and not exceed the manufacturer specifications for the controller.	<RE11>
		Robot contains only allowed sensors and they are connected only to the REV Expansion Hub or the REV Control Hub.	<RE12>
		Power and motor control wires must use consistent color coding with different colors used for the positive (red, white, brown, or black with a stripe) and Negative/Common (black or blue) wires.	<RE15>f
		Power, motor control, servo and sensor wires are the correct size.	<RE15>i
		If electronics are grounded to the *Robot* frame, the only approved method is the REV Robotics Resistive Grounding Strap. If needed, the REV Robotics Anderson Powerpole to XT30 adapter may connect to the Resistive Grounding Strap. No other grounding straps or cables are allowed.	<RE15>k
		Approved electrical and electronic devices may be modified to make them more usable; they may not be modified internally or in any way that affects their safety.	<RE16>
✔	✔	**Wheel/Tread Playing Field Damage Test - Optional**	**Rule #**
		Robot did not damage the Playing Field tile. [This is an optional test that is performed only when an Inspector believes that the drivetrain tread may damage a Playing Field tile.]	<I7>

General Comment(s) or Reason(s) for Failure (if any):

Robot Inspector

Appendix C – Field Inspection Checklist

Team Number: _____   Field Inspection Status (circle): **PASS / FAIL**

✔		**Drive Team Members Present**	**Rule #**
		Coach (required), driver 1 (required); driver 2 (optional); *Human Player* (optional)	<C06>
✔		**Driver Station and Robot Controller Hardware Rules**	**Rule #**
		Driver Station consists only of one Android device (Circle): Motorola Moto G 2nd Generation, Motorola Moto G 3rd Generation, Motorola Moto G4 Play, Motorola Moto G5, Motorola G5 Plus, Motorola Moto E4, Motorola Moto E5, or Motorola Moto E5 Play.	<RE07> <RE17>a
		Robot Controller Android device (if used) is one of the following models (Circle): Motorola Moto G 2nd Generation, Motorola Moto G 3rd Generation, Motorola Moto G4 Play, Motorola Moto G5, Motorola G5 Plus, Motorola Moto E4, Motorola Moto E5, Motorola Moto E5 Play. The Android device's USB interface only connects to a REV Expansion Hub or a USB hub.	<RE07>
		Driver Station Android device USB interface is only connected to either a Mini USB to OTG cable or combination of cables connected to one USB Hub, or one gamepad.	<RE17>b
		No more than one (1) optional Commercial Off The Shelf USB external battery connected to the Driver Station USB hub is allowed.	<RE17>c
		The Driver Station consists of no more than two of the allowed gamepads (Logitech F310, Xbox 360, wired Sony DualShock 4 for PS4, or Etpark Wired Controller for PS4) in any combination.	<RE17>a&d
		The touch display screen of the Driver Station must be accessible and visible to field personnel.	<RE17>e

DS	RC	**Driver Station (DS) and Robot Controller (RC) Software Rules**	**Rule #**
		Android operating system satisfies the requirements: Motorola Moto G 2nd Generation and Motorola Moto G 3rd Generation – version 6.0 or higher. All other allowed Android devices – version 7.0 or higher.	<RS03>
		REV Control Hub (if used) operating system is version 1.1.1 or higher.	<RS03>
		REV Expansion Hub (if used) firmware version is 1.8.2 or higher.	<RS03>
		Android phones are set to airplane mode, Wi-Fi is turned on, and Bluetooth is turned off.	<RS07>
NA		REV Control Hub (if used) has Wi-Fi turned on, Bluetooth is turned off, and the password is different than the factory default value of "password".	<RS07>
		Android devices are not connected to any local networks.	<RS09>
		Android phone(s) and REV Control Hub (if used) are named with the official team number followed by –DS or –RC as appropriate.	<RS01>
		All remembered Wi-Fi Direct Groups and Wi-Fi connections on Android devices have been removed.	
		DS and RC apps are version 6.0 or higher and the DS and RC apps have the same version numbers.	<RS03>
		Communication between the Robot and Driver Station is only through the RC and DS applications. Out of band communication is not allowed.	<RS09>
	NA	Driver Station uses the official FTC Driver Station app to control the Robot.	<RS06>
NA		The FTC Robot Controller app on the Android phone (if used) is the default application, the application launches, and no other messages pop up.	<RS05>
NA		Robot Controller is set to the correct Wi-Fi channel (if required by the competition).	<C14>

✔		**Robot Operation Verified at the Playing Field**	**Rule #**
		Robot Controller connects with the Driver Station.	
		Robot switches between autonomous and driver-controlled operation correctly.	<RS04>
		Robot starts and stops when commanded by the Driver Station.	
		The Stop Button, when pressed on the Driver Station, functions and stops the robot.	
		The team understands how to disable their Robot, if instructed to do so by a referee.	

✔	**Queuing Process Information Provided at the Playing Field**	**Rule #**
	Team understands that software changes are not allowed in the Queue Area.	
	Team understands that the match schedule is only an estimate. Matches may start prior to or after the scheduled time. It is the team's responsibility to monitor schedule changes and show up when required.	
	Team knows that they are responsible for attaching their Team Supplied Alliance Marker on two sides of their robot before they approach the competition playing field.	<RG05>

General Comments or Reason(s) for Failure (if any):

_____

Field Inspector

Appendix D – Control Award, sponsored by Arm, Inc. Submission Form & Instructions

To be considered for the Control Award Sponsored by Arm, Inc., *Teams* must submit a Control Award Submission Form. On this form, *Teams* identify and summarize the key control elements that make their *Robot* unique. Included is a description of key observable actions for judges to look for as well as the sensor and algorithm use that make it all possible. Judges will use this form for both evaluating control designs and when observing *Robots* on the competition field.

Information on this form will typically fit on one page, with no more than three (3) pages submitted.

Autonomous Objectives
List the overall actions that the *Robot* can complete. These should include scoring actions as well as other positioning and defensive operations. The *Robot* does not have to do accomplish all these in every program, but should be demonstrable in at least one autonomous program.

Sensors Used
List the sensors used to control the *Robot* and a brief description of how they are used.

Key Algorithms
List the key algorithms that make your *Robot* unique or are vital to its success on the field. Particularly complex or unique algorithms or those that integrate the use of multiple sensors are good candidates to highlight here.

Driver Controlled Enhancements
List any advanced control elements that are used during the *Driver-Controlled Period* to enhance performance. These may include signaling operations when a certain condition is detected on the field, auto-complete functions, fail-safe algorithms, or just any enhancements that make the control of the *Robot* easier or more efficient for the driver.

Autonomous Program Diagrams
For *Autonomous* operations, *Teams* should draw and label a typical path the *Robot* takes. The labeled points identify key observable actions the *Robot* makes. For each labeled point, a brief description of what is taking place should be noted (see example below). Especially describe those key operations where adjustments are made to ensure accurate and repeatable performance.

For *Teams* with multiple *Autonomous* programs, it is not necessary to document every program on a separate sheet. It is sufficient document the most commonly used or complex programs and note variances for the rest.

Additional Summary Information (optional)
For those *Teams* that have developed many different control features, they may want to provide additional information to assist the judges in understanding their work. This is a place where *Teams* can provide more detailed information about their designs. It should be organized such that separate topics are easily identified and can be quickly found.