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

2019-2020 *FIRST®* Tech Challenge

# Basic 'Bot Guide for TETRIX

## Part 1



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| Revision History |           |                 |
|------------------|-----------|-----------------|
| Revision         | Date      | Description     |
| 1                | 5/30/2019 | First Revision  |
| 1.2              | 7/02/2019 | Initial release |

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## Introduction

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### ***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](http://www.firstinspires.org).

### ***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!*

## ***Gracious Professionalism®***

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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](#).

## Introduction to the Guide

### Introduction

The Basic 'Bot Guide is designed to be a resource for teams looking for step-by-step instructional for building the basic chassis and structure needed in a *FIRST* Tech Challenge competition. There are multiple versions of this guide, previously called the "Push Bot Guide", this version the **Basic 'Bot Guide for TETRIX** has been created to use the new and differing parts in the 2019-2020 season's TETRIX kit of parts.

### Parts

- TETRIX FTC Competition Set
- Electronics Modules and Sensors Set
- Control & Communication Set 1 or 2
- (Optional) Only the tools included in the FTC Competition Set will be needed to build the chassis. The screws and nuts are a standard size and having more tools may allow more students to participate at the same time.
- (Optional) A ruler is not needed to build this robot, but it is necessary to make sure that the robot is competition ready

### Tips and Tricks

- Make sure that set screws are installed in every axle hub, motor hub, and axle collar.
- Refer to the legend provided in the Kit of Parts, if any parts are unfamiliar.
- Make sure that all assemblies are square. It is hard to drive a crooked robot straight!
- The drive wheels are powered by two DC motors, which are relatively heavy. The drive wheels are on the back of the robot, because that is where the most weight is. This weight is needed to help the wheels grip the surface better.
- Omni wheels are on the front of the robot, which allows the robot to turn more easily. The omni wheels can slide sideways with very little friction due to the rollers.
- Unless otherwise noted, the top image in each step shows the necessary parts; the lower image shows the completed assembly.

### Computer Aided Design (CAD)

- The drawings in this document were generated using Creo Parametric Computer Aided Design (CAD) software.
- CAD software is used to design an object on a computer.
  - **By designing on the computer first, the design can be tested (via the CAD software) to ensure everything will work together before actual construction.**
- The Creo software is available for free to *FIRST* teams for use in designing robots.

### CAD Coloring Legend

The CAD drawings color code the screws to help identify them, please see below table.

| Pitsco Part Number | Part                        | Color  |
|--------------------|-----------------------------|--------|
| 39098              | 5/16" socket head cap screw | red    |
| 39094              | keps nut                    | blue   |
| 39111              | 3/8" button head cap screw  | green  |
| 39097              | 1/2" socket head cap screw  | yellow |
| 39195              | motor mount screw           | orange |

## Construction

### Complete TETRIX Chassis

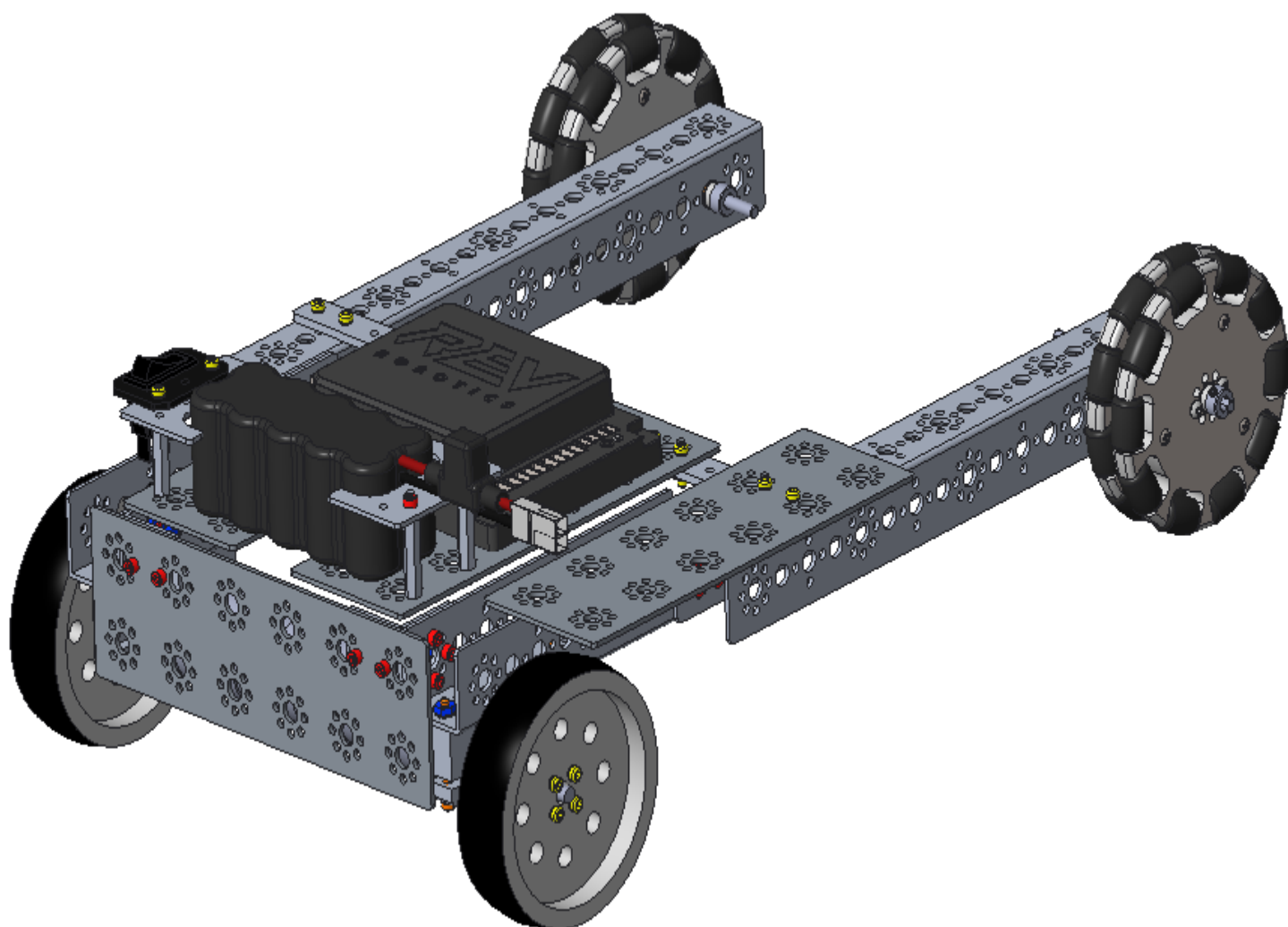


Figure 1- Completed TETRIX robot chassis

## Frame

### Step 1: Build the Left Rail

#### Parts Needed:

- 39067 - 160 mm channel (1)
- 39068 - 288 mm channel (1)
- 39098 - 5/16" socket head cap screw (4)
- 39094 - keps nut (4)

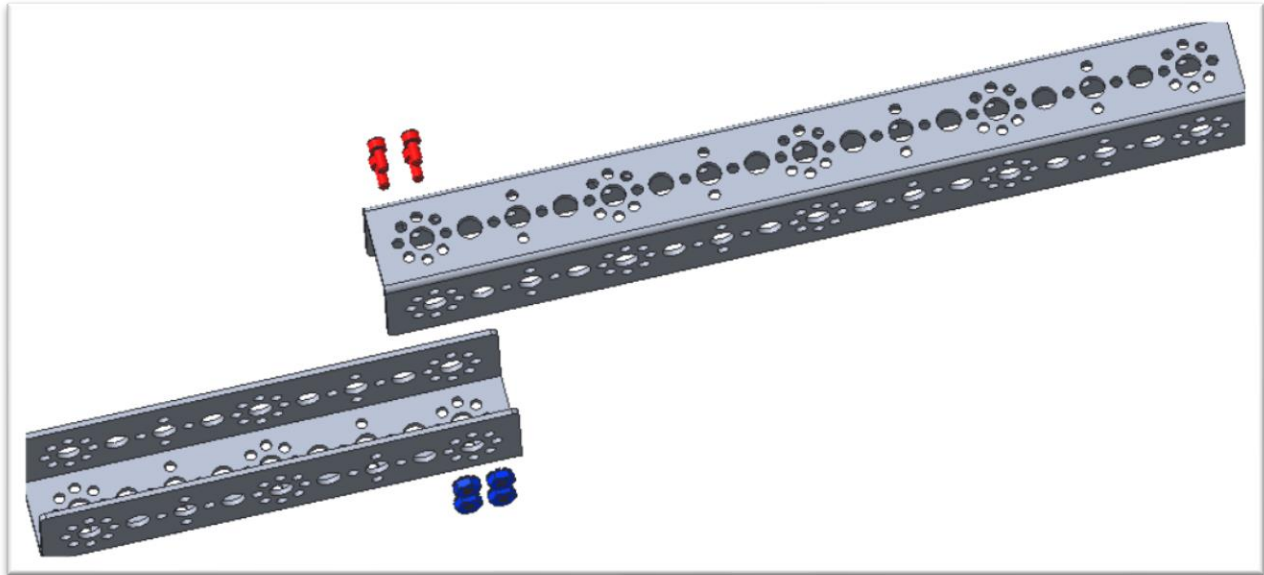


Figure 2- Unassembled view

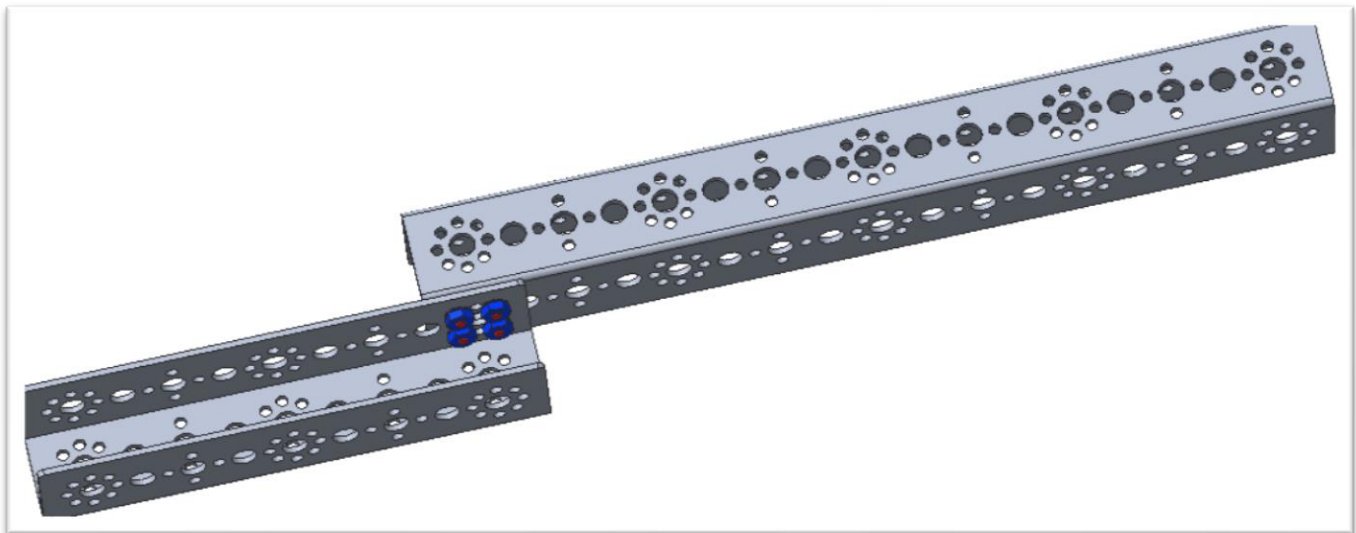


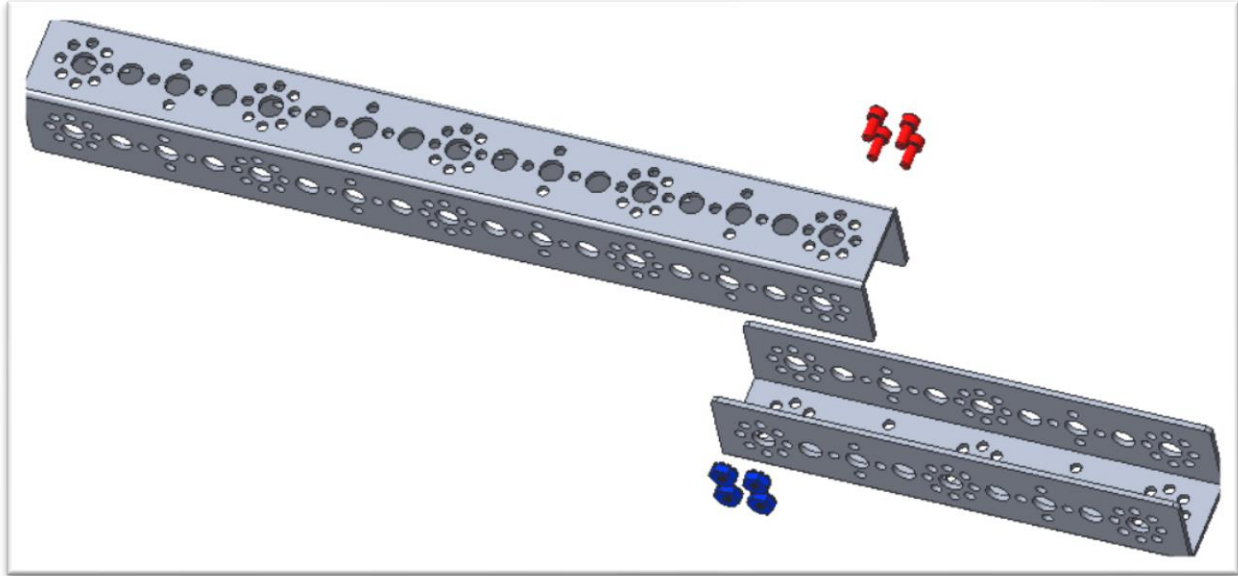
Figure 3- Assembled view



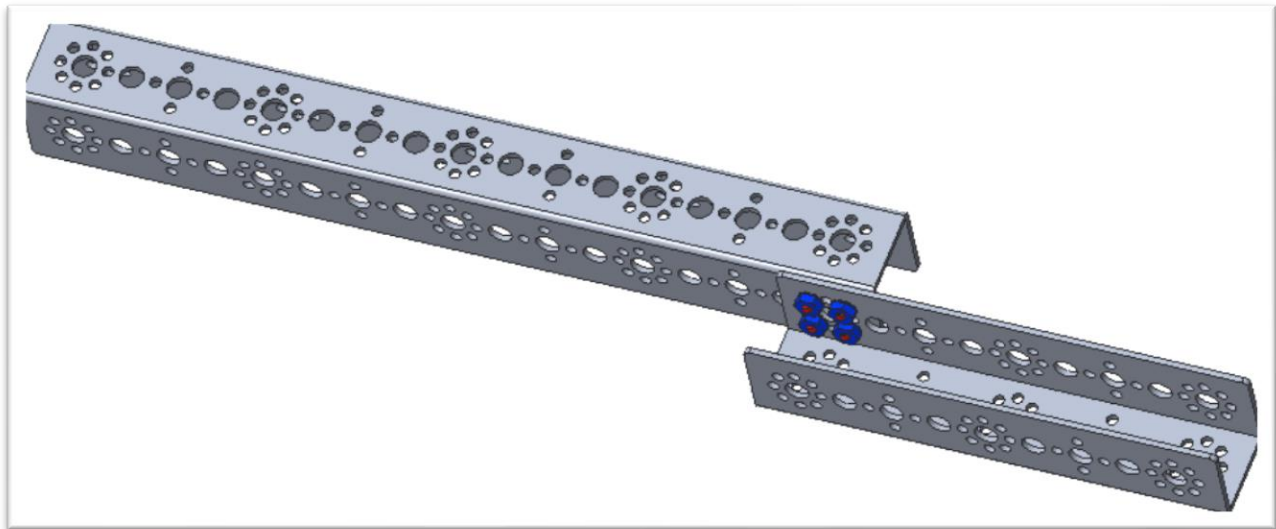
## **Step 2: Build the Right Rail**

### **Parts Needed:**

- 39068 - 288 mm channel (1)
- 39067 - 160 mm channel (1)
- 39098 - 5/16" socket head cap screws (4)
- 39094 - keps nuts (4)



*Figure 4- Unassembled view*

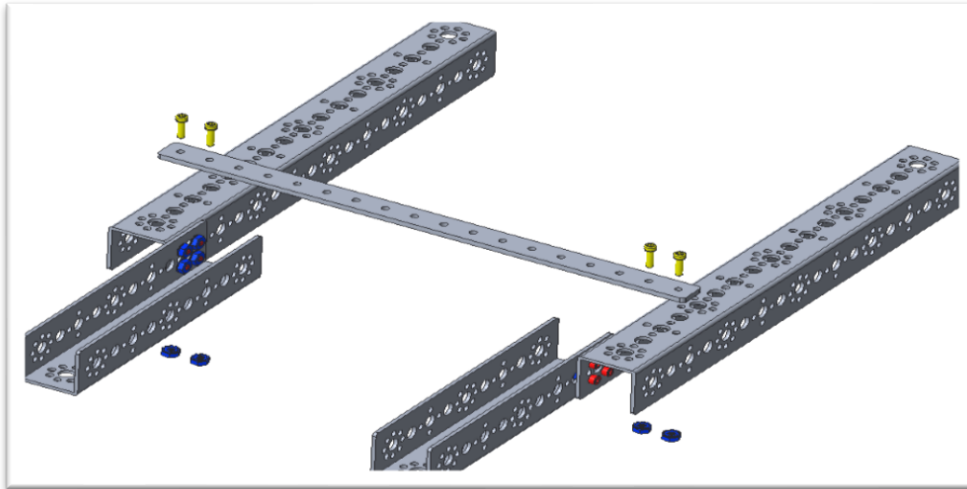


*Figure 5- Assembled view*

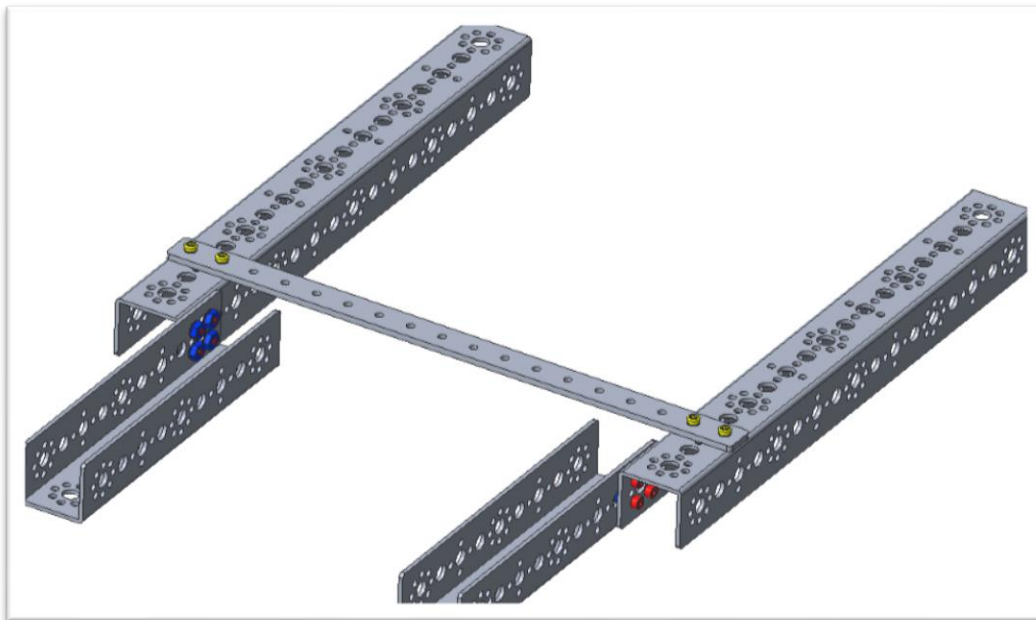
### **Step 3: Connect the Left and Right Rails**

#### **Parts Needed:**

39070 - 288 mm flat bar (1)  
39097 - 1/2" socket head cap screws (4)  
39094 - keps nuts (4)



*Figure 6- Unassembled view*



*Figure 7- Assembled view*

#### **Step 4: Add Structural Support Brackets**

**Parts Needed:**

39281 - inside corner bracket (2)

39098 - 5/16" socket head cap screws (6)

39094 - keps nuts (6)

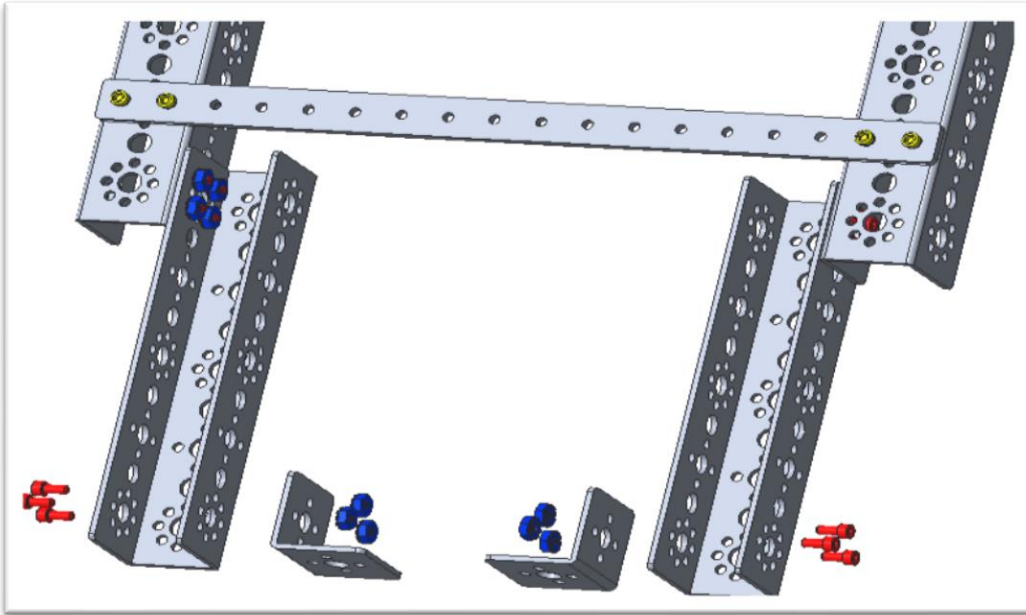


Figure 8- Unassembled view

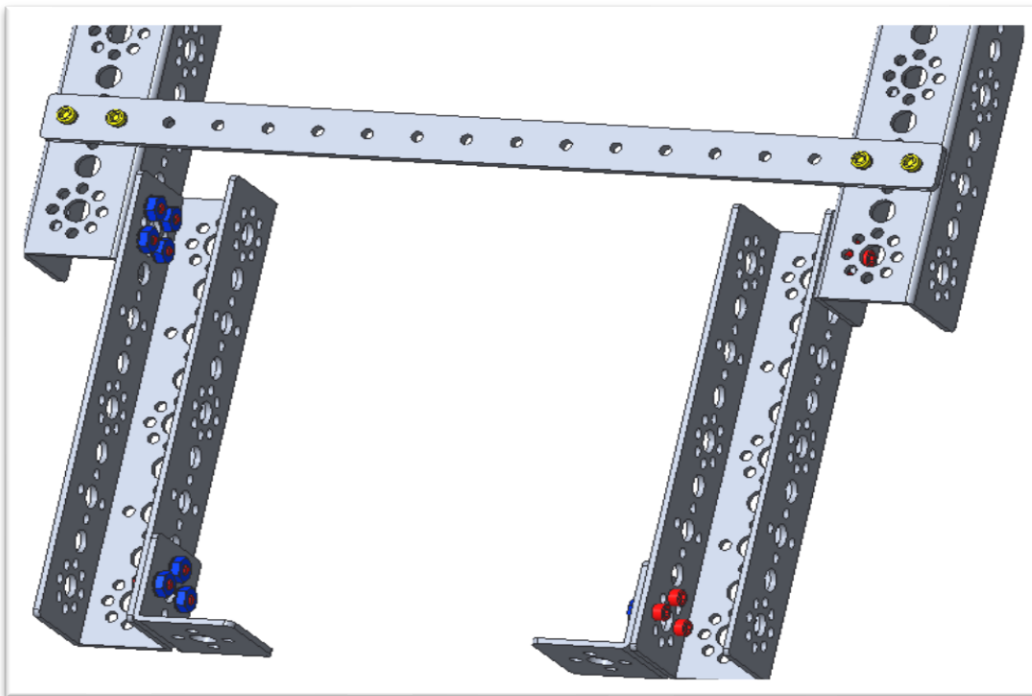


Figure 9- Assembled view

## Step 5: Add the Structural Support Plate

### Parts Needed:

39073 - flat building plate (1)  
 39098 - 5/16" socket head cap screws (4)  
 39094 - keps nuts (4)

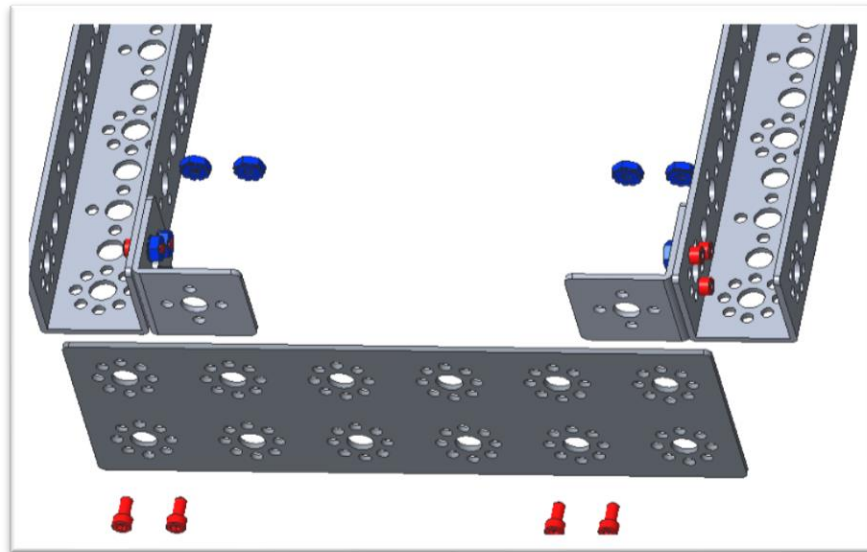


Figure 10- Unassembled view

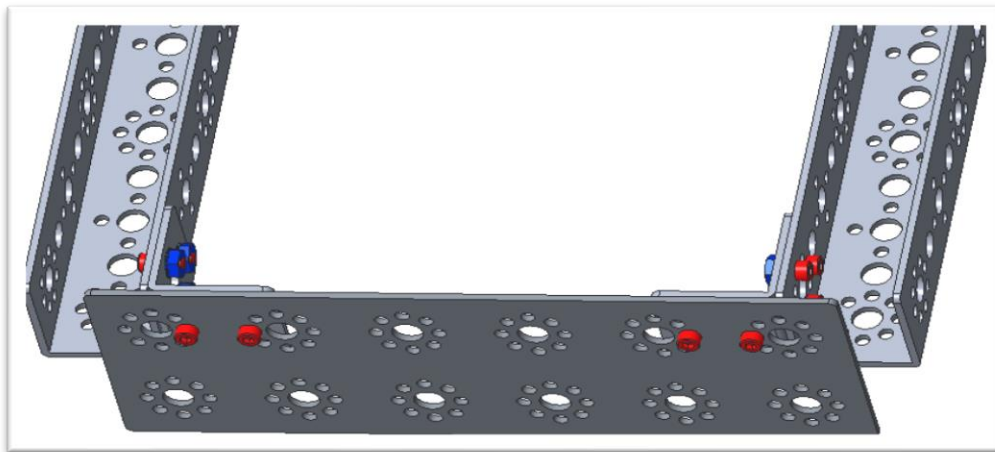


Figure 11- Assembled view

### Helpful Hint:

- Make sure that the frame is square. Do this by looking at the robot from above.
  - Once the frame is square, make sure that all the frame's bolts are tight.  
*It is hard to drive a crooked robot straight!*
- Make sure the left and right rails are parallel and the cross braces form right angles with them.

## **Step 6: Build Left Electronics Plate**

### **Parts Needed:**

39073 - flat building plate (1)  
39107 - 32 mm stand-off post (2)  
39098 - 5/16" socket head cap screws (2) (red)  
39097 - 1/2" socket head cap screws (2) (yellow)  
38009 - battery clip (1) [inside the electronics kit] (half of the package)

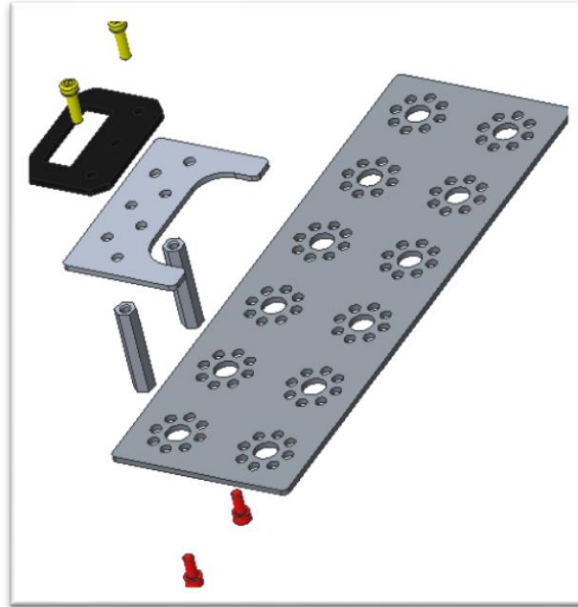


Figure 12- Unassembled view

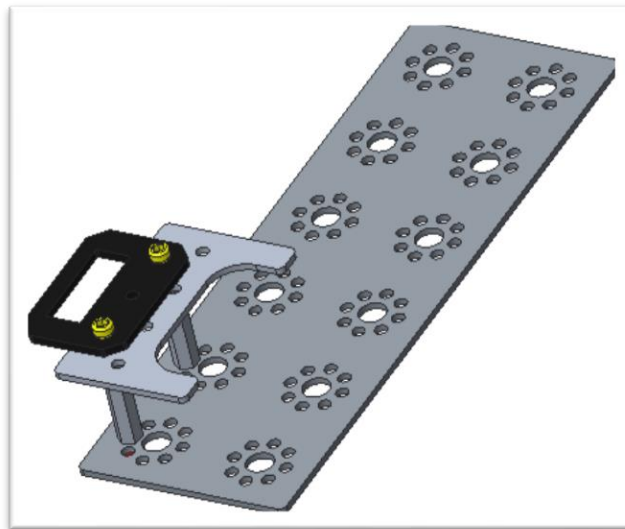


Figure 13- Assembled view

### **Step 7: Attach Left Electronics Plate to Frame**

**Parts Needed:**

39097 - 1/2" socket head cap screws (2)  
39094 - keps nuts (2)

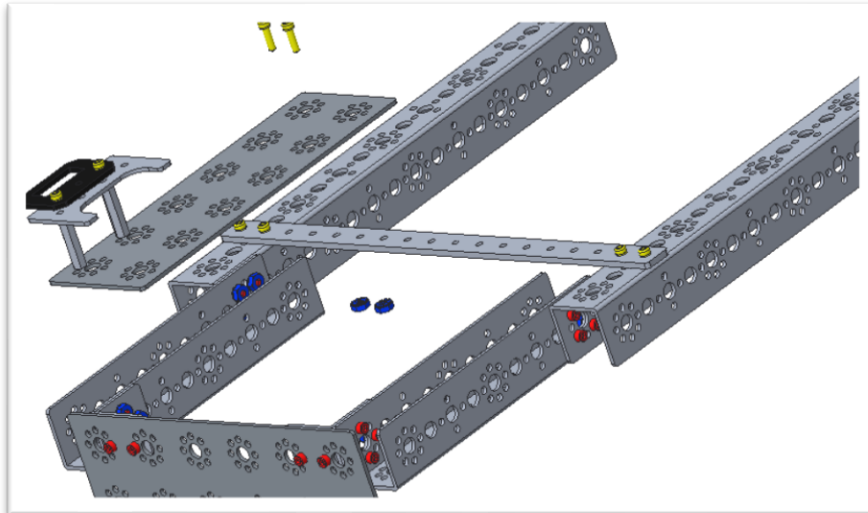


Figure 14- Unassembled view

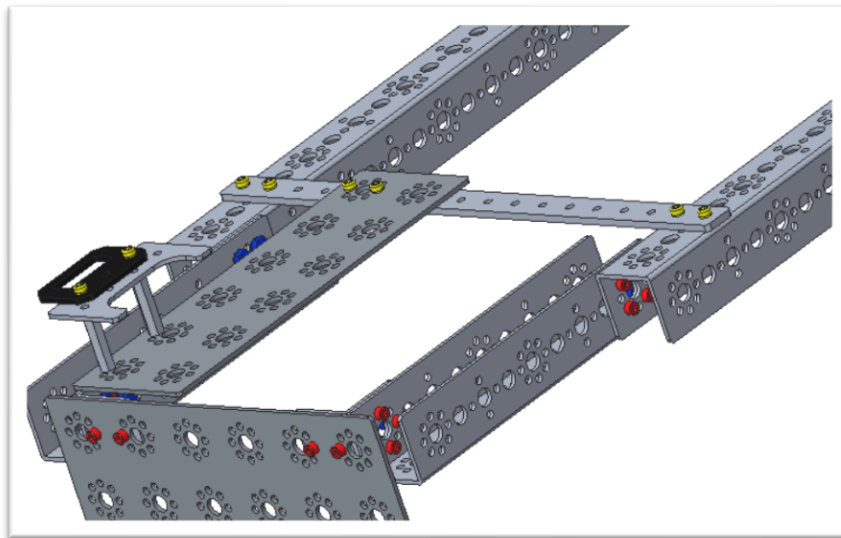


Figure 15- Assembled view

**Helpful Hint:**

- The plate does NOT attach to the frame at the clip/Structural Support Plate.



**Step 8: Build Right Electronics Plate****Parts Needed:**

39073 - flat building plate (1)  
39107 - 32 mm stand-off post (2)  
39098 - 5/16" socket head cap screws (4)  
38009 - battery clip (1) [inside the electronics kit] (half of the package)

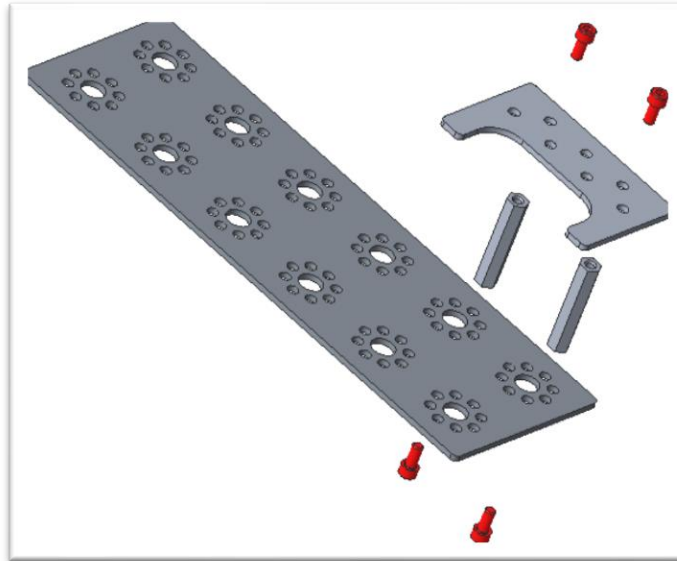


Figure 16- Unassembled view

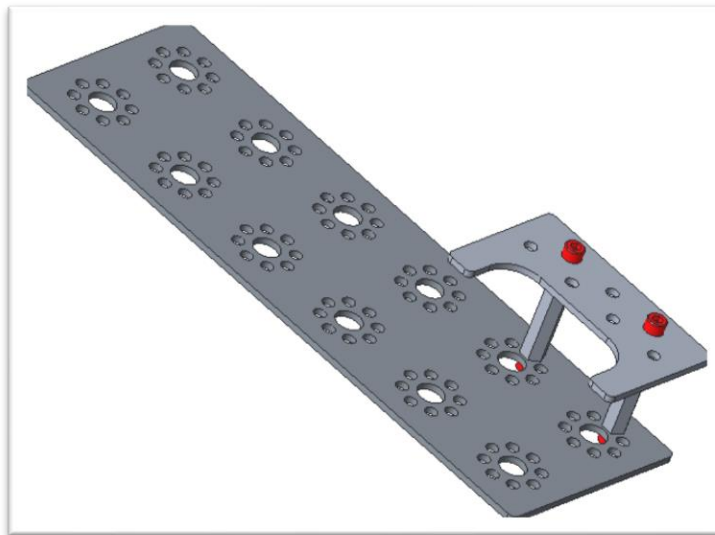
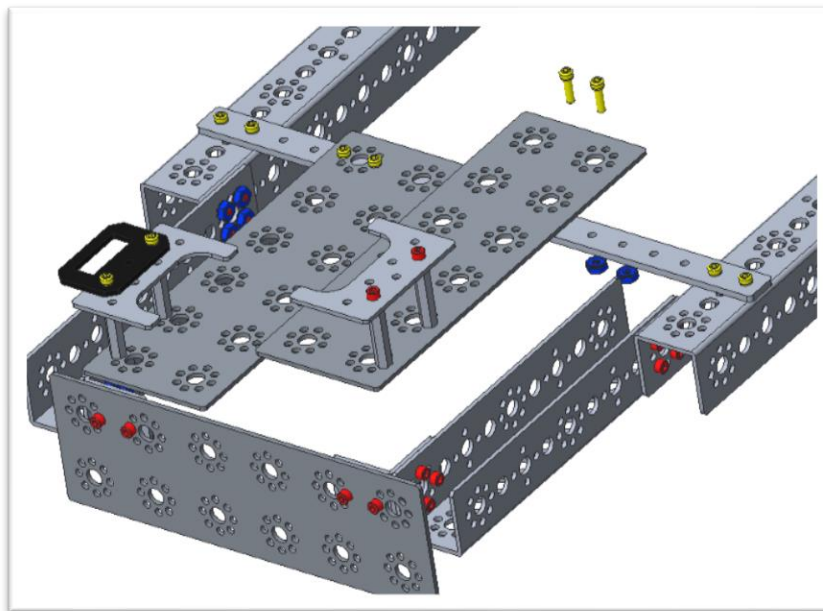


Figure 17- Assembled view

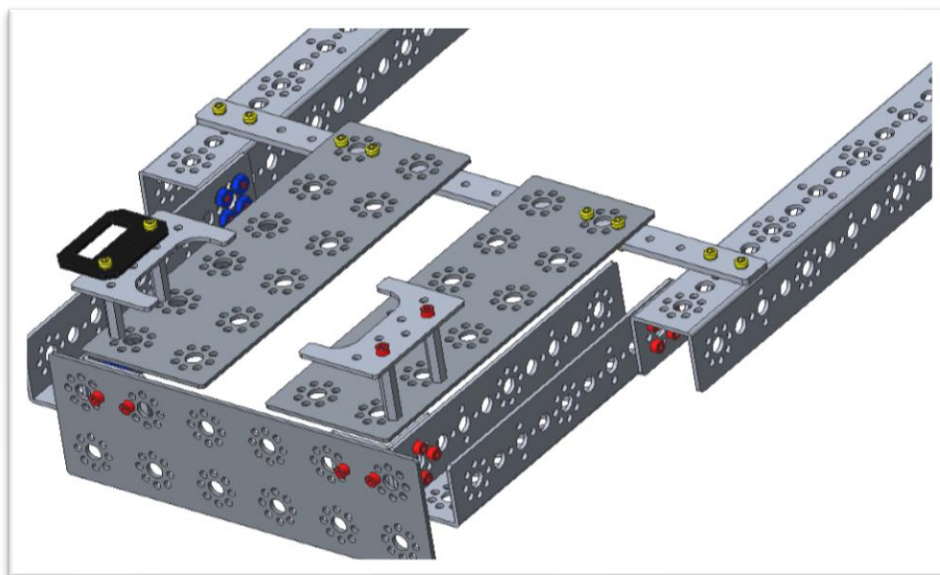
## **Step 9: Attach Right Electronics Plate to Frame**

### **Parts Needed:**

- 39097 - 1/2" socket head cap screws (2)
- 39094 - keps nuts (2)



*Figure 18- Unassembled view*



*Figure 19- Assembled view*

### *Helpful Hint:*

- The plate does NOT attach to the frame at the clip/Structural Support Plate.



## Drive Motors and Drive Wheels

### Step 1: Add Drive Wheel Motor Mounts

**Parts Needed:**

39089 - motor mounts (2) with included bolts (4)  
and included nuts (4)

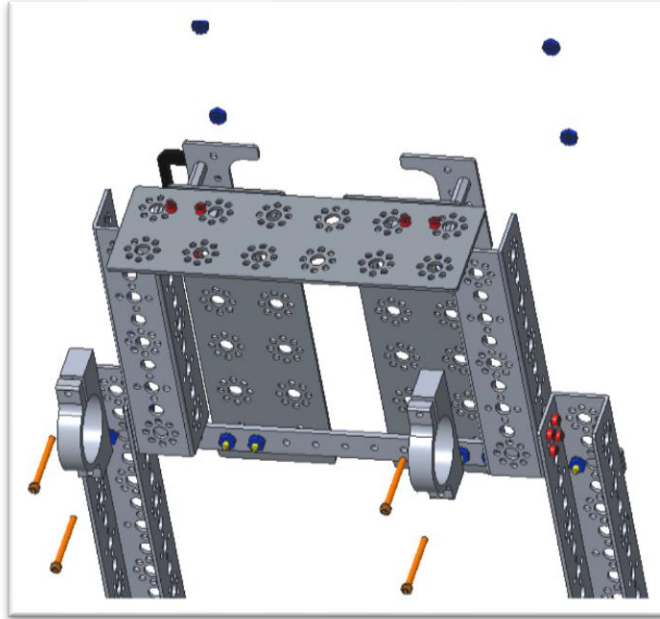


Figure 20- Unassembled view

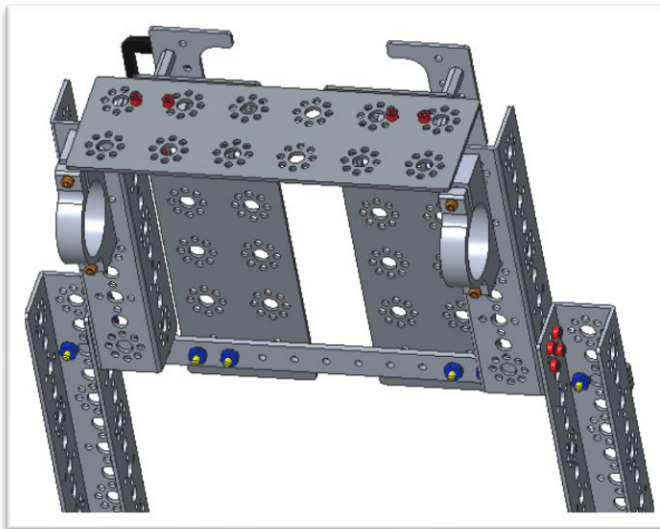


Figure 21- Assembled view

**Helpful Hint:**

- Do not tighten the motor mount bolts that control the clamp (i.e. the gap on one side of the mount) until the motors have been inserted (next step). When this bolt is tightened, the motors can't be inserted into the mount.

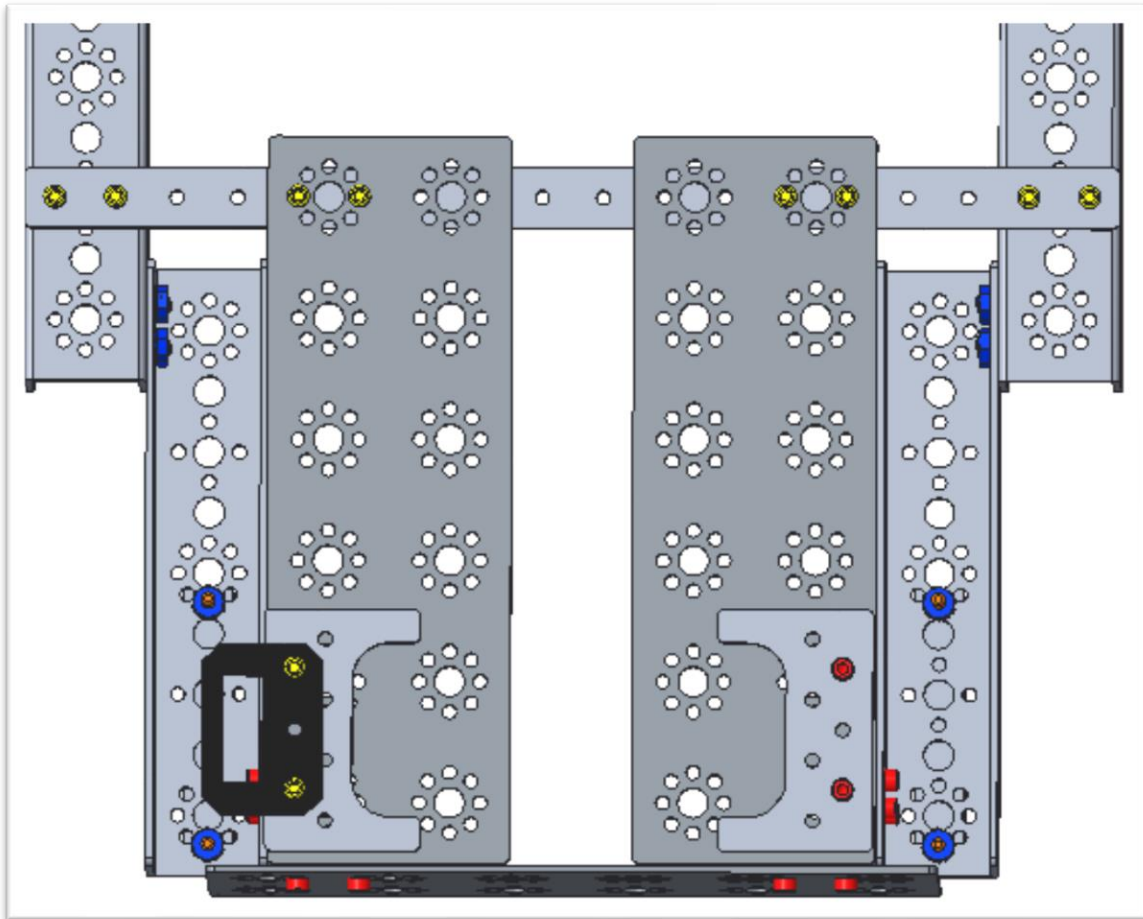


Figure 22- Assembled view from top of robot

## Step 2: Add Drive Motors

### Parts Needed:

44260 - TorqueNADO Motor (2) with included wire wraps (2)

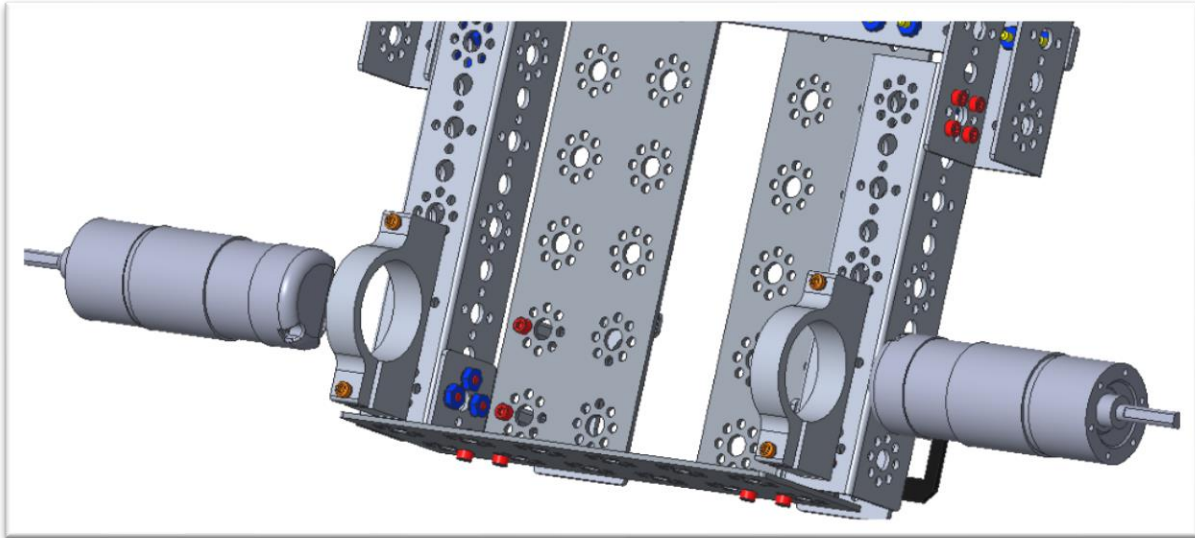


Figure 23- Unassembled view

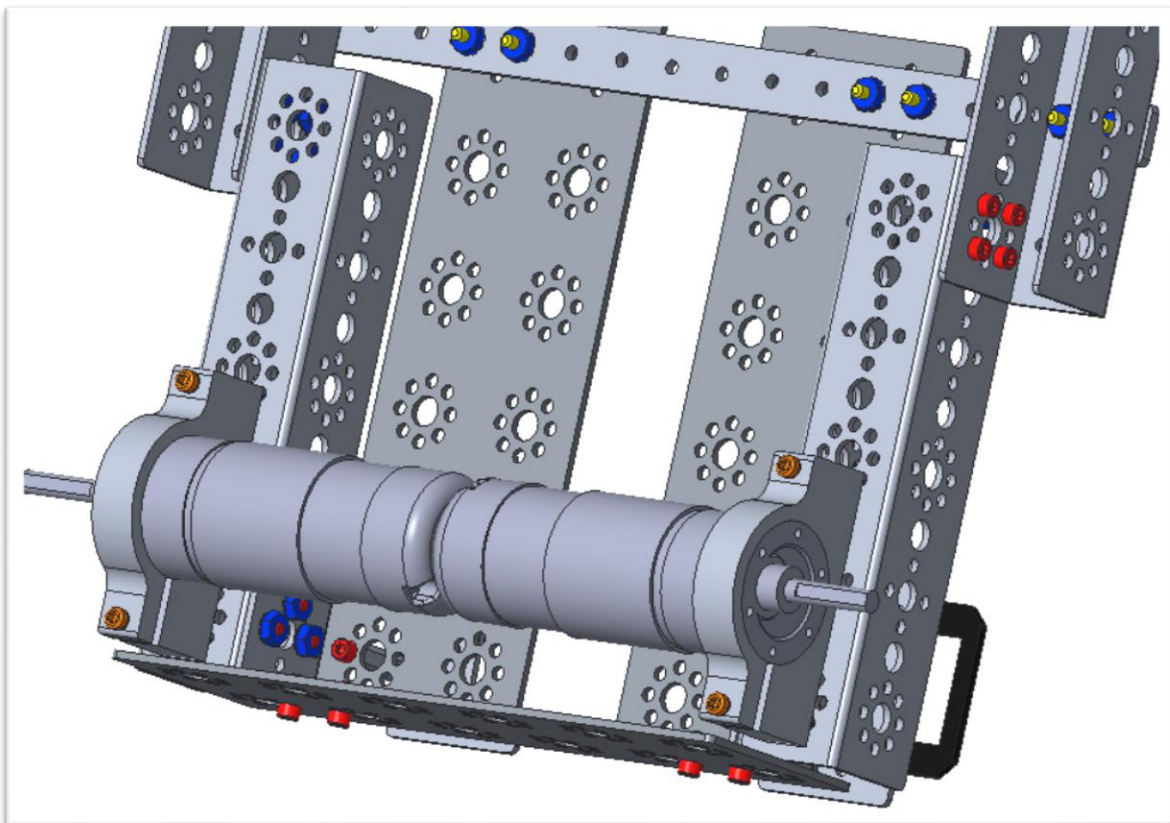


Figure 24- Assembled view

### **Step 3: Secure Drive Motors**

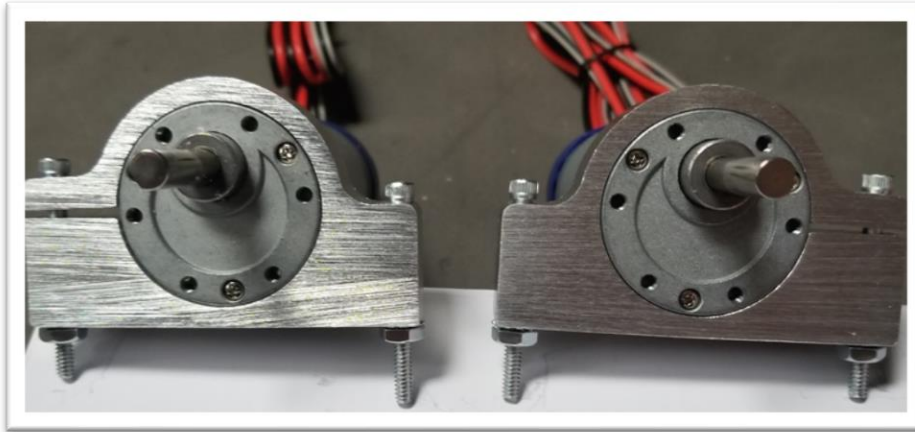


Figure 25- Motor Mount

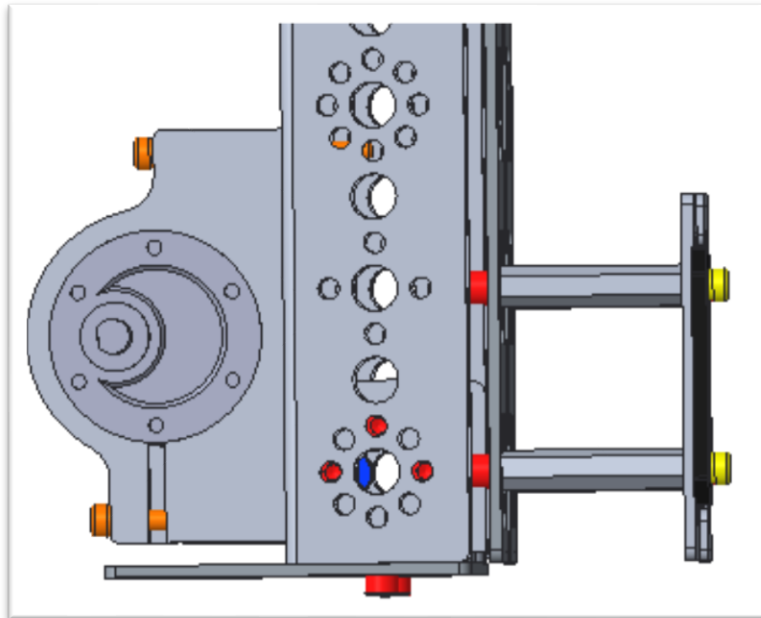


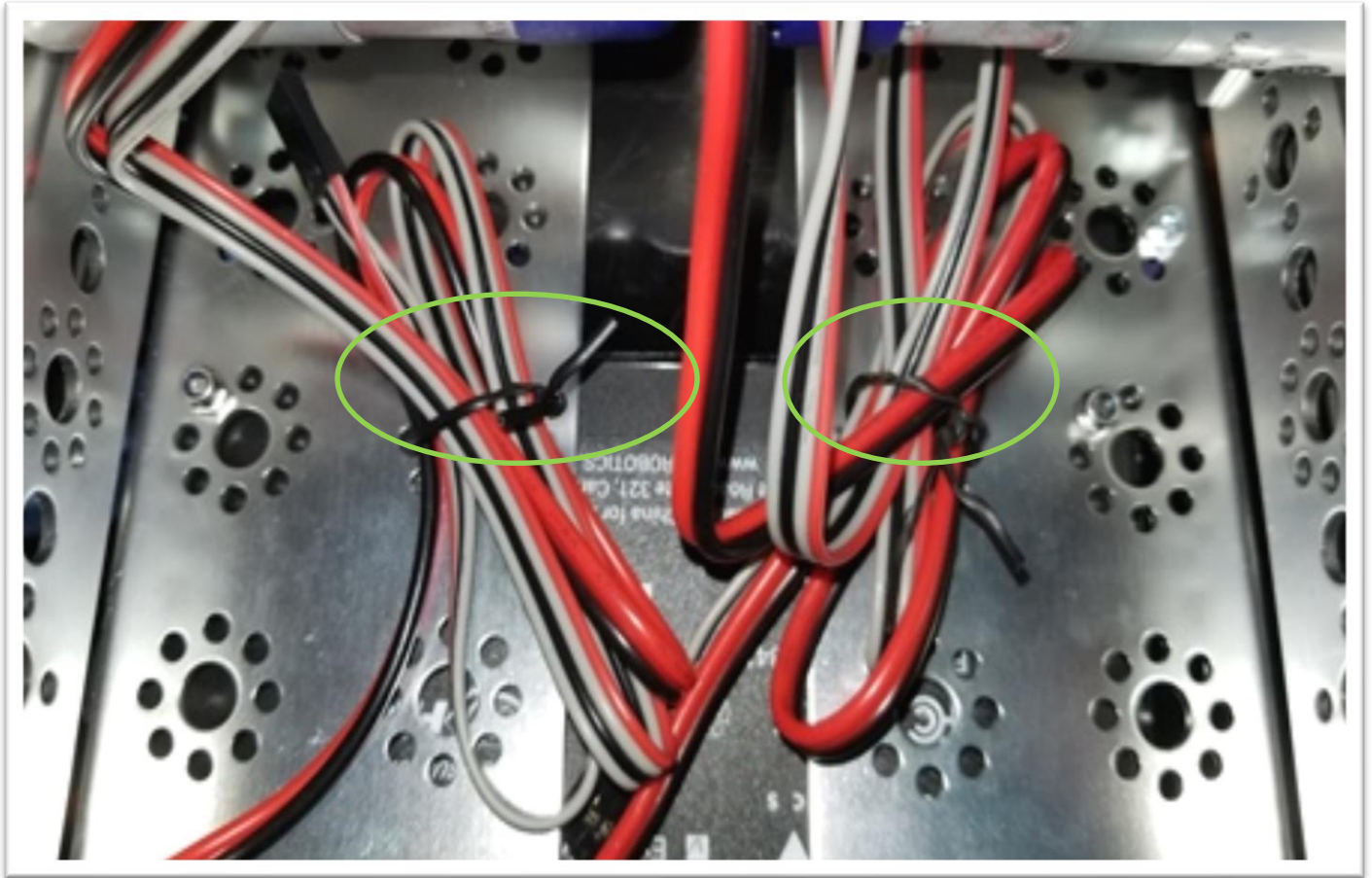
Figure 26- Mounted Motor

#### *Helpful Hints:*

- Tighten the motor mount bolt, so the motor will not rotate
- Mount the motor so that the axle is far away from the frame and so that the hole aligns with the slot (as shown in Figure 28).
- The left rail's motor is on the left. The right rail's motor is on the right.



#### **Step 4: Secure Drive Motor Wires**



*Figure 27- Secured motor wires*

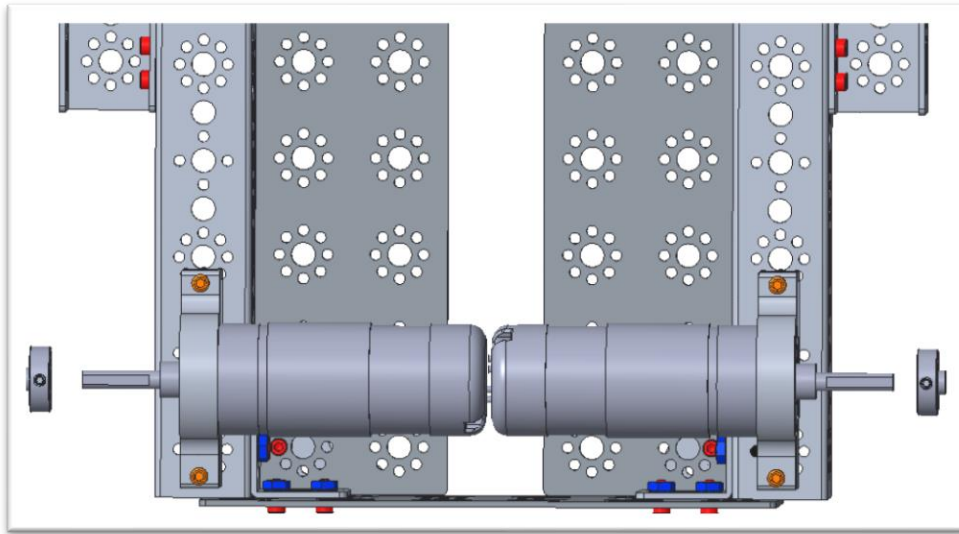
#### *Helpful Hint:*

- *Use the plastic covered wire that holds the loops of motor wire together to secure the wires to the Electronics Plating*

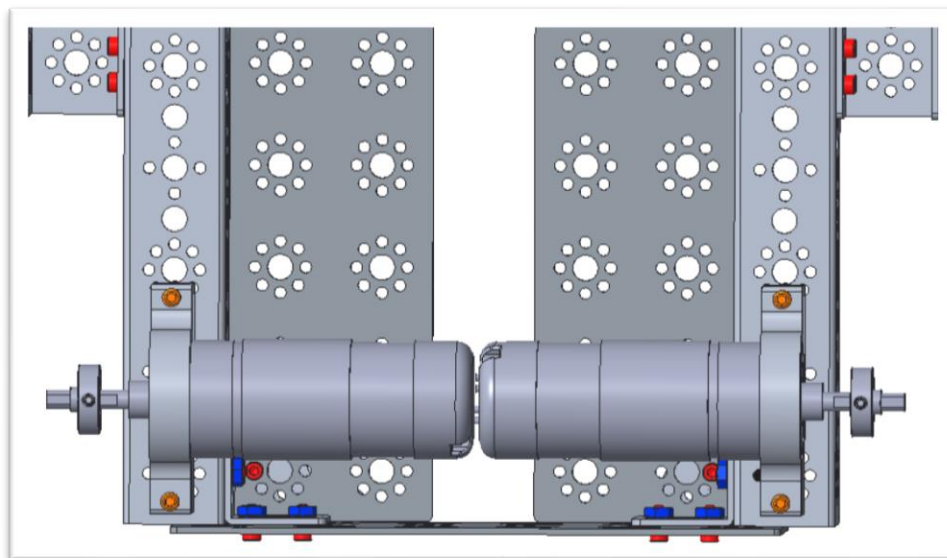
### **Step 5: Add Motor Hubs**

#### **Parts Needed:**

39079 - motor shaft hubs (2) with included set screws (2)



*Figure 28- Unassembled view*



*Figure 29- Assembled view*

#### **Helpful Hint:**

- Install the hubs 10 mm from the outside end (the end furthest from the motor) of the axle.
- Install motor hub set screws, so that the screws are on the flat side of the motor's axle, which will prevent the hubs from spinning on the axles.

## Step 6: Add Drive Wheels

### Parts Needed:

39055 - 4-inch wheels (2)  
39097 - 1/2" socket head cap screws (8)

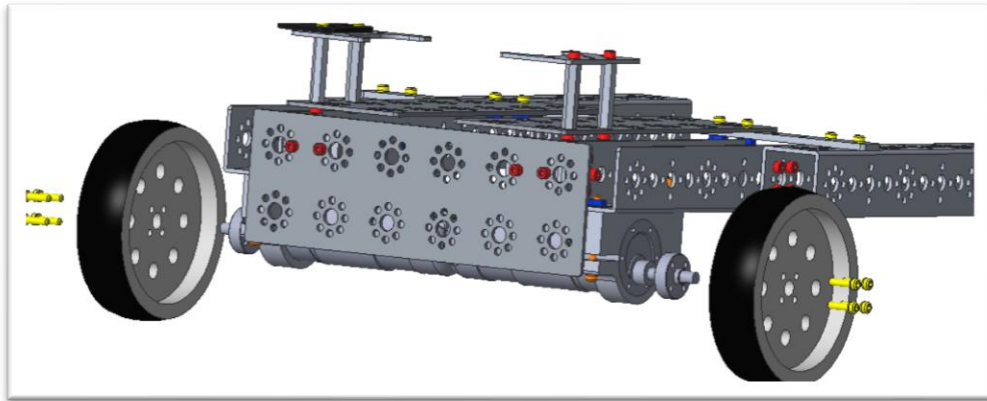


Figure 30- Unassembled view

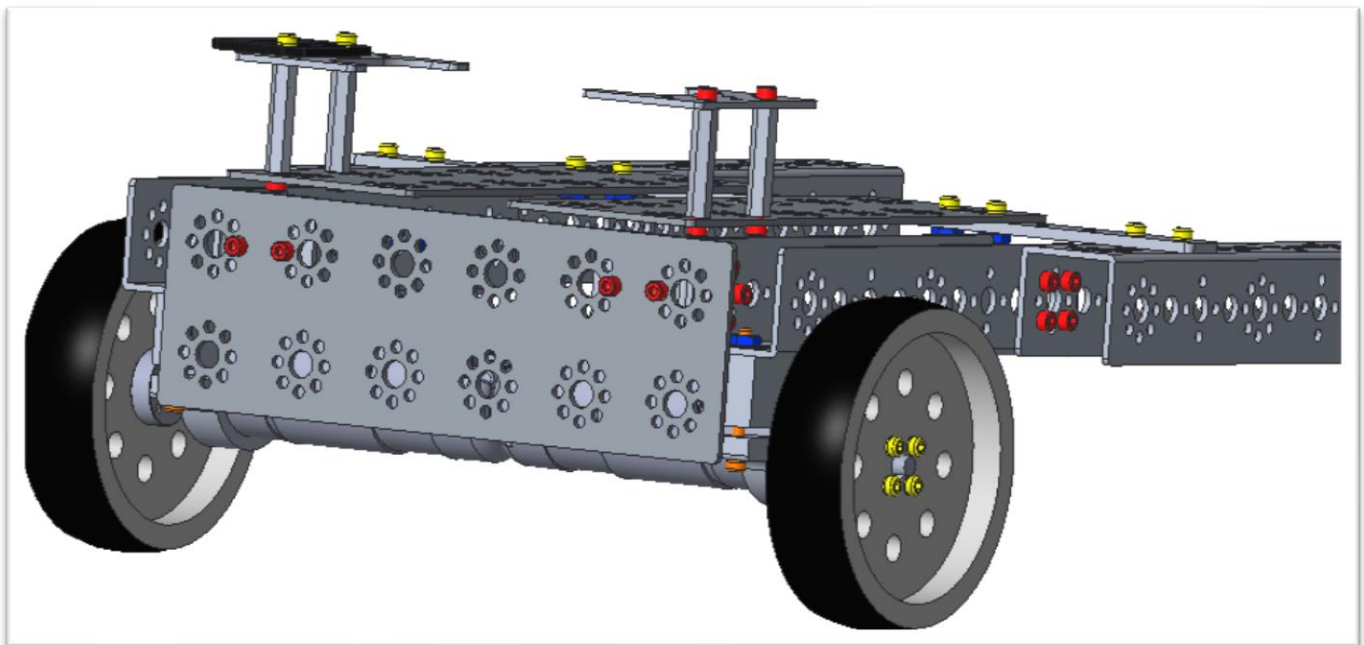


Figure 31- Assembled view

## Caster Wheels

### Step 1: Build the Omni Wheel Assembly

#### Parts Needed:

39055 - 4-inch wheels (2)

39097 - 1/2" socket head cap screws (8)

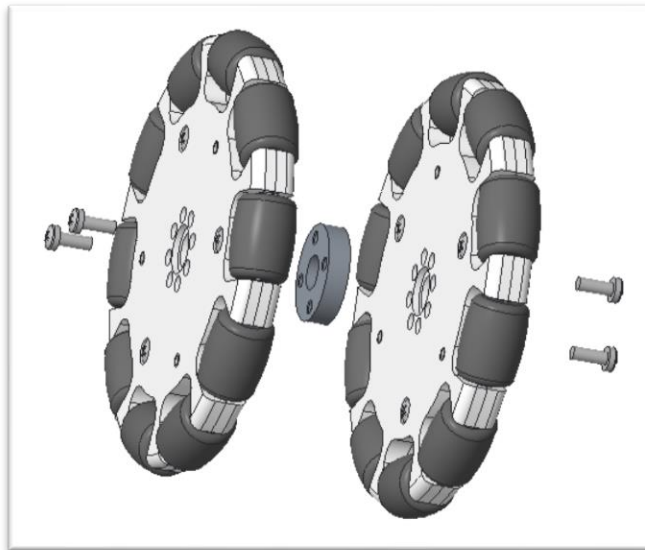


Figure 32- Unassembled view of a singular wheel, perform this step on both assemblies

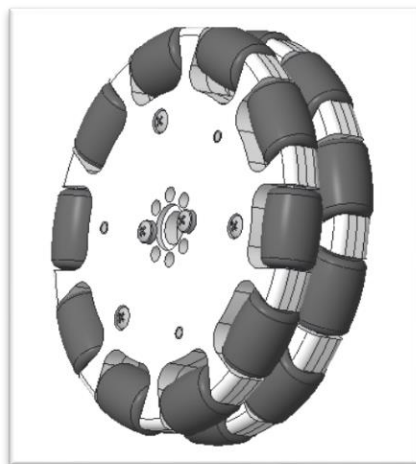


Figure 33- Assembled wheel view 1



Figure 34- Assembled wheel view 2

#### Helpful Hints:

- Assemble according to the instructions that come in the omni wheel pack, noting that screws on one wheel are in opposite holes from the screws on the other wheel.



**Step 2: Add Bronze Bushings to the Omni Wheel Assemblies from the previous step**

**Parts Needed:**  
39091 - 11 mm bronze bushings (4)



Figure 35- Unassembled view of singular wheel assembly, perform this step on both assemblies

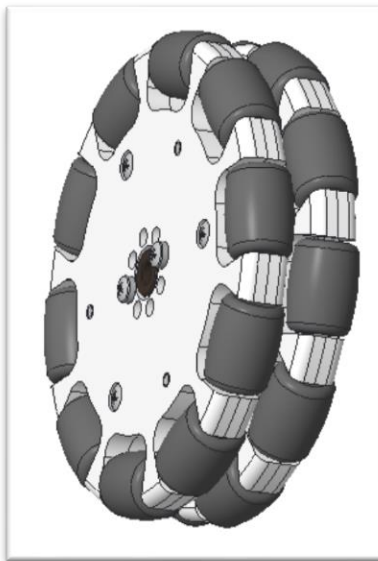


Figure 36- View 1

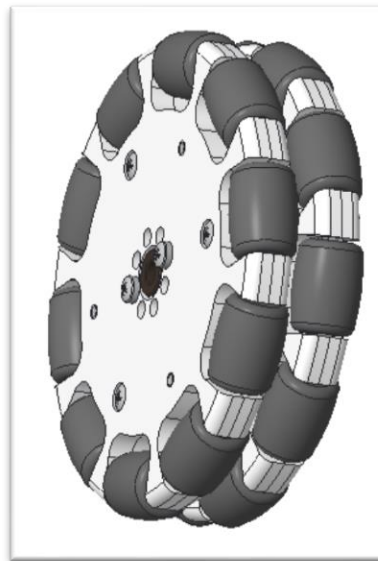


Figure 37- View 2

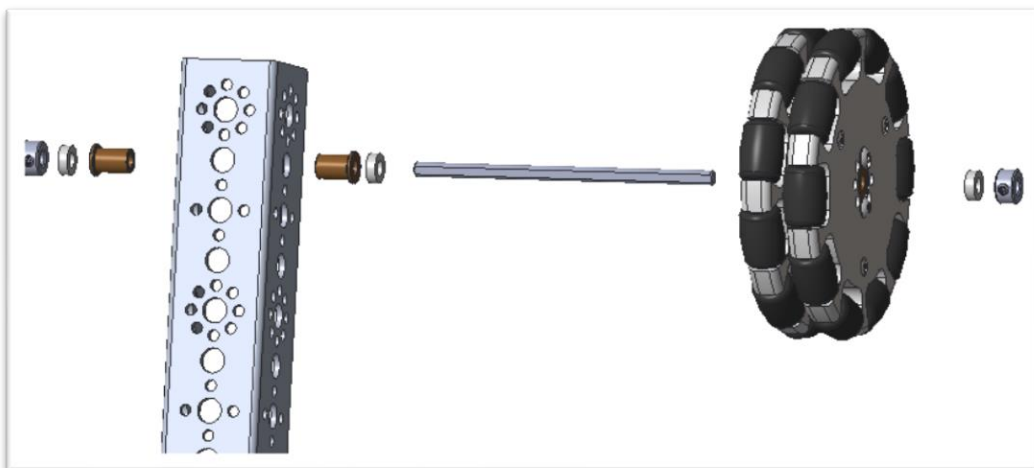
**Helpful Hint:**

- Sometimes the bronze bushings are hard to insert. To make this easier, secure an axle collar onto an axle. Slide a bronze bushing down the axle. Slide the omni wheel down the axle and press it against the axle collar.

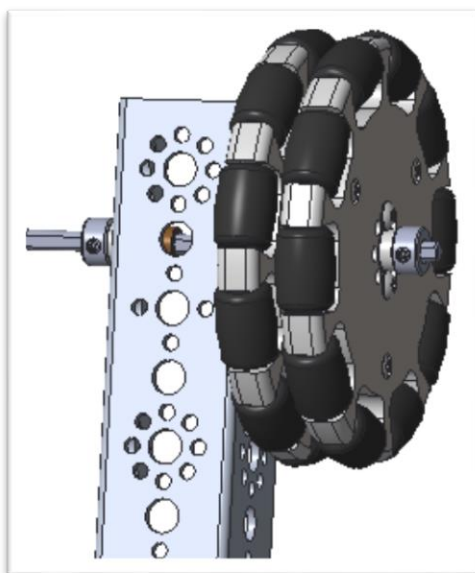
### **Step 3: Add the Omni Wheel Assemblies to the Frame chassis omni wheel assemblies**

#### **Parts Needed:**

39100 - 1/8" axle spacers (6)  
 39092 - axle set collars (4)  
 39091 - 11 mm bronze bushings (4)  
 REV-41-1361 – Nut, Locking, M3 (4)



*Figure 38- Unassembled View of left wheel (Right wheel is mirror image)*



*Figure 39- Assembled View of left wheel (Right wheel is mirror image)*

#### **Helpful Hint:**

- Order from the outside in: axle set collar, 1/8" axle spacer, omni wheel assembly, 1/8" axle spacer, 11 mm bronze bushing, channel, 11 mm bronze bushing, 3/8" spacer, axle set collar.

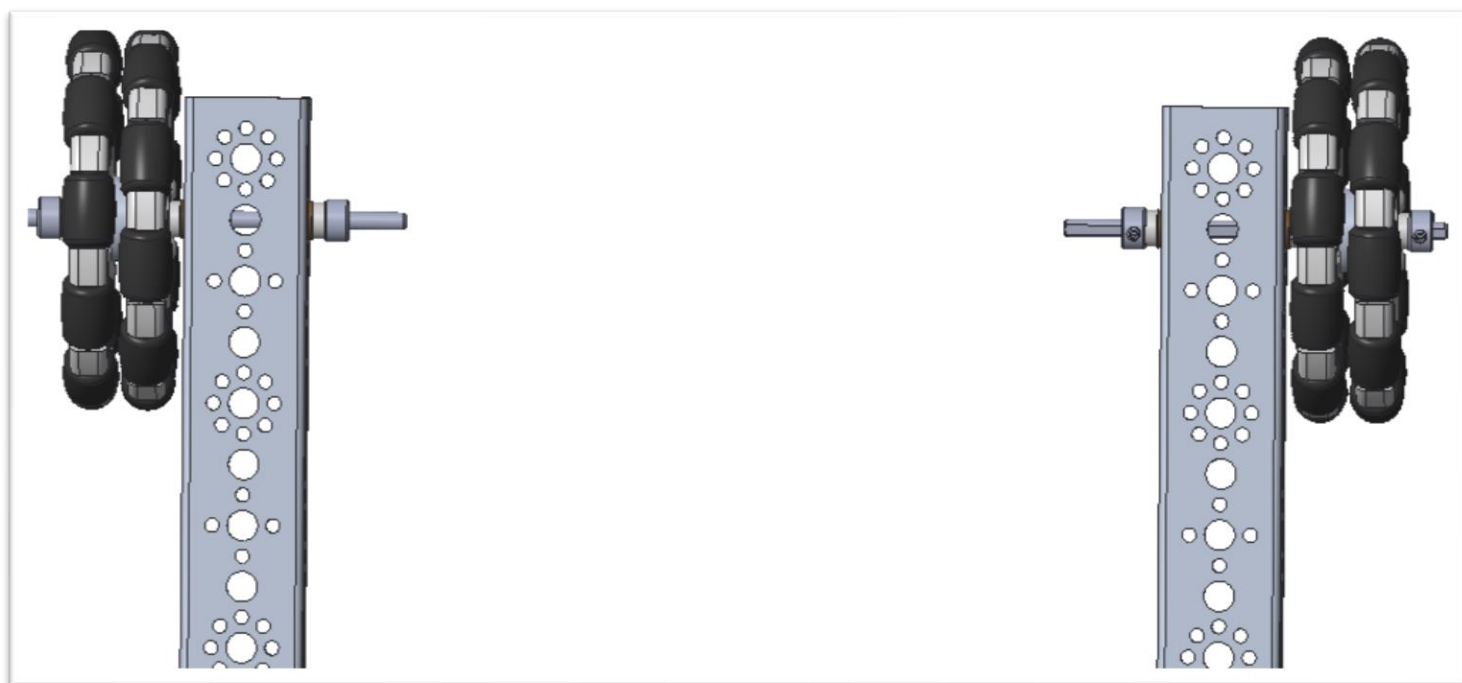


Figure 40- Wheel assembly top view

## Motor and Sensor Controller

### Step 1: Add the Rev Robotics Expansion Hub

**Parts Needed:**

REV-31-1153 expansion hub (1)  
REV-41-1360 screws (2)  
REV-41-1361 M3 Nyloc Nuts (2)

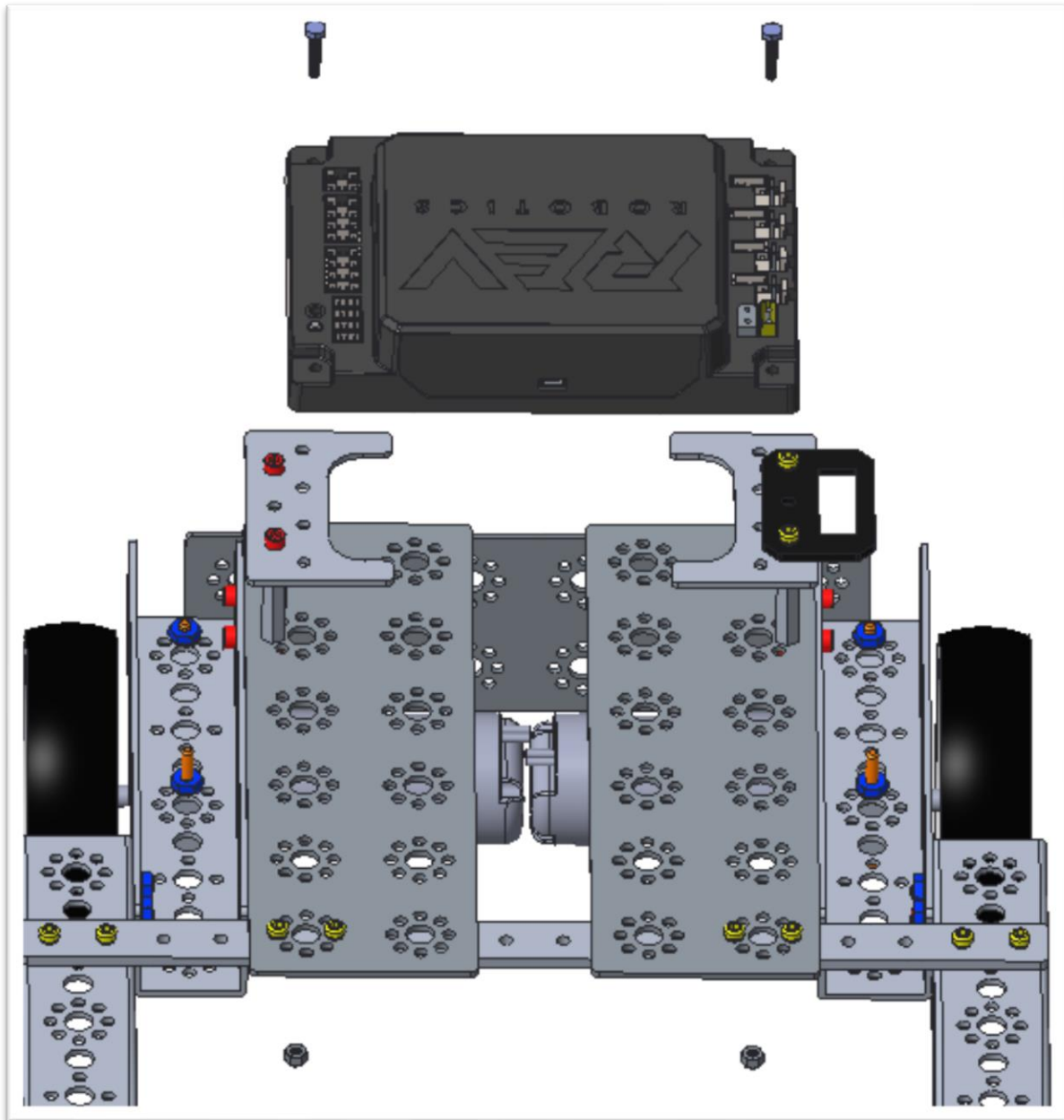


Figure 41- Unassembled view from top of robot

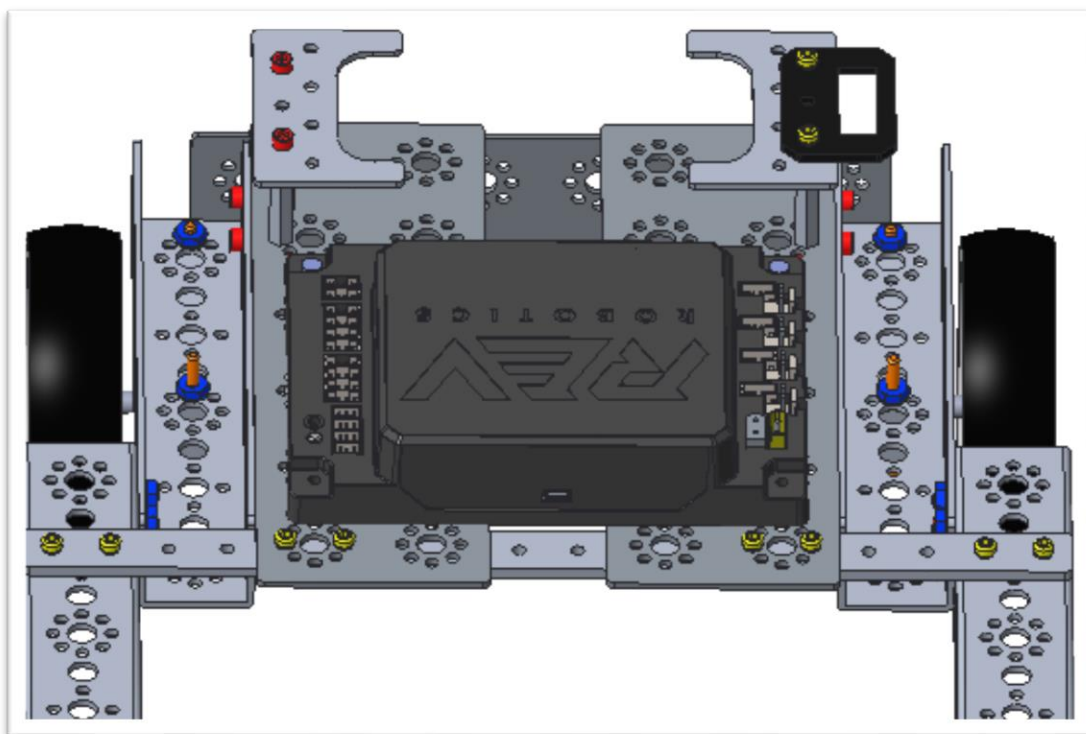


Figure 42- Assembled view from top of robot (Angle 1)

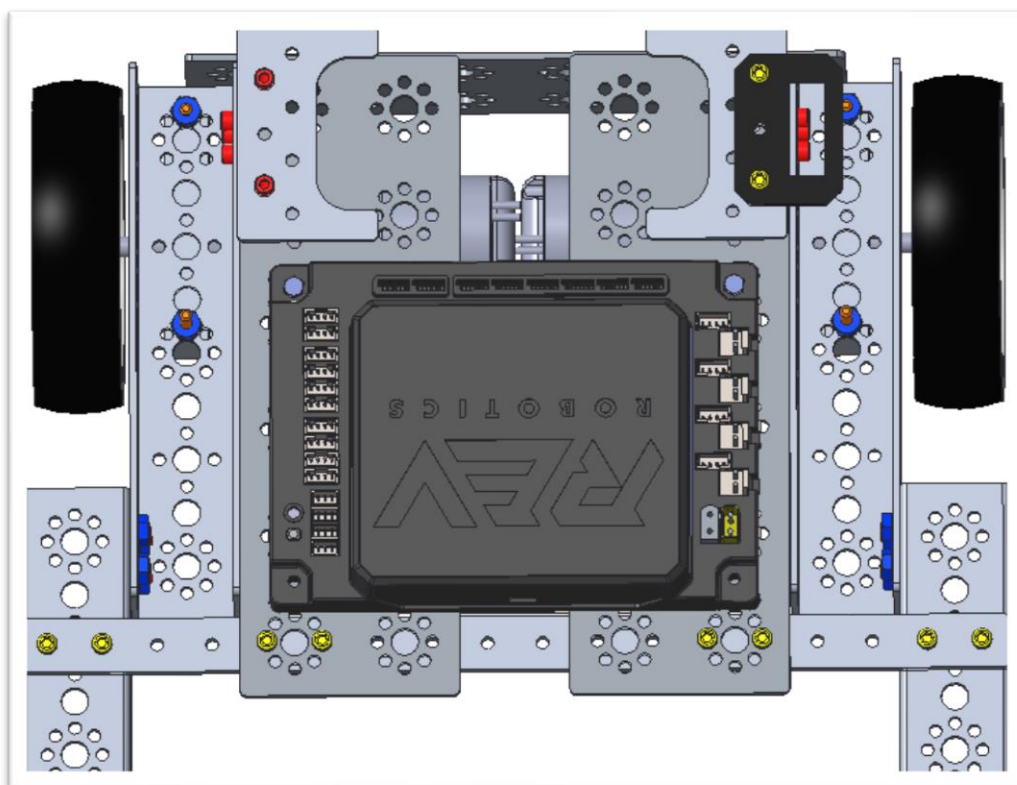
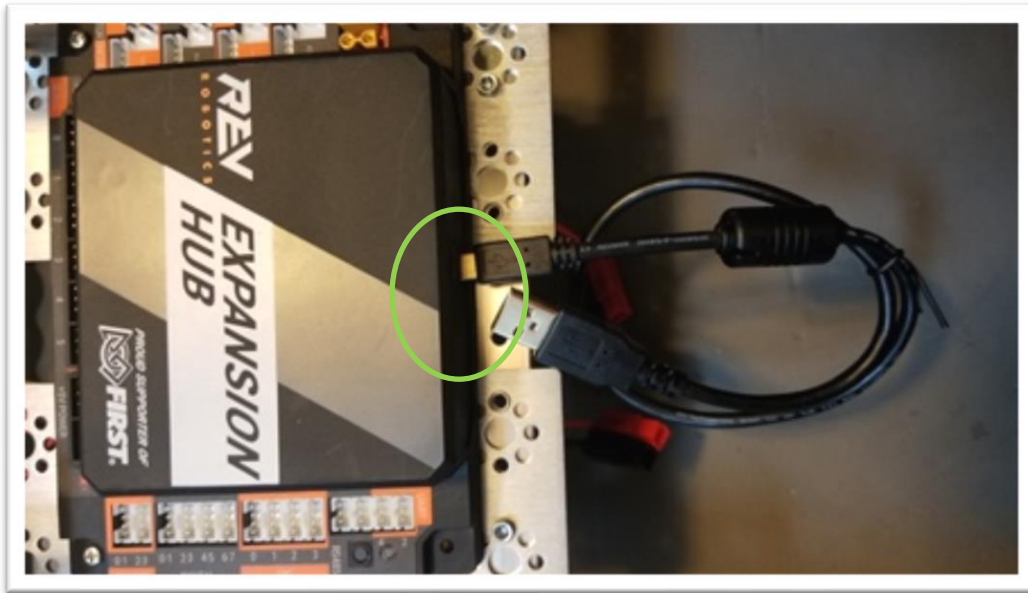


Figure 43- Assembled view from top of robot (Angle 2)

## **Step 2: Add the Expansion Hub to Phone Cable**

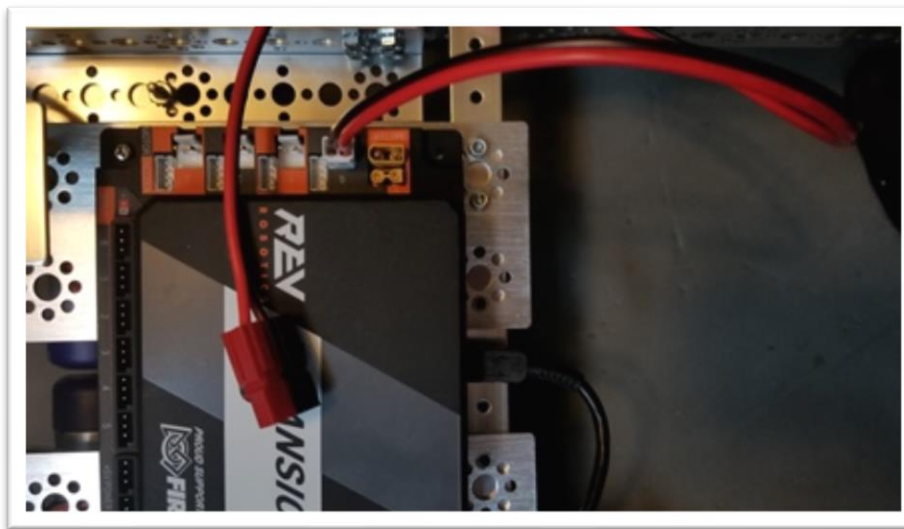
**Parts Needed:**  
5446 - Monoprice USB Cable (1)



*Figure 44- Plugging the mini USB into the Expansion Hub*

## **Step 3: Add the Left Drive Motor Power Cable**

**Parts Needed:**  
REV-31-1381 JST to Anderson Power Pole Cable (1)

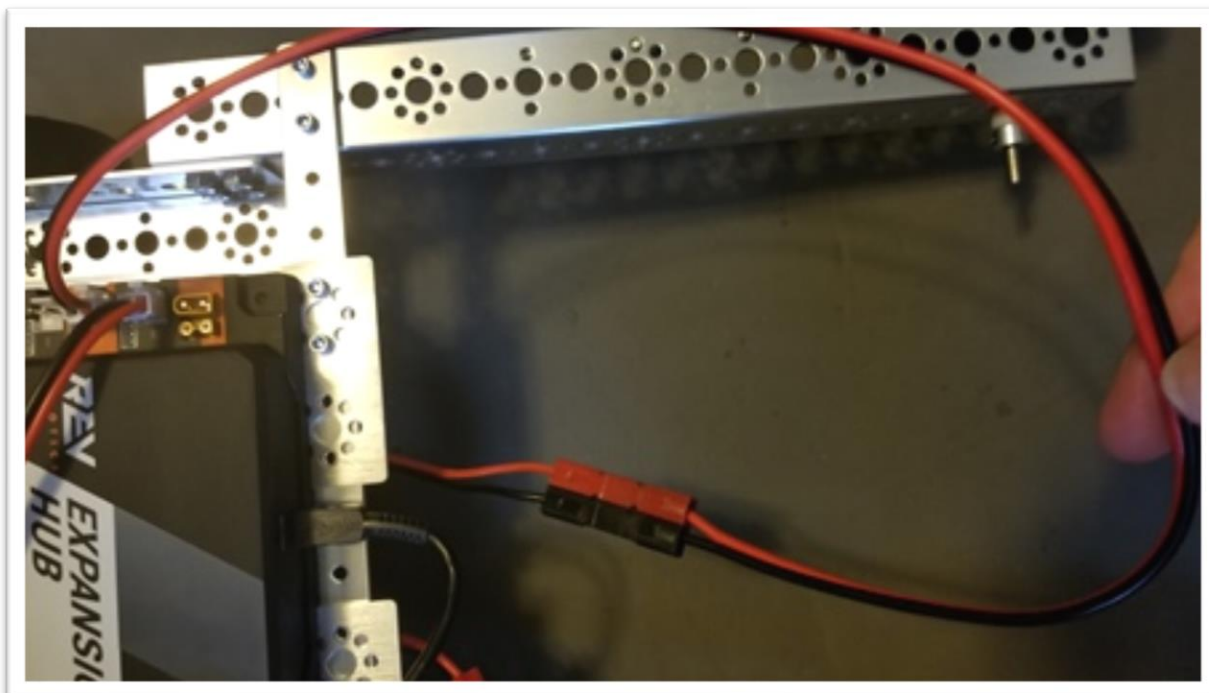


*Figure 45- Top view*



#### **Step 4: Add the Right Drive Motor Power Cable**

**Parts Needed:**  
REV-31-1381 JST to Anderson  
Power Pole Cable (1)



*Figure 46- Assembled view*

## Robot Controller

### Step 1: Add the Phone Support Plate

**Parts Needed:**  
39073 - flat building plate (1)

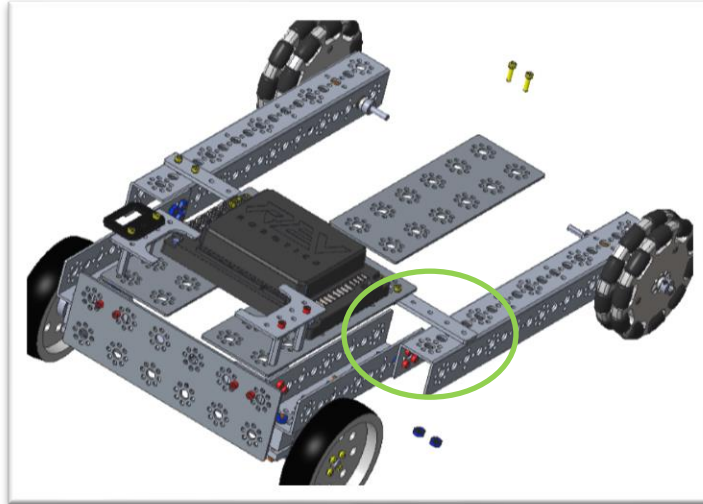


Figure 47- Detail of area where screws should be removed to attach plate



Figure 48- View with plate attached

#### Helpful Hint:

- Remove the two screws already on the right rail
- Add the plate and reattach the screws as they were



**Step 2: Add the Robot Controller Cell Phone to the Holder****Parts Needed:**

31902 - zip tie (1) Cell phone configured as the robot controller

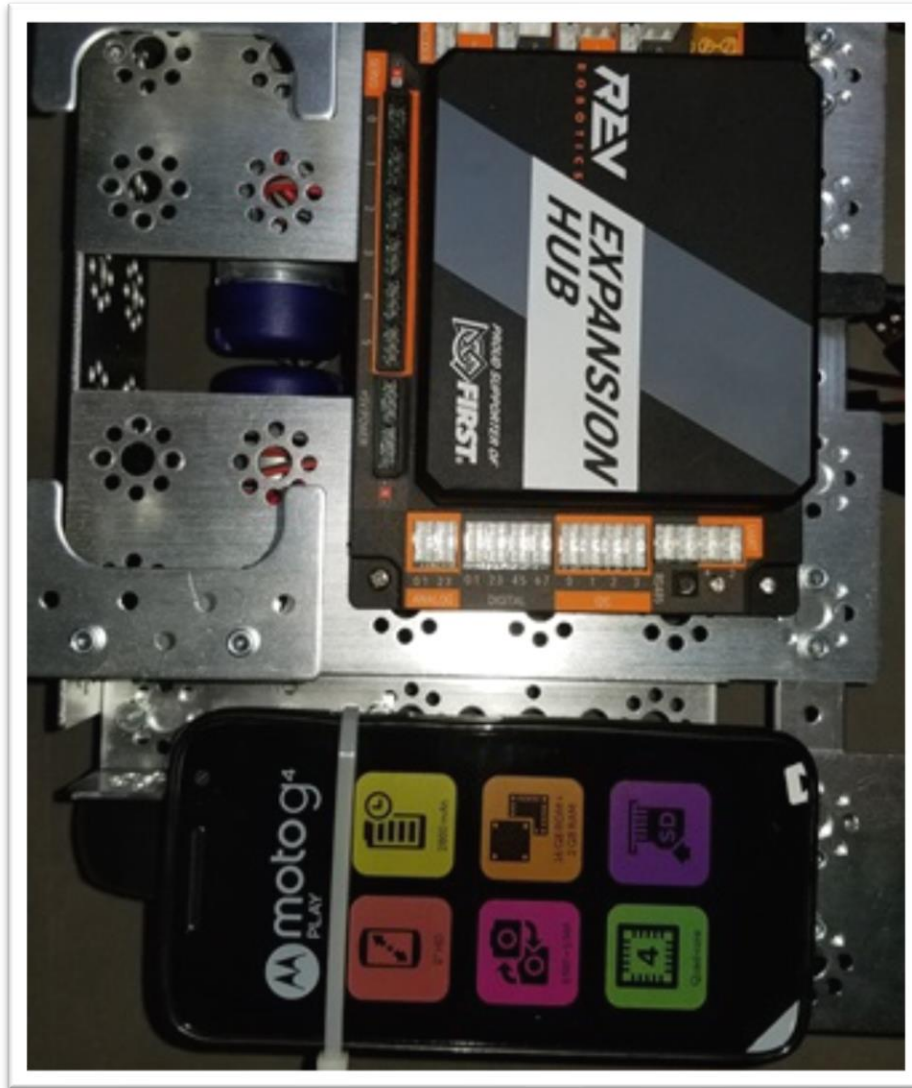


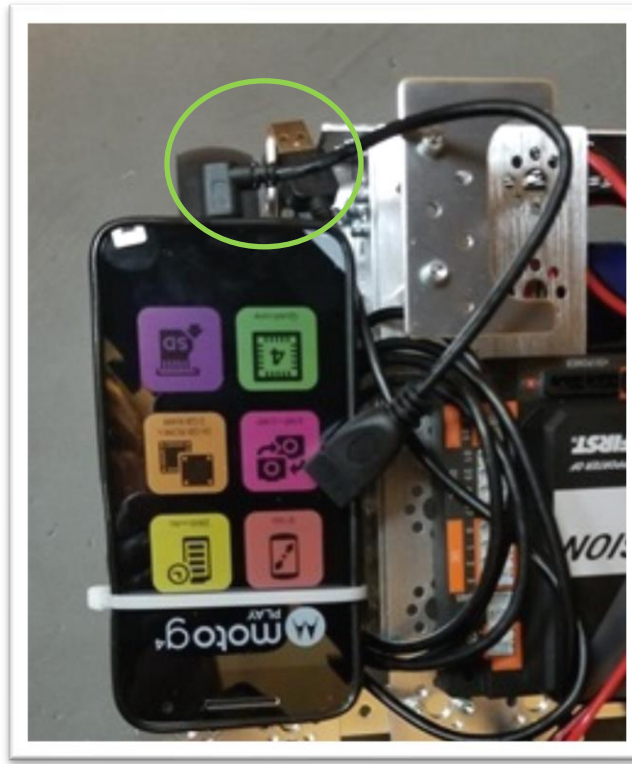
Figure 49- Assembled view

**Helpful Hints:**

- It is recommended that an approved material such as non-skid be layered between the phone and the plate to prevent damage to the phone.
- The foam that comes in the phone's packaging works well for this.

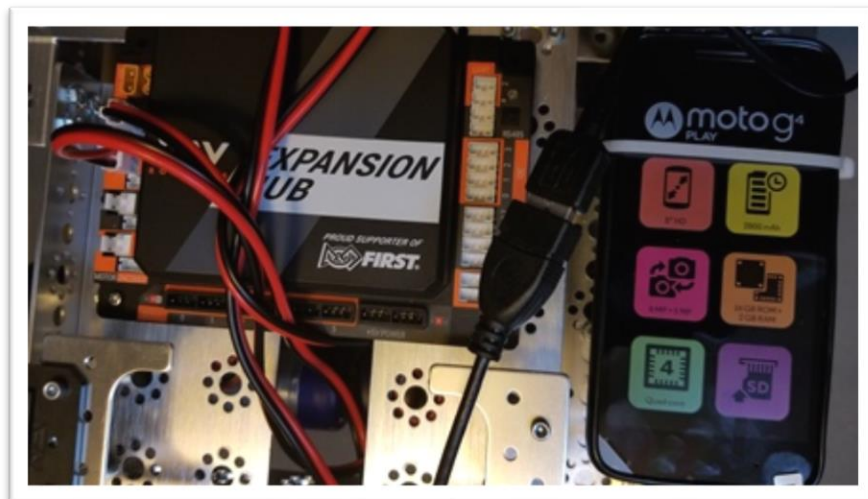
### **Step 3: Connect the Robot Controller to the Expansion Hub (Part 1)**

**Parts Needed:**  
USB On the Go (OTG)  
Adapter Cable (1)



*Figure 50- Micro USB plugged into cell phone*

### **Step 4: Connect the Robot Controller to the Expansion Hub (Part 2)**



*Figure 51- Plug the USB-A cable (from phone) into USB-A plug (on Expansion hub)*

## Power Switch

### Step 1: Add the Switc

**Parts Needed:**  
REV-31-1387 Switch (1)

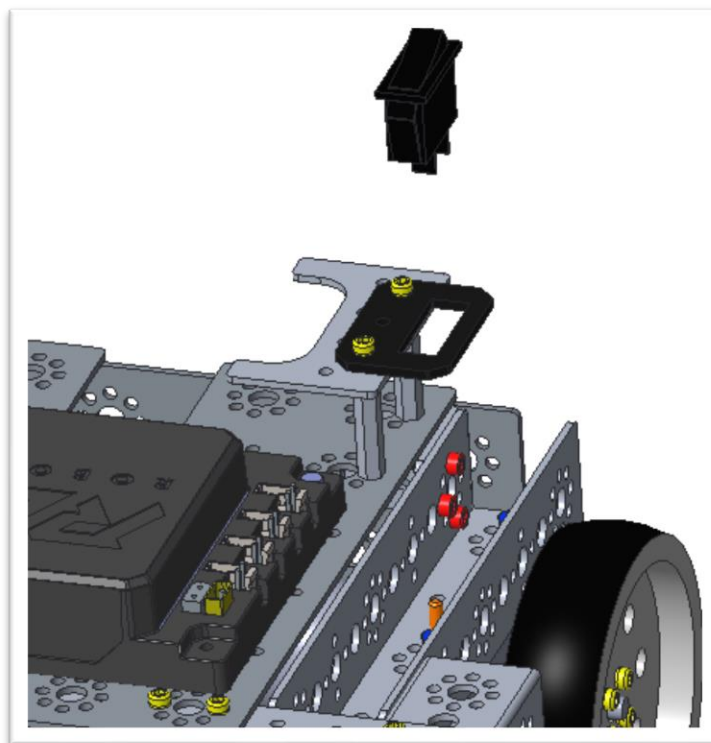


Figure 52- Unassembled view

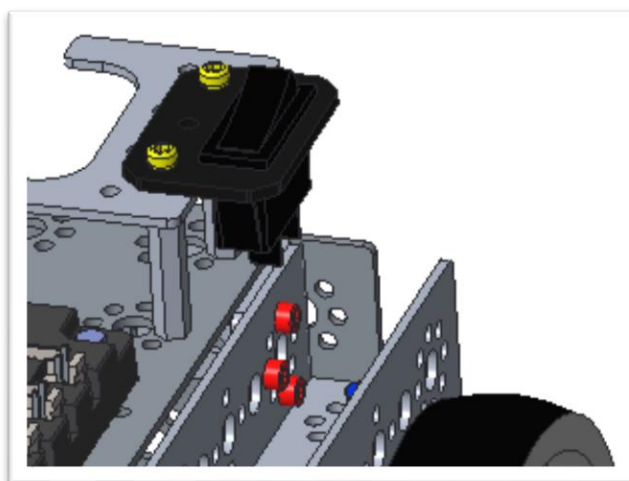
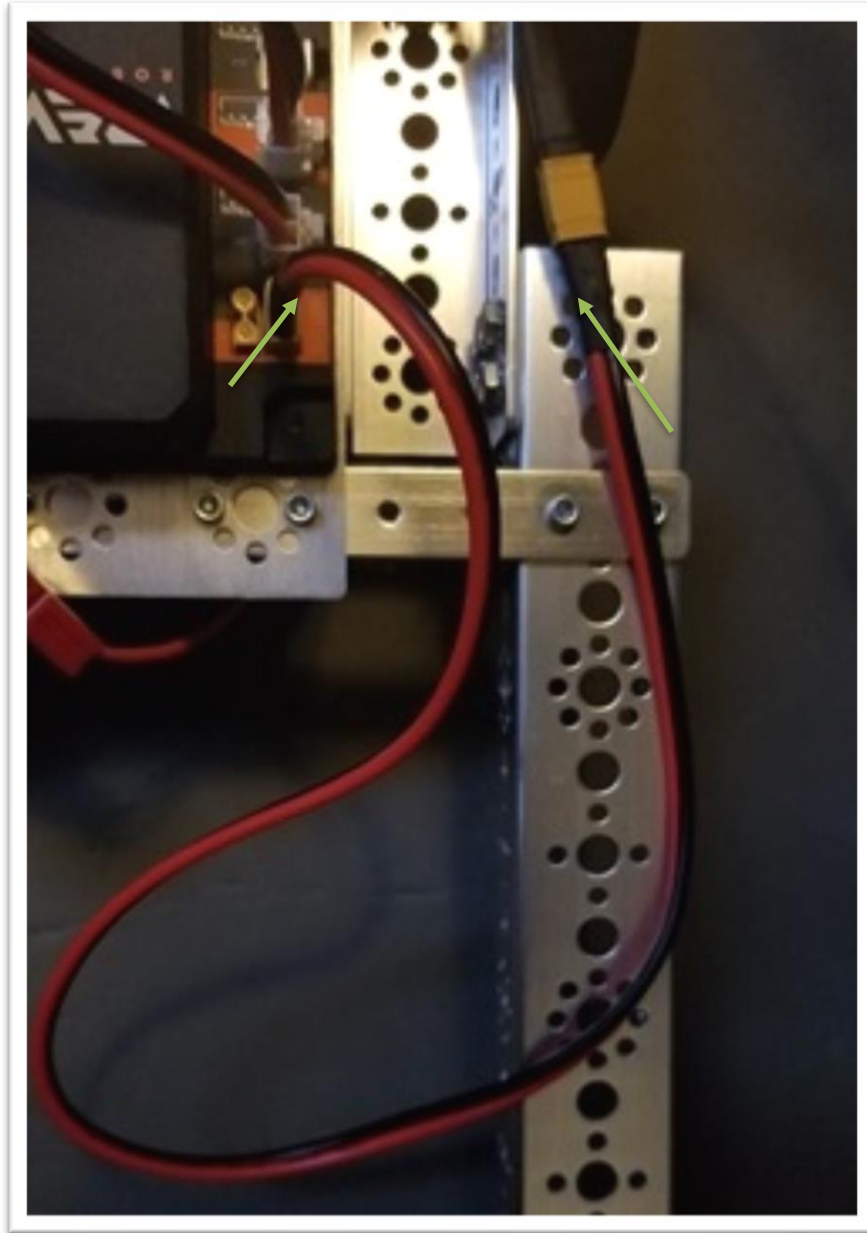


Figure 53- Assembled view

*(Please note, the wires attached to the switch are not shown in this picture)*

## **Step 2: Connect the Switch to the Motor and Sensor Controller**

**Parts Needed:**  
XT30 Extension Cable



*Figure 54- Connected switch and motor sensor*

## Battery

### Step 1: Add the Battery

**Parts Needed:**  
39057 - battery

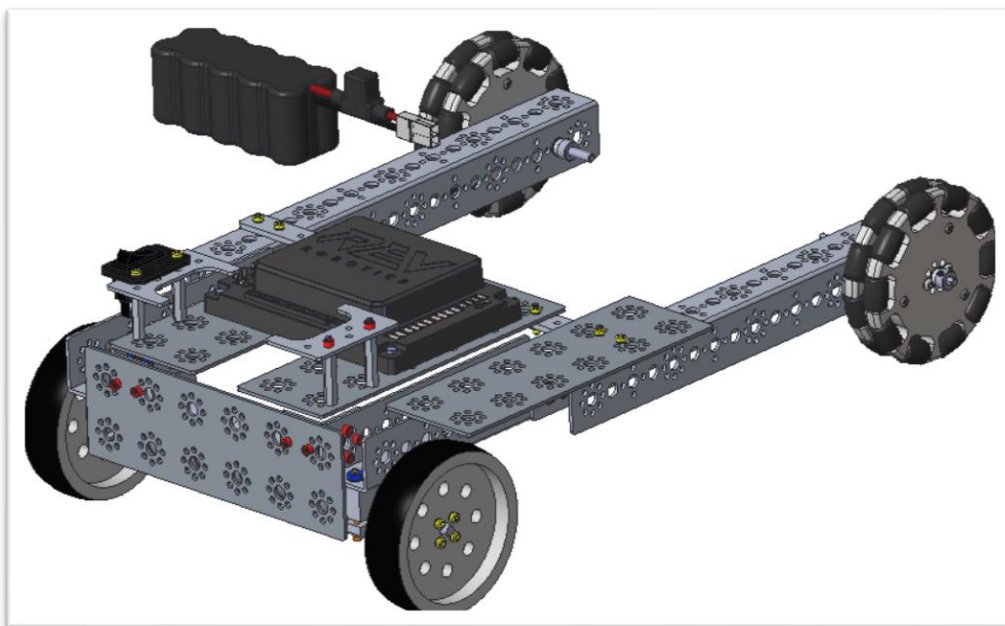


Figure 55- Unassembled view

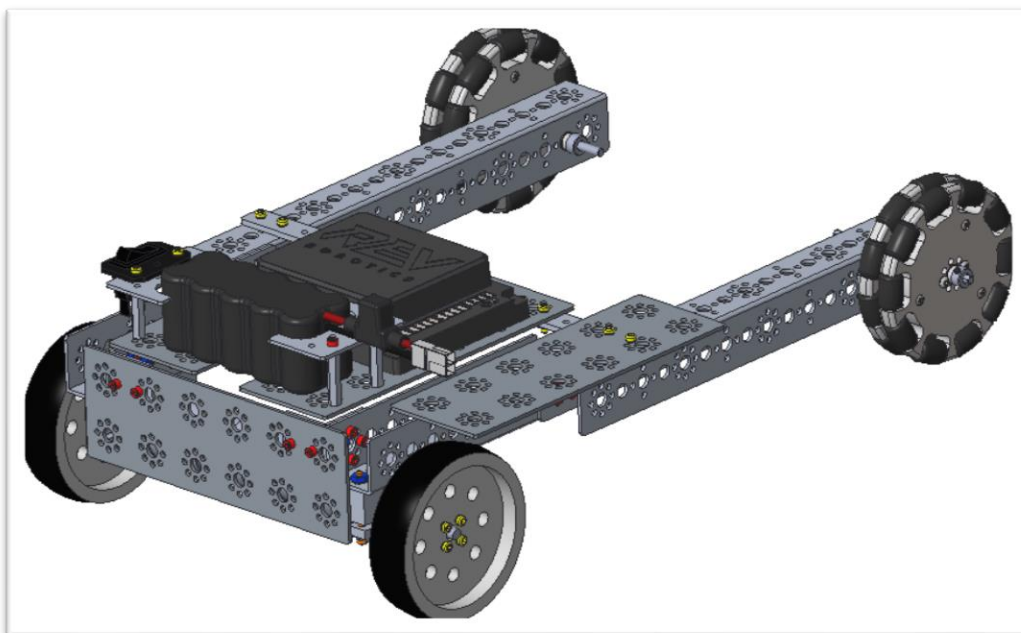


Figure 56- Assembled view



## **Step 2: Connect the Battery to the Switch**



*Figure 57- Fully assembled view from top of robot*

### *Helpful Hints:*

- *It is recommended that the battery be secured in the holder using a zip tie or some other mechanism to prevent it from being separated from the robot during competition.*
- *Care should be taken to make sure the mounting points for the battery DO NOT puncture or break the insulation of the battery or battery leads.*

## **Additional Supplies**

- Zip ties should be purchased for securing wires to the chassis. The standard four-inch size works well for this
- Electrical tape can be used to secure motor wires to the motor.
- Longer zip ties or Velcro straps can be used to keep the battery from falling out of the robot in case it tips over.

## Final Steps

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The frame has been built, however programming will be needed to make the robot functional. Testing should be done to determine whether anything needs to be changed or optimized for the season's game rules. It will also show whether more cables need to be secured or re-routed. Numbers and other stickers will be needed to make the robot competition ready.

Check the game rules for all the applicable stickers- [The Game Manual Part 1](#) includes a robot inspection checklist. *FIRST* strongly recommends that you go through the robot inspection checklist before a competition to be sure that you are prepared on the day of competition and don't have any disallowed parts on the robot.

[Visit the \*FIRST\* website for programming instructions.](#)

## Special Thanks and Best Wishes

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*FIRST*® Tech Challenge would like to sincerely thank the creators of this document **Dave and Lydean Spangler**. The Spangler's have worked tirelessly over many years and seasons to create, update and improve this document to give teams a "how to" guide for building the robot chassis of the robot to build upon and improve. We are forever grateful for their help and support in this endeavor.

Please direct any questions or comments about this guide to: [firsttechchallenge@firstinspires.org](mailto:firsttechchallenge@firstinspires.org) and put "Questions about the Robot Chassis Build Guide for TETRIX" in the subject line and we will redirect the emails to the appropriate responders.

## Appendix A – Resources

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### **Game Forum Q&A**

<http://ftcforum.usfirst.org/forum.php>

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 User Name 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](mailto:Firsttechchallenge@firstinspires.org)

### ***FIRST* Websites**

*FIRST* homepage – [www.firstinspires.org](http://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](mailto:firsttechchallenge@firstinspires.org). Thank you!