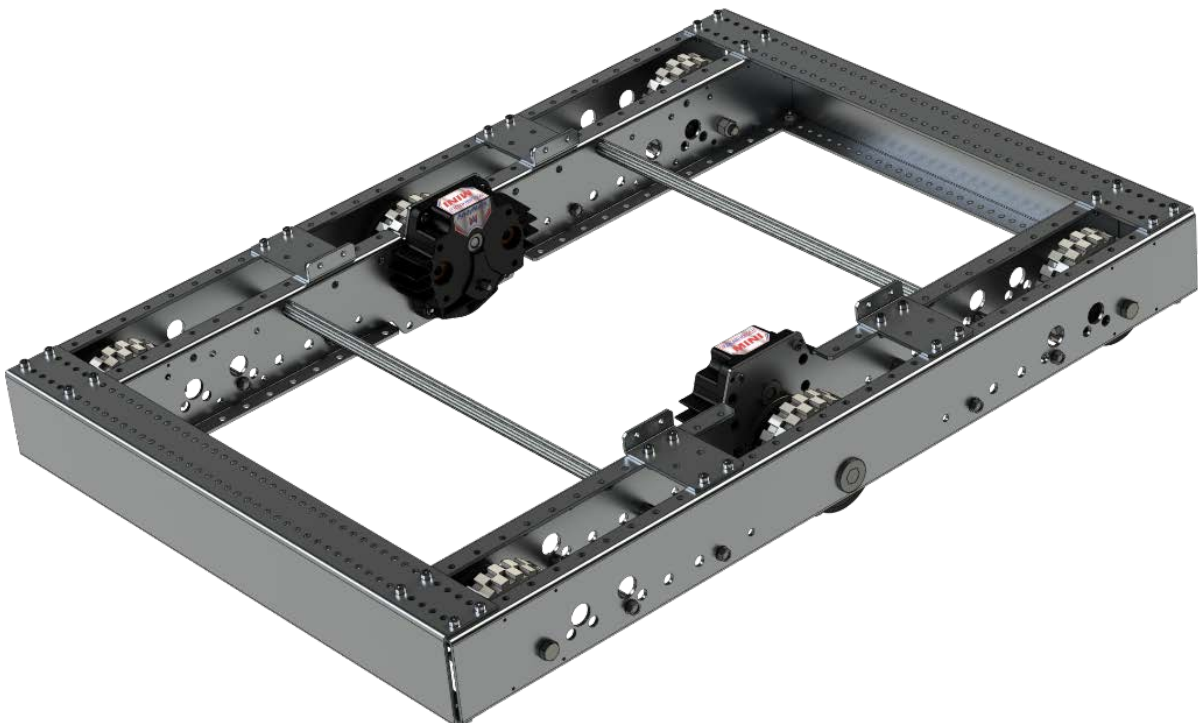




# User Guide

*AM14U2 Drive System for the  
2015 FIRST Robotics Competition*



## **AndyMark – Your Robot Parts Experts**

AndyMark, Inc. was founded in 2004 by Andy Baker and Mark Koors to design and sell unique mechanical parts for competition and educational robotics. Through their volunteer work with *FIRST* Robotics Competitions, they identified a niche market and began designing and selling robotics components for *FIRST* teams. At that time, many designs were being shared and re-created, but finding the correct fabrication resources for these parts was difficult for some *FRC* teams. AndyMark has been a proud supplier of the *FRC* program since 2005.

### **System Overview**

The 2015 AM14U2 Drive System is designed for use in the 2015 *FIRST* Robotics Competition (*FRC*). The AM14U2 Drive System includes standard AndyMark products and are designed to also work with additional AndyMark products.

### **Additional Instructions Available**

We encourage customers to seek product information at [www.andymark.com](http://www.andymark.com), contact us via e-mail at [sales@andymark.com](mailto:sales@andymark.com), or call Toll-Free **877-868-4770** with questions about any of our products.

Best of luck to all the *FIRST* Teams in the 2015 *FRC* season!

Detailed assembly tips and instruction videos can be found on the [AndyMark YouTube channel](#). Additional resources, drawings, and CAD are available on the "<http://www.andymark.com/KOP>" web page.

### **AM14U2 Recommended Hand Tool List (not included)**

| Component                               | Part Number                            | QTY | Part Photo  |
|---|--|-----|---|
| <b>Hammer</b>                           | available at your local hardware store | 1   |   |
| <b>3/8" Magnetic Nut Setter</b>         | <a href="#">am-2755</a>                | 1   |  |
| <b>5/16" Magnetic Nut Setter</b>        | <a href="#">am-2754</a>                | 1   |  |
| <b>9/16" Socket, 3/8" Drive</b>         | <a href="#">am-2743</a>                | 1   |  |
| <b>3/8" Socket, 3/8" Drive</b>          | <a href="#">am-2740</a>                | 1   |  |
| <b>5/32" Ball End Hex Driver</b>        | <a href="#">am-2751</a>                | 1   |  |
| <b>3/8" Drive Quick Release Ratchet</b> | <a href="#">am-2753</a>                | 1   |  |
| <b>1/2" - 9/16" Open-End Wrench</b>     | <a href="#">am-2746</a>                | 1   |  |

## Wheel Assembly Bill of Materials

| Component  | Part Number                                     | Quantity | Part Photo  |
|--|---|----------|---|
| 4" HiGrip Wheel                                      | <a href="#">am-2256</a>                         | 6        |    |
| 500EX Hex Hub  | <a href="#">am-2568</a>                         | 2        |    |
| Pulley, 42 Tooth                                     | <a href="#">am-2234</a> -half                   | 16       |    |
| Gates HTD 15mm wide, 170 Tooth Belt for Long Chassis | <a href="#">am-2570</a>                         | 4        |    |
| Gates HTD 15mm wide, 131 Tooth Belt for Wide Chassis | <a href="#">am-2571</a>                         | 4        |   |
| <b>Screw Kit</b>                                     |   |          |   |
| 10-24 x 1.25 Thread Forming Screws                   | am-1266<br>sold as pkg: <a href="#">am-1278</a> | 48       |  |
| <b>Bearing Kit</b>                                   |   |          |   |
| 1614ZZ Bearing                                       | <a href="#">am-0209</a>                         | 8        |  |
| FR8ZZ - HexHD Bearing                                | <a href="#">am-2986</a>                         | 2        |  |

## Toughbox Mini Overview

Each KOP chassis includes two (2) **AndyMark** Toughbox Mini Gearboxes ([am-2598](#)) unassembled. Each Toughbox Mini includes the parts needed to mount two 2.5" CIM motors. Each gearbox has mounting holes for optional encoders.

### Gearbox Specifications:

- Gear Profile: 20 dp, 14.5 degree pressure angle
- Gear Material: Cold-formed 4140 Steel
- Gear Ratio: 8.45:1
  - CIM Gear: 14 Tooth (8mm bore w/ 2mm keyway)
  - Large Cluster Gear: 50 Tooth (3/8" Hex bore)
  - Small Cluster Gear: 19 Tooth (3/8" Hex bore)\*
  - Large Output Gear: 45 Tooth (1/2" Hex bore)\*
- Output Shaft: 1/2" Hex, 4140 Steel
- Housing Material: Nylon 6/6 with long fiber reinforcements






\*To change the speed of the AM14U2, different gear ratios can be used in the Toughbox Mini. The AM14U2 features a center wheel directly driven by a TB Mini Hex Output Shaft. To change the ratio and drive speed, the standard 19 tooth Small Cluster Gear and 45 tooth Large Output Gear will need to be replaced with two gears totaling 64 teeth.

**More information about these optional gears can be found at "AndyMark.com/TBmini".**

| Ratio                    | CIM Gear                               | Lg. Cluster                            | Sm. Cluster                            | Lg. Output                             | AM14U2 Speed**     |
|--------------------------|--|--|--|--|--------------------|
| <b>5.95:1</b>            | <b>14T</b> ( <a href="#">am-0034</a> ) | <b>50T</b> ( <a href="#">am-0149</a> ) | <b>24T</b> ( <a href="#">am-0177</a> ) | <b>40T</b> ( <a href="#">am-0178</a> ) | <b>12.1 ft/sec</b> |
| <b>7.31:1</b>            | <b>14T</b> ( <a href="#">am-0034</a> ) | <b>50T</b> ( <a href="#">am-0149</a> ) | <b>21T</b> ( <a href="#">am-2564</a> ) | <b>43T</b> ( <a href="#">am-2565</a> ) | <b>9.8 ft/sec</b>  |
| <b>8.46:1 (Included)</b> | <b>14T</b> ( <a href="#">am-0034</a> ) | <b>50T</b> ( <a href="#">am-0149</a> ) | <b>19T</b> ( <a href="#">am-0176</a> ) | <b>45T</b> ( <a href="#">am-0179</a> ) | <b>8.5 ft/sec</b>  |
| <b>10.71:1</b>           | <b>14T</b> ( <a href="#">am-0034</a> ) | <b>50T</b> ( <a href="#">am-0149</a> ) | <b>16T</b> ( <a href="#">am-0747</a> ) | <b>48T</b> ( <a href="#">am-0885</a> ) | <b>6.7 ft/sec</b>  |
| <b>12.75:1</b>           | <b>14T</b> ( <a href="#">am-0034</a> ) | <b>50T</b> ( <a href="#">am-0149</a> ) | <b>14T</b> ( <a href="#">am-0151</a> ) | <b>50T</b> ( <a href="#">am-0150</a> ) | <b>5.6 ft/sec</b>  |

\*\*AM14U2 speed estimation is based on calculations using 4" wheels, and one CIM motor per TB Mini running at 4100 rpm, or 75% of free speed.

## Toughbox Mini Bill of Materials

| Component                       | Part Number             | Quantity | Part Photo  |
|---------------------------------|-------------------------|----------|---|
| <b>TB Mini Housing</b>          | <a href="#">am-0650</a> | 1        |  |
| <b>TB Mini Hex Output Shaft</b> | <a href="#">am-2566</a> | 1        |  |
| <b>TB Mini Small Hex Shaft</b>  | <a href="#">am-0152</a> | 1        |  |

| TB Mini Kit 1 – Gears - Yellow        |   |   |   |
|---------------------------------------|---|---|---|
| 50 Tooth, 3/8 Hex Gear                | <a href="#">am-0149</a>                         | 1 |    |
| 14 Tooth, 8mm CIM Gear                | <a href="#">am-0034</a>                         | 2 |    |
| 19 Tooth, 3/8" Hex Gear               | <a href="#">am-0176</a>                         | 1 |    |
| 45 Tooth, 1/2" Hex Gear               | <a href="#">am-0179</a>                         | 1 |    |
| TB Mini Kit 2 – Bearings - Purple     |   |   |   |
| R6ZZ Bearing                          | <a href="#">am-0516</a>                         | 2 |    |
| FR6ZZ Bearing                         | <a href="#">am-0028</a>                         | 1 |    |
| FR8ZZ HexHD Bearing                   | <a href="#">am-2986</a>                         | 1 |   |
| TB Mini Kit 3 – CIM Hardware - Red    |   |   |   |
| 2x2x10mm Machine Key                  | <a href="#">am-1121</a>                         | 2 |  |
| 5/16" Washer                          | am-1009<br>sold as pkg: <a href="#">am-1219</a> | 4 |  |
| 8mm Retaining Clip                    | <a href="#">am-0033</a>                         | 2 |  |
| 10-32 x 0.625" SHCS with Yellow Patch | am-1120<br>sold as pkg: <a href="#">am-1246</a> | 4 |  |
| TB Mini Kit 4 – TB Hardware - Blue    |   |   |   |
| 10-32 x 0.75" SHCS                    | am-1047<br>sold as pkg: <a href="#">am-1280</a> | 4 |  |
| 10-32 Nylock Nut                      | am-1042<br>sold as pkg: <a href="#">am-1211</a> | 4 |  |
| Grease Pack                           | <a href="#">am-2768</a>                         | 1 |  |
| 1/2" E-Clip Ring                      | <a href="#">am-0206</a>                         | 1 |  |

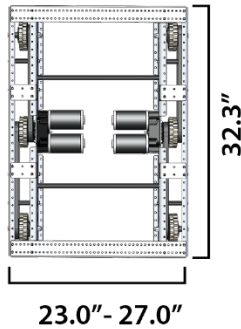
## AM14U2 Chassis Frame Bill of Materials

| Component  | Part Number                                     | QTY | Part Photo  |
|--|---|-----|---|
| AM14U2 Outer Plate                                 | <a href="#">am-2951</a>                         | 2   |     |
| AM14U2 Inner Plate                                 | <a href="#">am-2952</a>                         | 2   |     |
| AM14U2 End Plate                                   | <a href="#">am-2953</a>                         | 2   |     |
| 2x3 Hole Bracket                                   | <a href="#">am-2954</a>                         | 4   |    |
| 500 Churro, 24.25"                                 | <a href="#">am-2974</a>                         | 2   |     |
| 500 Churro, 3.375"                                 | <a href="#">am-2569</a>                         | 8   |    |
| <b>Chassis Kit 1 – Support Screws – Light Blue</b> |   |     |   |
| 1/4-20 x 3/4" Thread Rolling Screw                 | am-1310<br>sold as pkg: <a href="#">am-1321</a> | 20  |    |
| <b>Chassis Kit 2 – Axle Bolts - Orange</b>         |   |     |   |
| 3/8-16 x 4.25" HHS Bolt                            | <a href="#">am-1297</a>                         | 4   |  |
| 3/8-16 Nylock Nut                                  | <a href="#">am-1054</a>                         | 4   |  |
| <b>Chassis Kit 3 – Wheel Spacers - Green</b>       |   |     |   |
| 0.570" Hex Spacer                                  | <a href="#">am-1305</a>                         | 2   |  |
| Plastic Spacer 0.280"                              | <a href="#">am-1306</a>                         | 4   |  |
| Plastic Spacer 0.850"                              | <a href="#">am-1307</a>                         | 4   |  |
| <b>Chassis Kit 4 – 10-32 Hardware A - Grey</b>     |   |     |   |
| 10-32 x 0.5" SHCS                                  | am-1002<br>sold as pkg: <a href="#">am-1178</a> | 32  |  |
| 10-32 Nylock Nut                                   | am-1042<br>sold as pkg: <a href="#">am-1211</a> | 32  |  |
| <b>Chassis Kit 5 – 10-32 Hardware B - Aqua</b>     |   |     |   |
| 10-32 x 0.5 SHCS                                   | am-1002<br>sold as pkg: <a href="#">am-1178</a> | 8   |  |
| 10-32 Nylock Nut                                   | am-1042<br>sold as pkg: <a href="#">am-1211</a> | 8   |  |

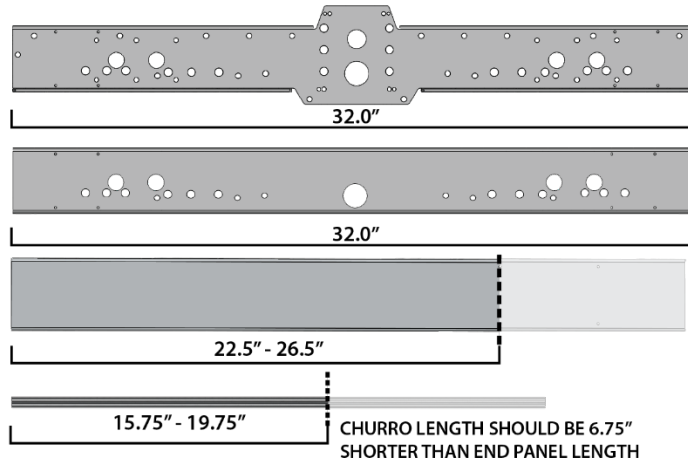
## Frame Diagrams & Cut Lines:

The AM14U2 is designed for multiple configurations. Chassis pieces **should be measured** and cut down to size, some possible configurations are shown below. Ensure that your final frame size complies with all 2015 FRC rules. Belts for **LONG** and **WIDE** configurations **ONLY** are included in this kit. Belts for **SQUARE** can be purchased separately.

### LONG CHASSIS



NOTE: Ensure your final frame size complies with all FRC robot perimeter rules.

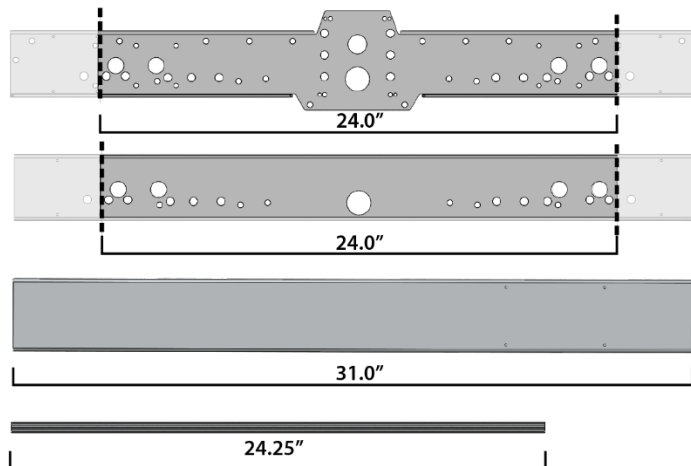
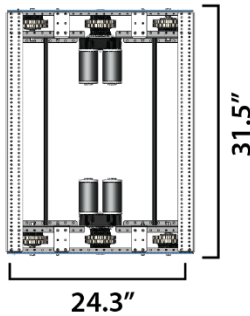


NO CUTS ARE NEEDED ON THE INNER PLATE OR OUTER PLATE

CUT END PANEL AT CHOSEN DIMENSION BETWEEN HOLE LINES

CUT CHURRO TO LENGTH

### WIDE CHASSIS



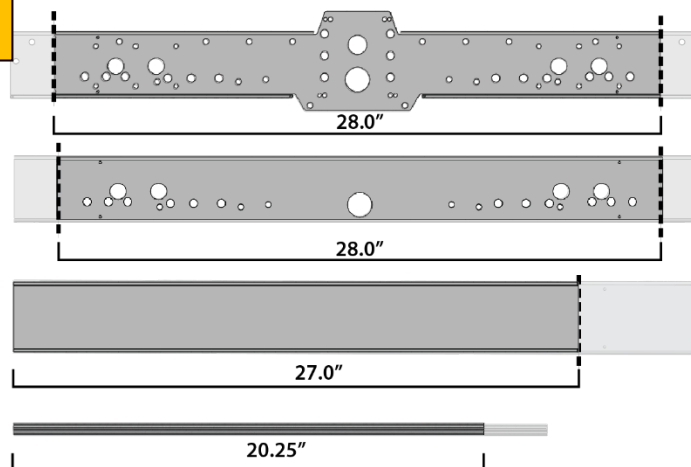
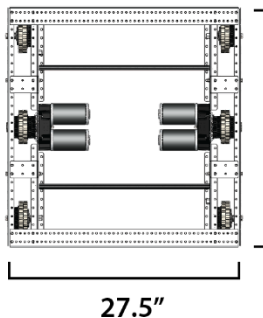
CUT OUTER PLATE AT HOLE LINE ON BOTH ENDS.

CUT INNER PLATE AT HOLE LINE ON BOTH ENDS.

NO CUTS ARE NEEDED ON THE END PLATE OR CHURRO.

### SQUARE CHASSIS

151T Belts (am-2706) for this chassis are sold separately.



CUT OUTER PLATE AT HOLE LINE ON BOTH ENDS.

CUT INNER PLATE AT HOLE LINE ON BOTH ENDS.

CUT END PLATE AT HOLE LINE ON ONE END.

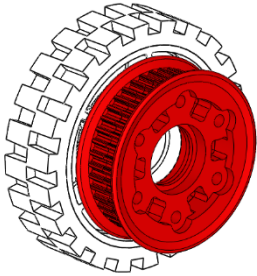
CUT CHURRO TO 20.25"



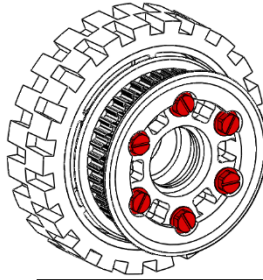
## 4" HiGrip Wheel and Pulley Assembly Instructions

### Outer Wheels (QTY 4)

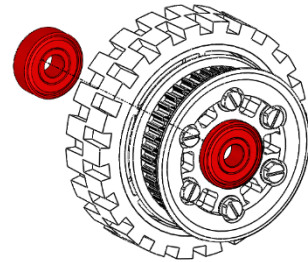
**Step 1:** Add two pulley halves (am-2234-half) to the wheel (am-2256).



**Step 2:** Using six 10-24 x 1.25" (am-1266) thread forming screws attach the pulley halves to the wheel.



**Step 3:** Press two 1614ZZ Bearings (am-0209) into each side of the wheel/pulley.

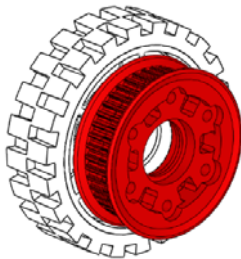


**4X**

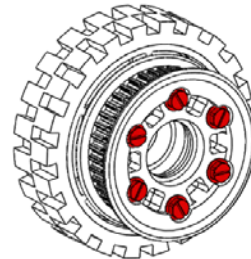
**NOTE:** Tighten the screws in a triangle pattern to ensure the pulley aligns evenly on the wheel.

### Center Wheels (QTY 2)

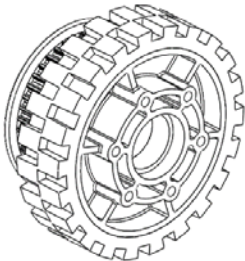
**Step 1:** Add two pulley halves (am-2234-half) to the wheel (am-2256).



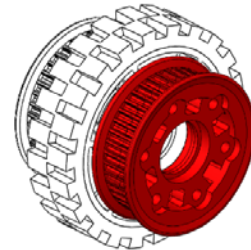
**NOTE:** Tighten the screws in a triangle pattern to ensure the pulley aligns evenly on the wheel.



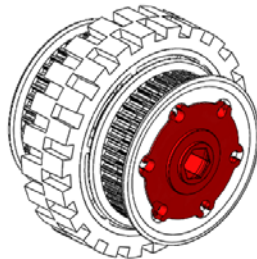
**Step 3:** Flip wheel over.



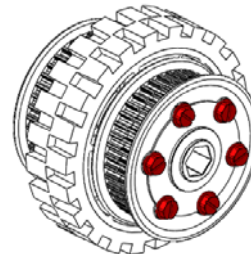
**Step 4:** Add two more pulley halves (am-2234-half) to the wheel.



**Step 5:** Insert one 500EX Hex Hub (am-2568) into the pulley on one side of the wheel.



**Step 6:** Add six 10-24 x 1.25" (am-1266) screws to secure the pulley and hub to the wheel.

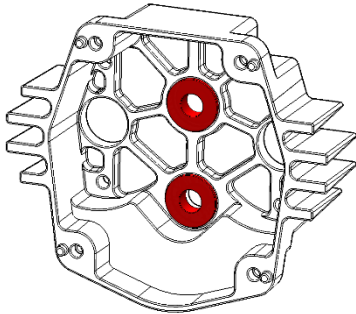


**2X**

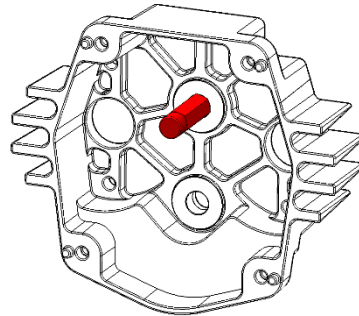


# Toughbox Mini & Chassis Assembly Instructions

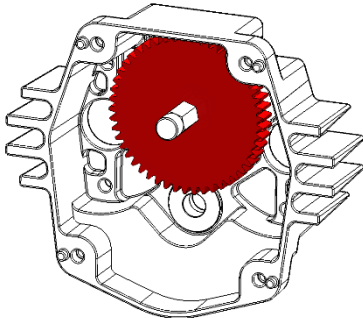
**Step 1:** Press two R6ZZ bearings (am-0516) into the two center holes of the TB Mini Housing (am-0650).



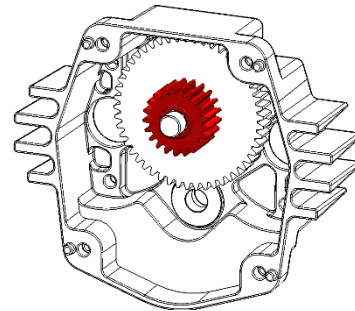
**Step 2:** Insert TB Small Hex Shaft (am-0152) into R6ZZ bearing closest to the flat edge of the housing.



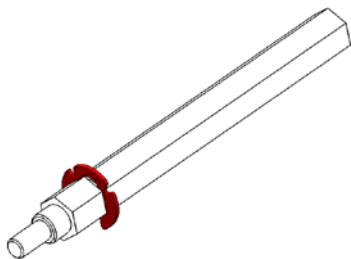
**Step 3:** Place 50 tooth gear (am-0149) on the TB Small Hex Shaft with **flat side up**.



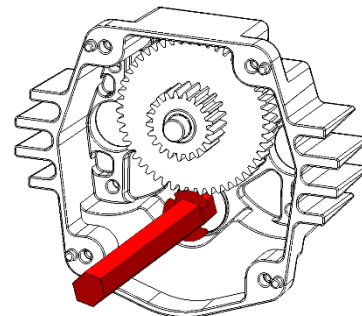
**Step 4:** Place 19 tooth gear (am-0176) on the TB Small Hex Shaft with **flat side down**.



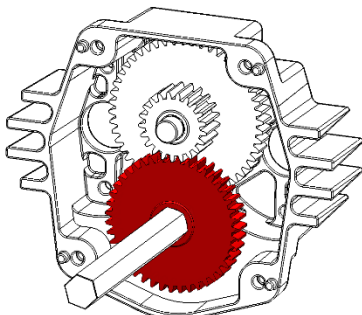
**Step 5:** Tap the ½" E-Clip (am-0206) onto the groove on the TB Hex Output Shaft (am-2566).



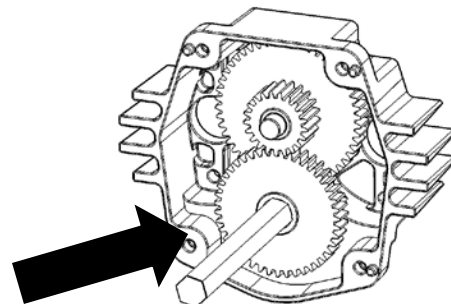
**Step 6:** Insert small end of the TB Hex Output Shaft (am-2566) into the other R6ZZ bearing.



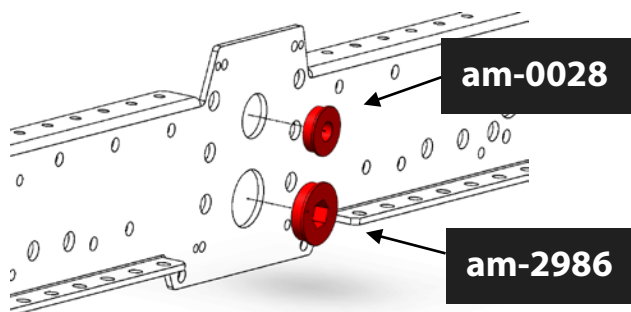
**Step 7:** Place 45 Tooth Gear (am-0179) on TB Hex Output Shaft **flat side down**.



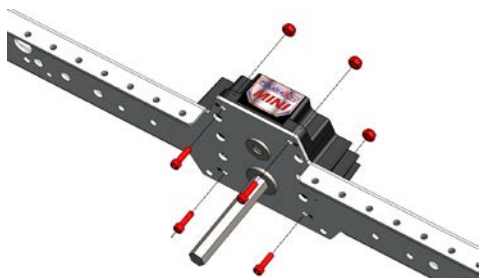
**Step 8:** Apply grease to all of the gear teeth.



**Step 9:** Press FR6ZZ (am-0028) and FR8ZZ-HexHD (am-2986) bearings into center holes on the Inner Plate (am-2952) with the **bearing flanges on the same side** as the bottom flange. This will keep the bearings from falling out during operation.

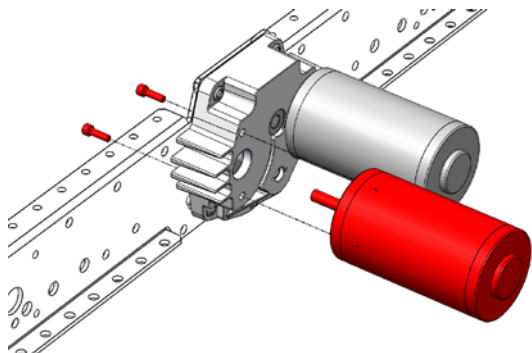


**Step 11:** Attach TB Mini to Inner Plate with four 10-32 x 0.750 Bolts (am-1047) and four 10-32 NyLock nuts (am-1042). The nuts will fit into the hex pockets on the TB Mini housing and will hold the nut while tightening.

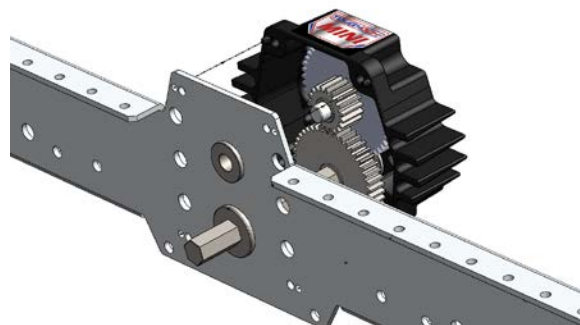


**NOTE:** The gears should spin freely when the shaft is rotated by hand

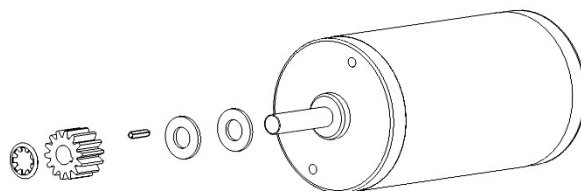
**Step 13:** Line up the CIM motors with the mounting holes in the TB mini. The housing can be used to align the motor. Secure the CIM motors (am-0255) to TB Mini with two each 10-32 x 0.625" SHCS w/ Yellow Patch (am-1120).



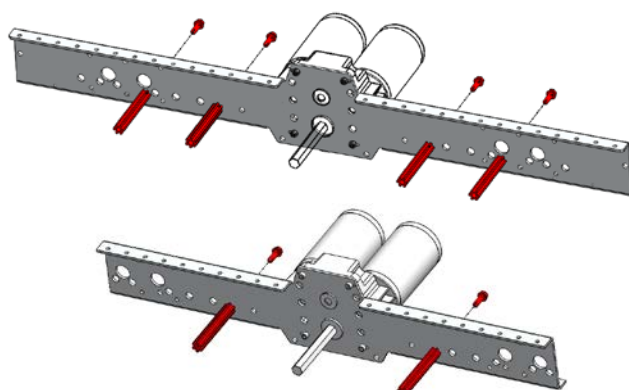
**Step 10:** Place Gearbox onto the Inner Plate using the plastic studs to align the housing. The bottom flanged edge of the inner plate will be facing towards the gearbox housing.



**Step 12:** Place the two 5/16" Washers (am-1009) onto the CIM Motor shaft. Place the 2x2x10mm Machine Key (am-1121) into the keyway. Push the 14 Tooth, 8mm Key Gear onto the shaft, to the face of the washers, while aligning the keyway with the machine key. Use a 3/8" socket to press the 8mm Retaining Clip (am-0033) onto the face of the gear.

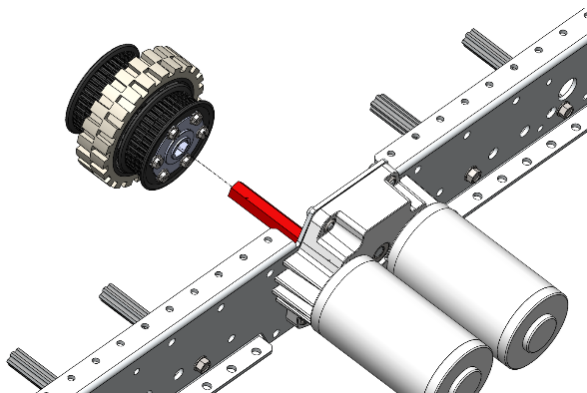


**Step 14:** Attach 3.375" Churro Standoffs with 1/4-20 x 0.750" Thread Rolling Screws (am-1310). A 1/2" wrench can be used to hold the churro while tightening.

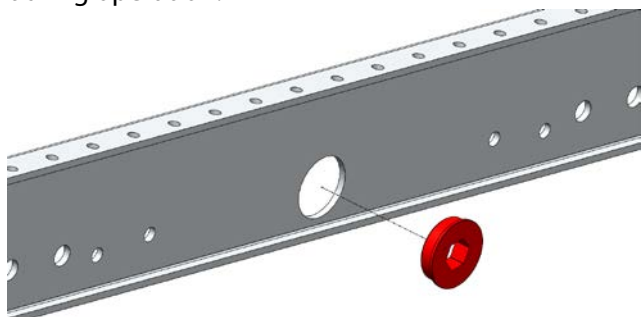


**NOTE:** The long chassis will use four standoffs per side. The wide and square chassis will use two standoffs per side. Additional churros can be added to wide and long for extra support by drilling 1/4" holes in the inner and outer plates.

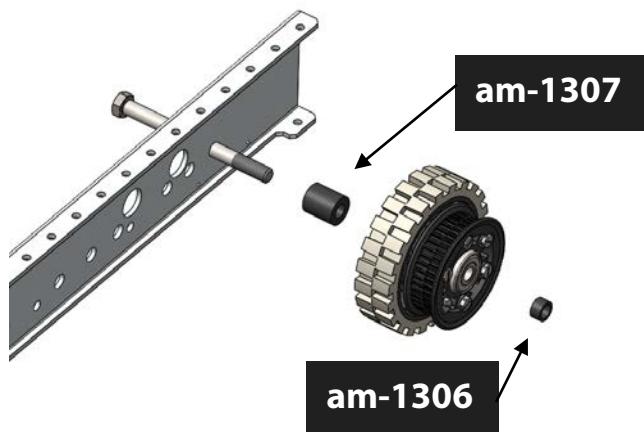
**Step 15:** Place an Inner Wheel Assembly onto the TB Hex Output shaft with the hub facing towards the inner plate.



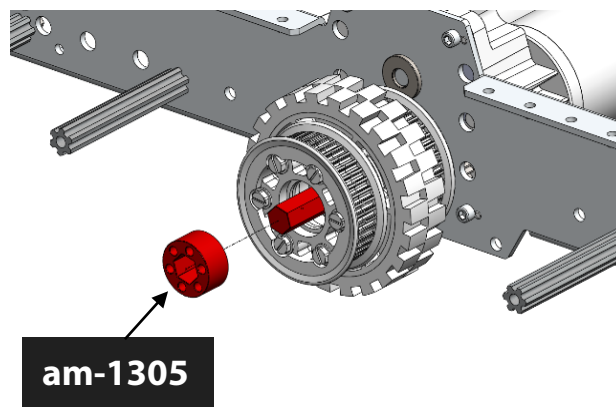
**Step 17:** Press the FR8ZZ-HexHD Bearing (am-2986) into the center hole of the Outer Plate (am-2951). The bearing flange will be on the same side as the plate flanges to ensure the bearing does not fall out during operation.



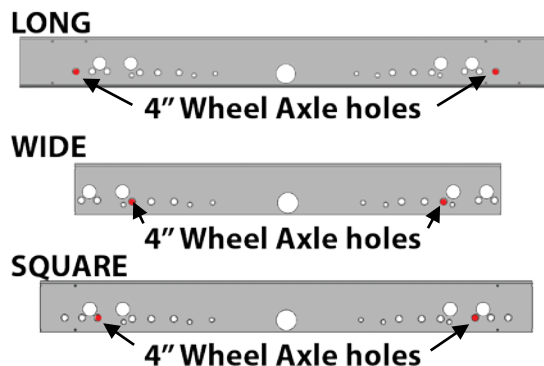
**Step 19:** Add a long spacer (am-1307), wheel assembly and short spacer (am-1306) to the axle bolt. The shorter 0.28" (am-1306) spacer is used on the pulley side of the wheel.



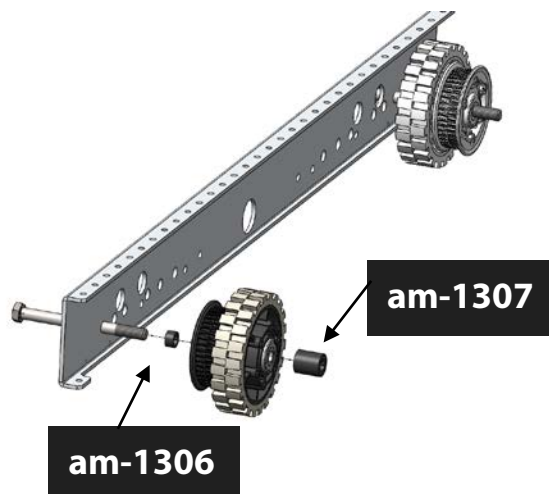
**Step 16:** Place the Hex Spacer (am-1305) onto the TB Hex Output shaft and press into the pulley. The shaft will help to align the spacer hex with the wheel hub hex.



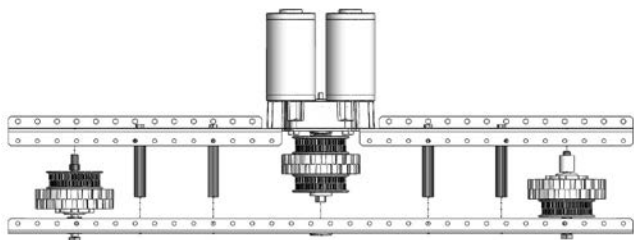
**Step 18:** There are different axle bolt locations for the different chassis configurations. Slide an axle bolt (am-1297) into the correct axle hole on the outer plate.



**Step 20:** For the second wheel on this side, the spacer and wheel orientation is reversed to allow one pulley on either side to line up with a center wheel assembly pulley. The front and back wheels will be in opposite orientations.

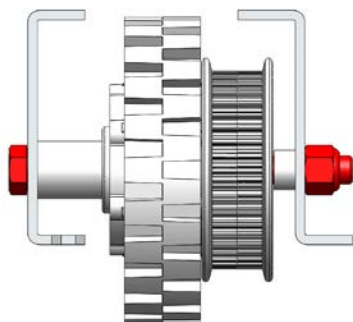


**Step 21:** Carefully line up and place the outer plate assembly onto the inner plate assembly. The axle bolts will slide through corresponding bolt holes on the inner plate and the TB mini shaft will slide through the FR8ZZ-HexHD bearing on the outer plate. Make sure to place belts around the wheel pulleys before securing outer plate.

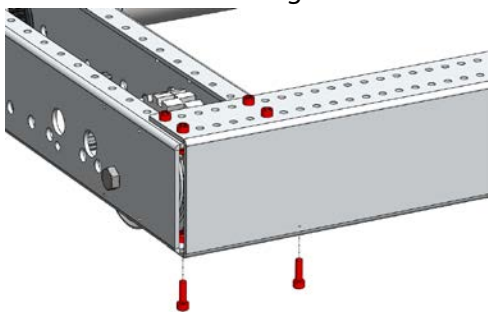


*The long chassis requires 170 tooth belts (am-2570).  
The wide chassis requires 131 tooth belts (am-2571).  
The square chassis requires 151 tooth belts (am-2706).*

**Step 23:** Tighten down axle bolts. The spacers should be flush with the inside plate but the wheel should still easily turn.

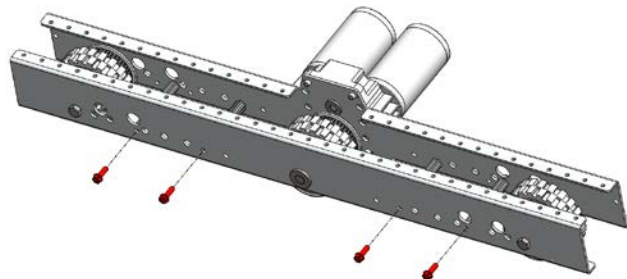


**Step 25:** Make sure to cut both the end plate and center churros to the proper length for your chosen chassis in order to comply with 2015 FRC robot rules. Attach end plates to the drive modules using 10-32 x 0.5" SHCS.

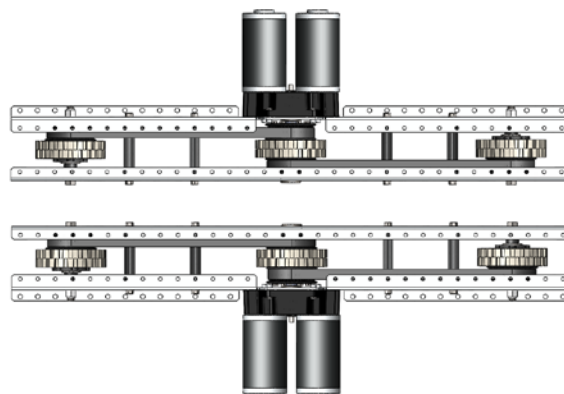


**NOTE:** The long chassis will use 6 screws per corner. The wide and square configurations will use 5 screws per corner.

**Step 22:** Finger tighten the axle bolts with the 3/8-16 NyLock Nuts (am-1054) to secure the assembly. Attach the Outer Plate to the churro standoffs using 1/4"-20 x 0.750" Thread Rolling Screws (am-1310).



**Step 24:** You have made one side drive module. Repeat steps 1-23 to create the other drive module.



**NOTE:** The belts should be parallel to the side plates.

**Step 26:** Add the long Churro Tubes (am-2974) and 2x3 Hole Brackets (am-2954) as stiffeners across the robot frame. Feel free to move these to other holes to accommodate electronics and/or other mechanisms.

