AndyMark®

User Guide

AM14U3 Chassis Base Kit for the FIRST® Robotics Competition

AM14U3

TOUGHBOX MINI

November 2017
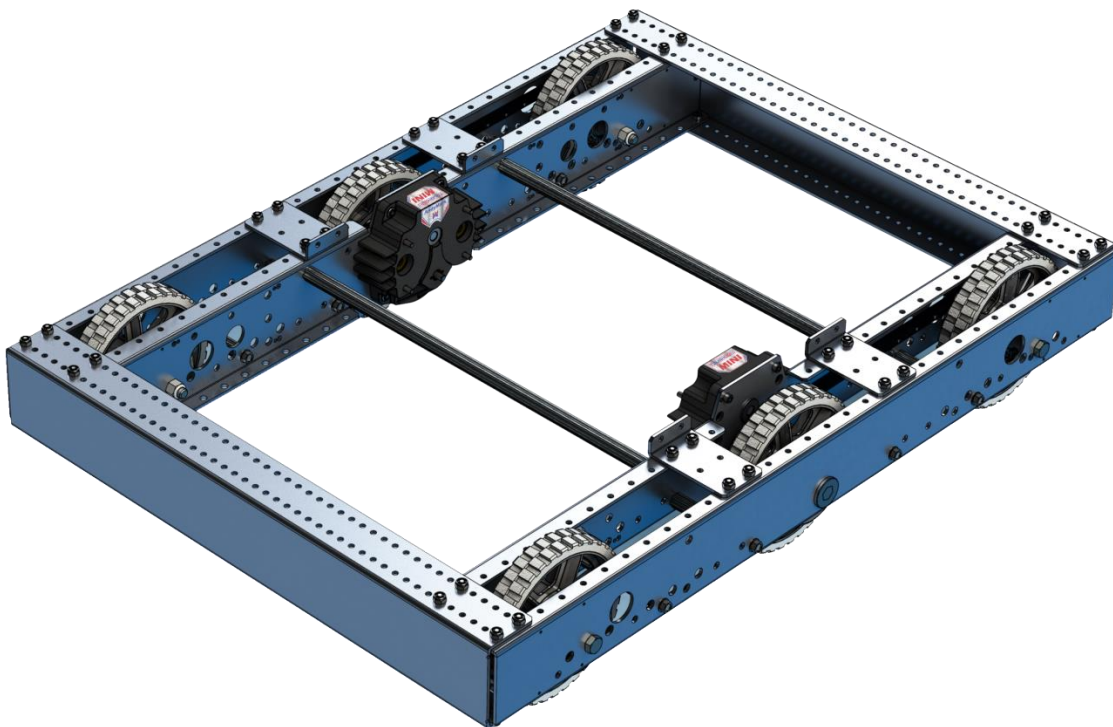
AndyMark – Your Robot Parts Experts

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 Competition events 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 to the *FIRST®* Robotics Competition since 2005.

System Overview
The AM14U3 Drive Chassis Base Kit is designed to help teams accomplish the basics in the *FIRST®* Robotics Competition. The AM14U3 Base Kit includes standard AndyMark products and is designed to also work with additional AndyMark products.

Additional Instructions Available
We encourage customers to seek product information at **AndyMark.com**, contact us via e-mail at **support@andymark.com**, or call Toll-Free **877-868-4770** with questions about any of our products.

Detailed assembly tips and instructional videos can be found at **AndyMark.com/FRCVideos**. Additional resources, drawings, and CAD are available on the **AndyMark.com/KOP** web page.

AM14U3 Recommended Hand Tool List (not included)

Component	Part Number	QTY	Part Photo
Hammer	Available at your local hardware store.	1	
Cordless Drill or Driver	Available at your local hardware store.	1	
3/8" Magnetic Nut Setter	am-2755	1	
5/16" Magnetic Nut Setter	am-2754	1	
9/16" Socket, 3/8" Drive	am-2743	1	
3/8" Socket, 3/8" Drive	am-2740	1	
5/32" Ball End Hex Bit Driver	am-2748	1	
3/8" Drive Quick Release Ratchet	am-2753	1	
1/2" - 9/16" Open-End Wrench	am-2746	1	

Wheel Assembly Bill of Materials

Component	Part Number	Quantity	Part Photo
6" HiGrip Wheel	am-0940a	6	
500EX Hex Hub	am-2568	2	
Pulley Half, 42 Tooth	am-2234-half	16	
Gates HTD 15mm wide, 160 Tooth Belt for Long Chassis	am-2266	4	
Gates HTD 15mm wide, 120 Tooth Belt for Wide Chassis	am-2704	4	
Gates HTD 15mm wide, 131 Tooth Belt for Square Chassis	am-2571	4	
Screw Kit – (am-14U3_white)			
10-24 x 1.25" Thread Forming Screws	am-1266	48	
Bearing Kit – (am-14U3_LightGreen)			
1614ZZ Bearing	am-0209	8	
FR8ZZ - HexHD Bearing	am-2986	2	

Toughbox Mini Overview

Each AM14U3 Chassis Base Kit includes two (2) **AndyMark** Toughbox Mini Gearboxes, unassembled (am-2598_107). Each Toughbox Mini includes the parts needed to mount two 2.5" CIM motors (am-0255). Each gearbox has mounting holes for optional encoders such as the USDigital E4T Optical Encoder (am-3132).

Gearbox Specifications:
- Gear Profile: 20 DP, 14.5° pressure angle
- Gear Material: Cold-formed 4140 Steel
- Gear Ratio: 10.71:1
  - CIM Gear: 14 Tooth (8mm bore w/ 2mm keyway)
  - Large Cluster Gear: 50 Tooth (3/8" Hex bore)
  - Small Cluster Gear: 16 Tooth (3/8" Hex bore)*
  - Large Output Gear: 48 Tooth (1/2" Hex bore)*
- Output Shaft: 1/2" Hex, 4140 Steel
- Housing Material: Nylon 6/6 with long fiber reinforcements
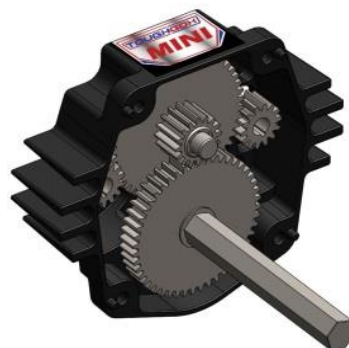
*To change the drive speed of the AM14U3, different gear ratios can be used in the Toughbox Mini. The AM14U3 features a center wheel directly driven by a TB Mini Hex Output Shaft. To change the ratio and drive speed, the standard 16 tooth Small Cluster Gear and 48 tooth Large Output Gear will need to be replaced with two gears totaling 64 teeth. The higher the ratio, the slower the output speed.
More information about these optional gears can be found at "AndyMark.com/TBmini".

Ratio	CIM Gear	Lg. Cluster	Sm. Cluster	Lg. Output	AM14U3 Speed**
5.95:1	**14T** (am-0034)	**50T** (am-0149)	**24T** (am-0177)	**40T** (am-0178)	18.0 ft/sec
7.31:1	**14T** (am-0034)	**50T** (am-0149)	**21T** (am-2564)	**43T** (am-2565)	14.7 ft/sec
8.45:1	**14T** (am-0034)	**50T** (am-0149)	**19T** (am-0176)	**45T** (am-0179)	12.7 ft/sec
10.71:1 (included)	**14T** (am-0034)	**50T** (am-0149)	**16T** (am-0747)	**48T** (am-0885)	10.0 ft/sec
12.75:1	**14T** (am-0034)	**50T** (am-0149)	**14T** (am-0151)	**50T** (am-0150)	8.4 ft/sec

**AM14U3 speed estimation is based on calculations using 6" 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
TB Mini Housing	am-0650	1	
TB Mini Hex Output Shaft	am-2566a	1	
TB Mini Small Hex Shaft	am-0152	1	
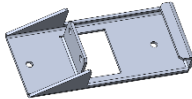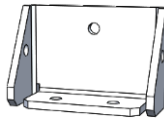
TB Mini Kit 1 – Gears – (am-14U3_Yellow)			
50 Tooth, 3/8" Hex Gear	am-0149	1	
14 Tooth, 8mm CIM Gear	am-0034	2	
16 Tooth, 3/8" Hex Gear	am-0747	1	
48 Tooth, 1/2" Hex Gear	am-0885	1	
TB Mini Kit 2 – Bearings – (am-14U3_Purple)			
R6ZZ Bearing	am-0516	2	
FR6ZZ Bearing	am-0028	1	
FR8ZZ HexHD Bearing	am-2986	1	
TB Mini Kit 3 – CIM Hardware – (am-14U3_Red)			
2x2x10mm Machine Key	am-1121	2	
5/16" Washer	am-1009	4	
8mm Retaining Clip	am-0033	2	
10-32 x 0.625" SHCS with Nylon Thread Lock Patch	am-1120	4	
TB Mini Kit 4 – TB Hardware – (am-14U3_DarkBlue)			
10-32 x 0.75" SHCS	am-1047	4	
10-32 Nylock Nut	am-1042	4	
Red Tacky Grease Pack	am-2768	1	
1/2" E-Clip Ring	am-0206	1	

AM14U3 Chassis Frame Bill of Materials

Component	Part Number	QTY	Part Photo
AM14U3 Outer Plate	am-2951a	2	
AM14U3 Inner Plate	am-2952a	2	
AM14U3 End Plate	am-2953a	2	
2x3 Hole Bracket	am-2954	4	
500 Churro, 24.25"	am-2974	2	
500 Churro, 3.375"	am-2569	8	
Chassis Kit 1 – Support Screws – (am-14U3_LightBlue)			
1/4-20 x 0.75" Thread Rolling Screw	am-1310	20	
Chassis Kit 2 – Axle Bolts – (am-14U3_Orange)			
3/8-16 x 4.25" HHS Bolt	am-1297	4	
3/8-16 Nylock Nut	am-1054	4	
Chassis Kit 3 – Wheel Spacers – (am-14U3_Green)			
0.570" Hex Spacer	am-1305	2	
Plastic Spacer 0.280"	am-1306	4	
Plastic Spacer 0.850"	am-1307	4	
Chassis Kit 4 – 10-32 Hardware – (am-14U3_Gray)			
10-32 x 0.5" SHCS	am-1002	40	
10-32 Nylock Nut	am-1042	40	

AM14U3 Additional Parts

Bumper Hardware Included Parts

Component	Part Number	QTY	Part Photo
Side Mount Bumper Bracket	am-3674	4	
Front/Corner Bumper Bracket	am-3675	8	
10-32 3 Prong Tee Nut	am-1143	32	
10-32 x 0.625" SHCS	am-1007	24	
10-32 Nylock Nut	am-1042	24	
10-32 x 1.00" Thumb Screws	am-1390	16	

Note: Additional items are needed for bumper assembly including pool noodles, robust red and blue fabric, industrial staples and corner brackets. For supplies, visit **AndyMark.com.**

Battery Tray Parts

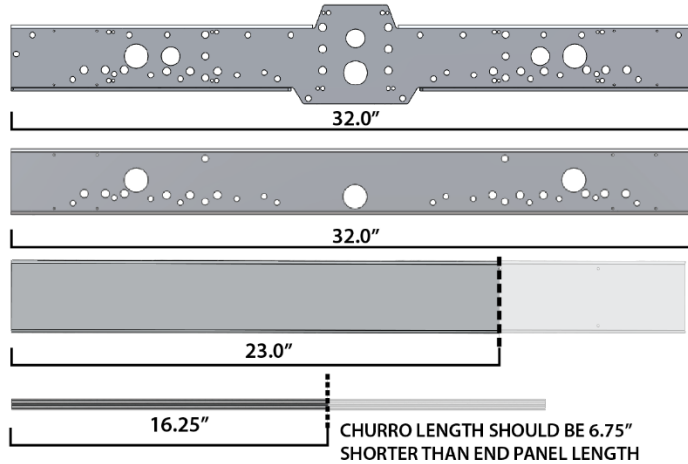| Component	Part Number	QTY	Part Photo
10-32 x 0.5 SHCS	am-1002	10	
1/4-20 Nylock Nut	am-1015	2	
10-32 Nylock Jam Nut	am-1063	10	
1/4-20 J-Bolt	am-1325	1	
Ball Bungee Cord, 9"	am-2719	1	
Battery Strap	am-2940	1	
Battery Holder	am-2941	2	

Frame Diagrams & Cut Lines:

The AM14U3 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 current rules. Belts for **LONG, SQUARE** and **WIDE** configurations are included in the full AM14U3 Kit.

LONG CHASSIS

32.3"

23.5"
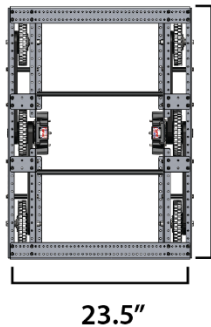
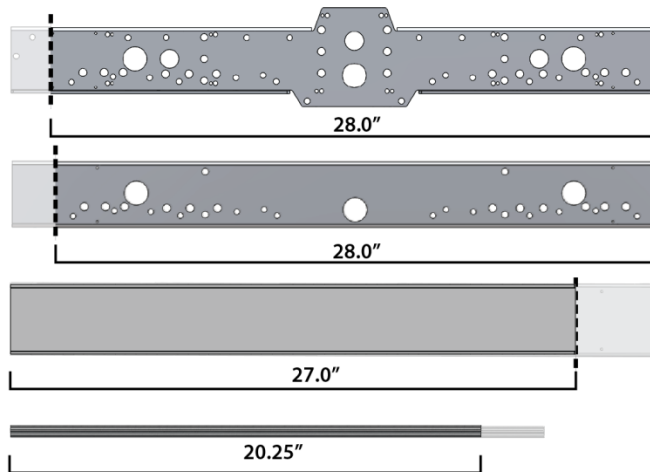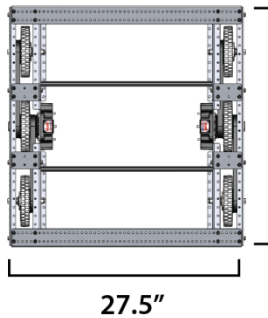NOTE: Ensure your final frame size complies with all FRC robot perimeter rules.

NO CUTS ARE NEEDED ON THE INNER PLATE OR OUTER PLATE

32.0"

32.0"

CUT END PLATE AT HOLE LINE ON ONE END.

23.0"

16.25"

CHURRO LENGTH SHOULD BE 6.75" SHORTER THAN END PANEL LENGTH
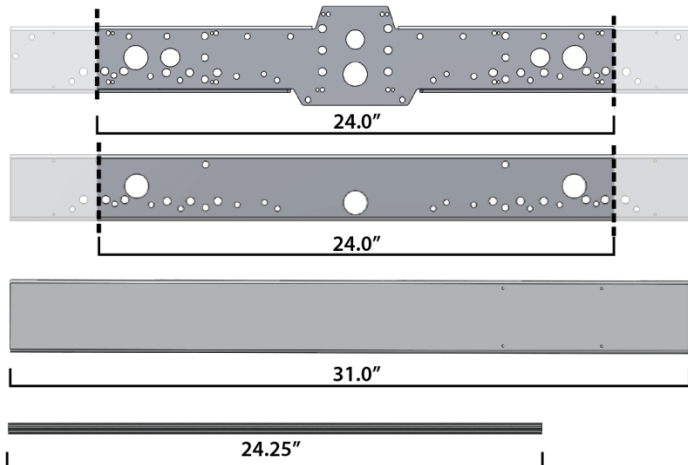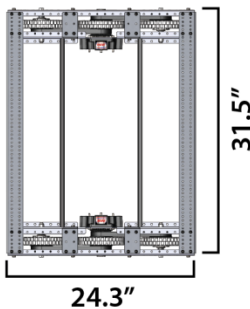
CUT CHURRO TO 16.25"

SQUARE CHASSIS

28.3"

27.5"

CUT OUTER PLATE AT HOLE LINE ON BOTH ENDS.

28.0"

CUT INNER PLATE AT HOLE LINE ON BOTH ENDS.

28.0"

CUT END PLATE AT HOLE LINE ON ONE END.

27.0"

CUT CHURRO TO 20.25"

20.25"

WIDE CHASSIS

31.5"

24.3"

CUT OUTER PLATE AT HOLE LINE ON BOTH ENDS.

24.0"

CUT INNER PLATE AT HOLE LINE ON BOTH ENDS.

24.0"

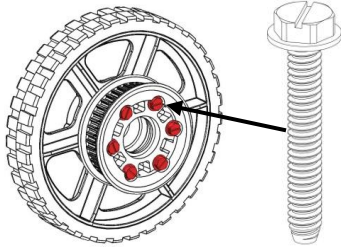NO CUTS ARE NEEDED ON THE END PLATE OR CHURRO.

31.0"

24.25"

FIRST

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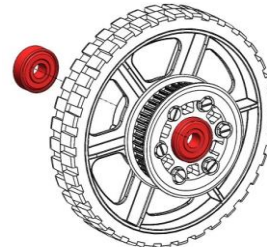# 6" HiGrip Wheel and Pulley Assembly Instructions

Outer Wheels (QTY 4)

Step 1: Add two pulley halves (am-2234-half) to the wheel (am-0940a).

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

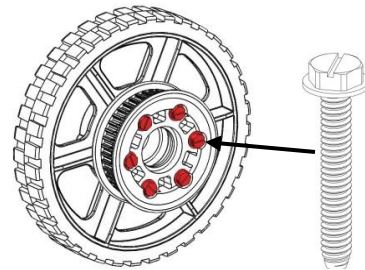**NOTE: Tighten the screws in a triangle pattern to ensure the pulley aligns evenly on the wheel.**

Center Wheels (QTY 2)

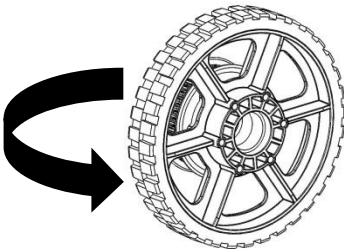**Step 1:** Add two pulley halves (am-2234-half) to the wheel (am-0940a).

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

NOTE: Tighten the screws in a triangle pattern to ensure the pulley aligns evenly on the wheel.
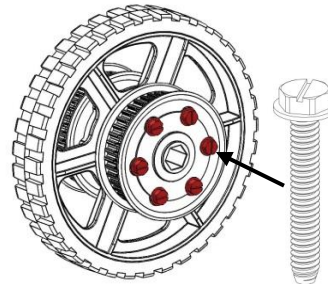
Step 3: Flip wheel over.

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

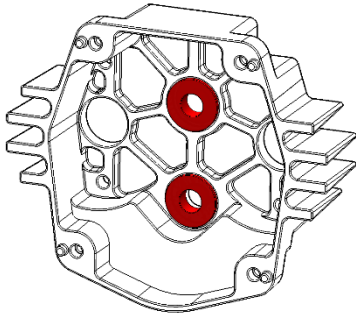**Step 5**: Insert one 500EX Hex Hub (am-2568) into the pulley on one side of the wheel.

Step 6: Add six 10-24 x 1.25" (am-1266) thread forming screws to attach the pulley and hub to the wheel.
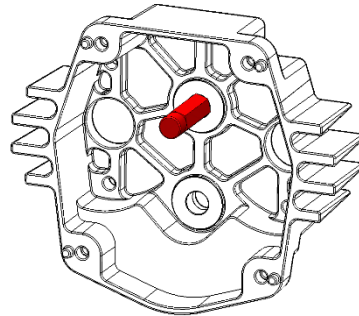
2X

FIRST

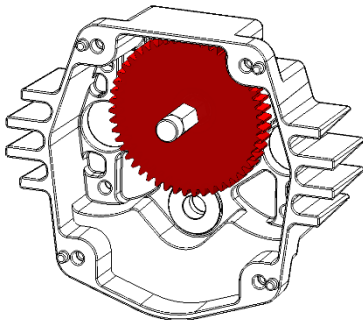AndyMark

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).
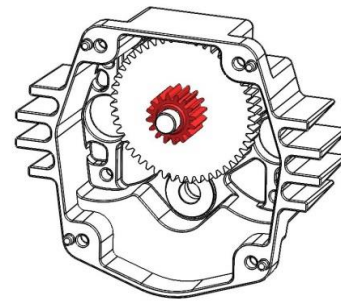
Step 2: Insert the TB Small Hex Shaft (am-0152) into R6ZZ bearing closest to the flat edge of the housing.
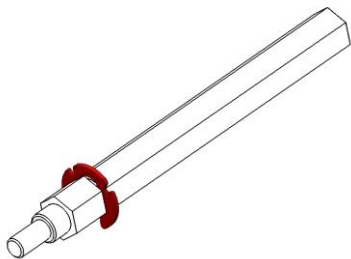
Step 3: Place the 50 tooth gear (am-0149) on the TB Small Hex Shaft with **flat side up**.

Step 4: Place the 16 tooth gear (am-0747) on the TB Small Hex Shaft with **flat side down.**

Step 5: Tap the 1/2" E-Clip (am-0206) onto the groove on the TB Hex Output Shaft (am-2566a).

Step 6: Insert the small end of the TB Hex Output Shaft (am-2566a) into the other R6ZZ bearing.
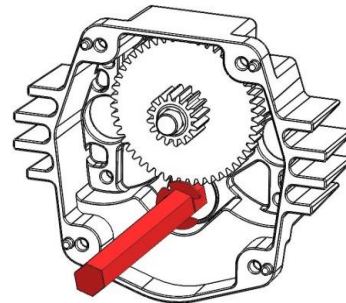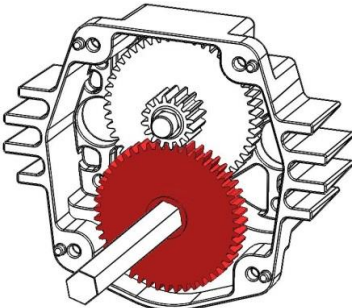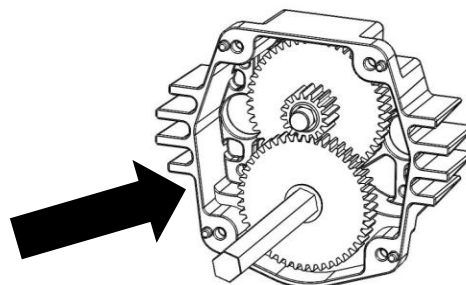
**Step 7:** Place the 48 Tooth Gear (am-0885) on TB Hex Output Shaft **flat side down**.

Step 8: Apply Red Tacky Grease (am-2768) to all of the gear teeth.

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


am-0028

am-2986
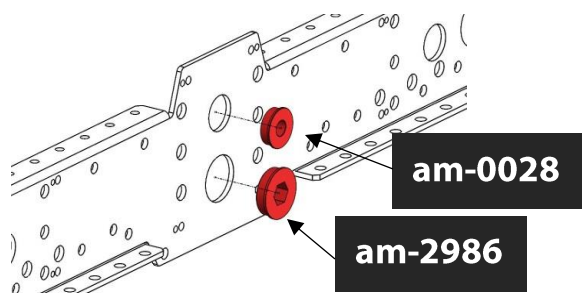
Step 11: Attach the TB Mini to Inner Plate with four 10-32 x 0.75" SHCS (am-1047) and four 10-32 Nylock nuts (am-1042). The nuts will fit into the hex pockets on the TB Mini housing and will hold the nut while tightening.
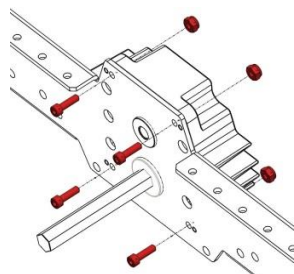

> **NOTE: The gears should spin freely when the shaft is rotated by hand**

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 the TB Mini Housing with two each 10-32 x 0.625" SHCS w/ Nylon Patch (am-1120).
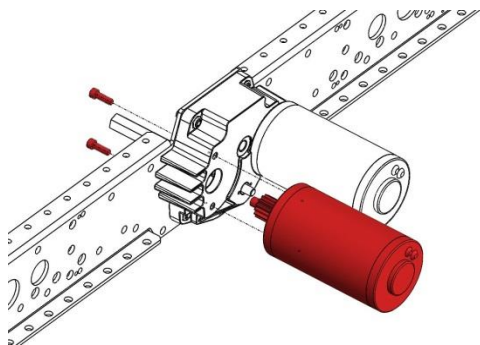

Step 10: Place the TB Mini onto the Inner Plate using the plastic studs to align the housing. The bottom flanged edge of the Inner Plate will be facing towards the gearbox housing.
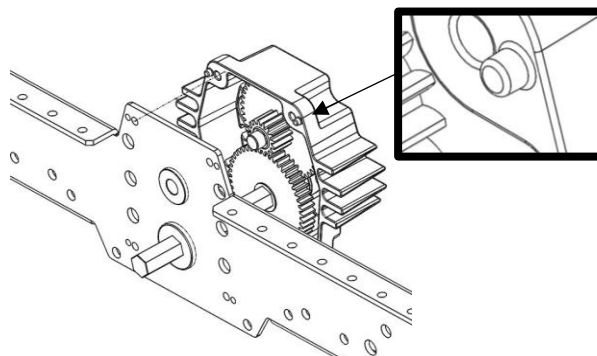
Step 12: Place two 5/16" Washers (am-1009) onto the CIM Motor shaft. Place the 2x2x10mm Machine Key (am-1121) into the keyway of the motor shaft. Push the 14 Tooth, 8mm Key Gear onto the shaft, to the face of the washers, while aligning the keyway with the machine key. Use a 7/16" socket to press the 8mm Retaining Clip (am-0033) onto the face of the gear.
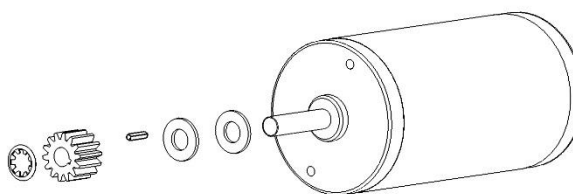
Step 14: Attach **four** 3.375" Churro Standoffs with 1/4-20 x 0.75" Thread Forming Screws (am-1310) onto the Inside Plate. A 1/2" wrench can be used to hold the churro while tightening.
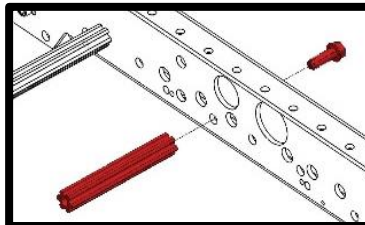
> **NOTE: The Churro Standoffs are intended to help with the structure of the chassis. Be sure to install four on each Inner Plate.**

A B C D
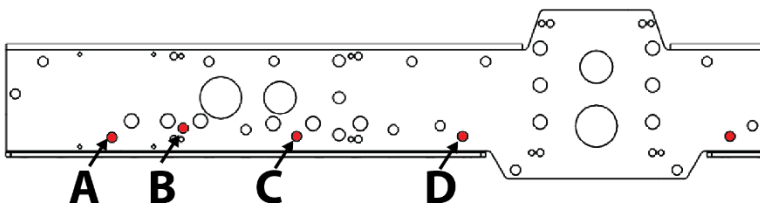
LONG uses holes C & D
SQUARE uses holes A & D
WIDE uses holes B & D

Step 15: Place a Center Wheel Assembly onto the TB Hex Output shaft with the hub facing towards the Inner Plate.

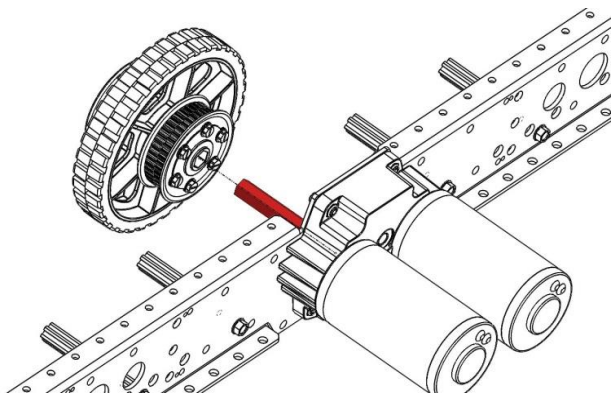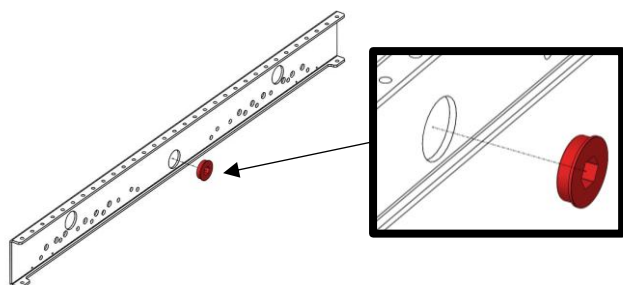**Step 17:** Press the FR8ZZ-HexHD Bearing (am-2986) into the center hole of the Outer Plate (am-2951a). The bearing flange will be on the same side as the plate flanges to ensure the bearing does not fall out during operation.

Step 19: Add the long spacer (am-1307), Outer Wheel Assembly and the short spacer (am-1306) onto the axle bolt. The shorter 0.28" (am-1306) spacer is used on the pulley side of the wheel.
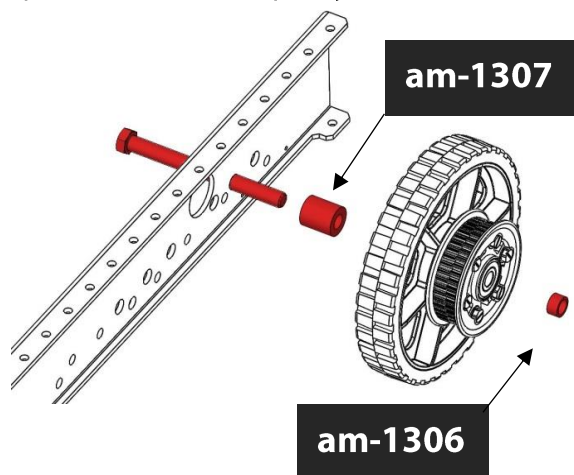
am-1307

am-1306

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 bore with the wheel hub hex bore.

am-1305
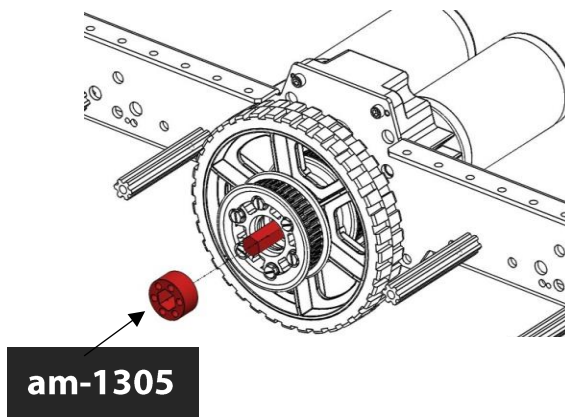
Step 18: There are different axle bolt locations for the different chassis configurations. Slide an axle bolt (am-1297) into the correct axle hole on the Outer Plate.

LONG

6" Wheel Axle Holes

SQUARE

6" Wheel Axle Holes

WIDE

6" Wheel Axle Holes
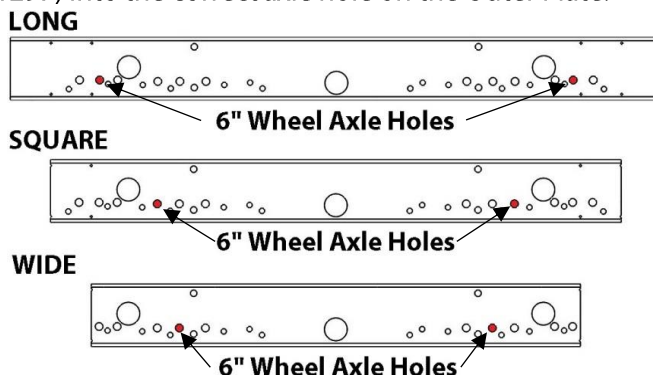
Step 20: For the second Outer Wheel Assembly on this side, the spacer and wheel orientation is reversed to allow one pulley on either side to line up with a Center Wheel Assembly pulley. The front and back wheels will be in opposite orientations.

am-1307

am-1306

FIRST

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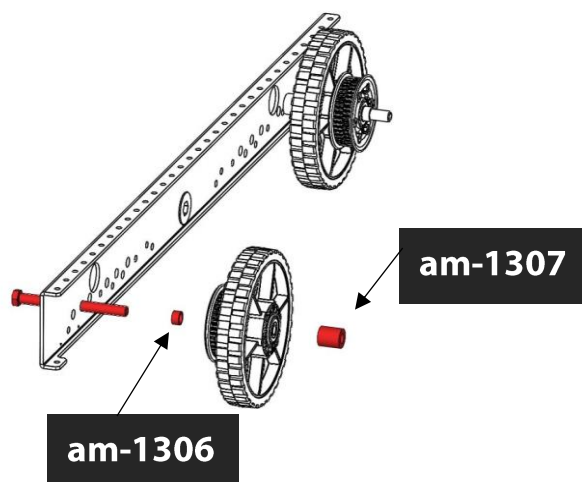
Step 21: Place a belt on each Outer Wheel pulley and wrap them around the Center Wheel pulleys. Carefully line up and place the Outer Plate assembly onto the Inner Plate assembly. The axle bolts will slide through corresponding bolt holes on the Inner Plate and the TB Mini shaft will slide through the FR8ZZ-HexHD bearing on the Outer Plate.
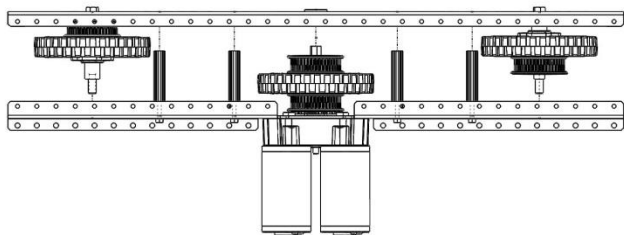
The long chassis requires 160 tooth belts (am-2266).
The wide chassis requires 120 tooth belts (am-2704).
The square chassis requires 131 tooth belts (am-2571).

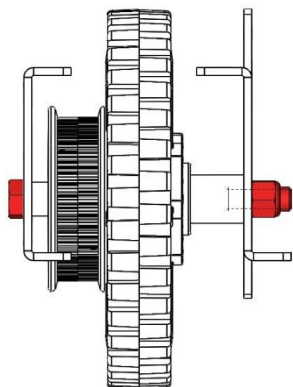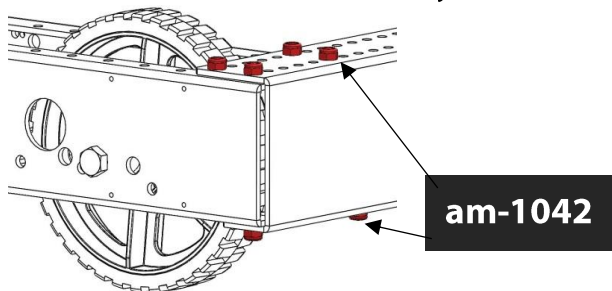**Step 22:** Finger tighten the axle bolts with the 3/8-16 Nylock Nuts (am-1054) to secure the assembly. Attach the Outer Plate to the churro standoffs using 1/4"-20 x 0.75" Thread Forming Screws (am-1310).

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

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

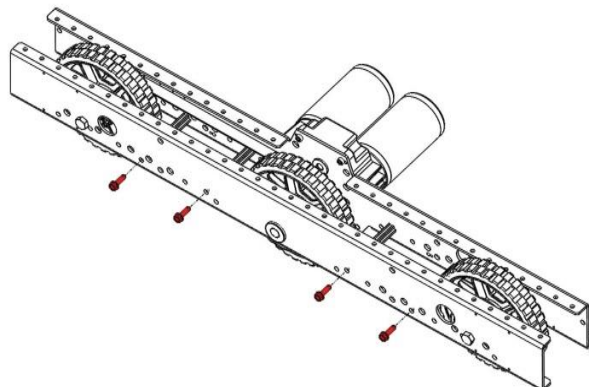*NOTE: The belts should be parallel to the side plates.*

Step 25: Attach End Plates to the drive modules using #10-32 x 0.5" SHCS and #10-32 Nylock Nuts. **It is recommended that the nuts be installed on the outside faces of the End Sheet for accessibility.**
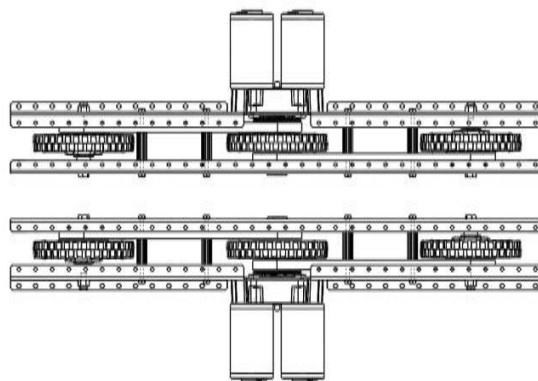

am-1042

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

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 other mechanisms.

am-2974

am-2954
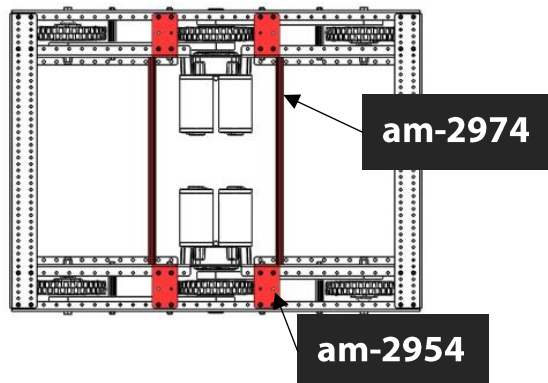
AM14U3 Bumper Attachment Suggested Method

Step 1: Plan out which edges of the drive base frame perimeter will be covered with bumpers. Ensure this design complies with all bumper rules. Brackets should be attached to the frame in the corners, at the ends of bumper segments, and behind any long bumper lengths.

Step 2: Cut ¾" wood into bumper planks that are 5" tall and to desired lengths ensuring it meets the minimum length according to the current rule manual. For corner sections that overlap, a l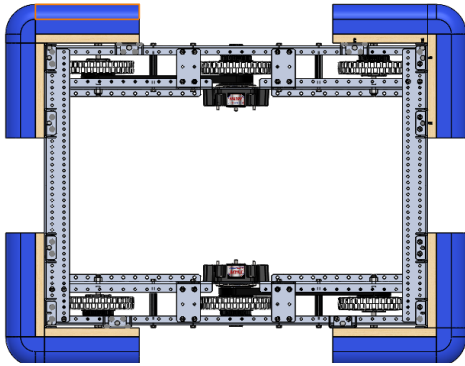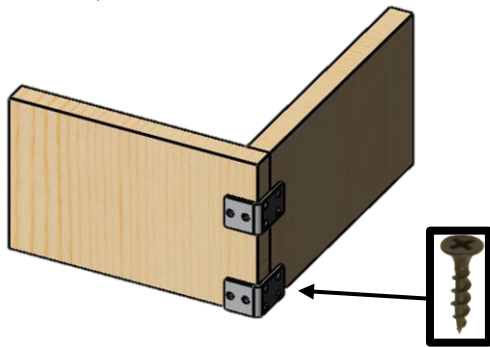onger plank may be needed to comply with bumper rules. For the corner bumper configuration, 8 planks are needed for each red set and blue set of bumpers.
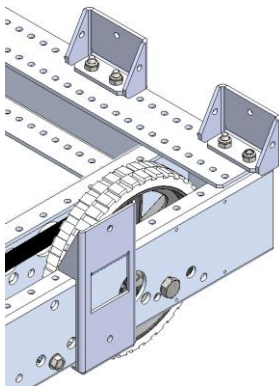

Step 3: Bumpers can either be made in straight sections or in sections that wrap around corners.
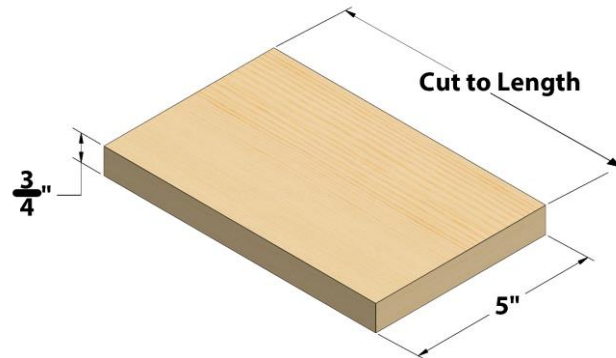

Tip: To ensure that bumpers designed to wrap around corners are rigid, it is recommended that the corner edge be strengthened with angled corner connectors such as am-3066 (not included).

Step 4: Attach brackets as shown to the chassis. Brackets can be oriented to support both the corners of the chassis and the edges of the bumper planks. For longer bumper segments, additional brackets may be necessary to provide enough support.

NOTE: Screws holding the chassis corner will need to be removed to install brackets on the corner.
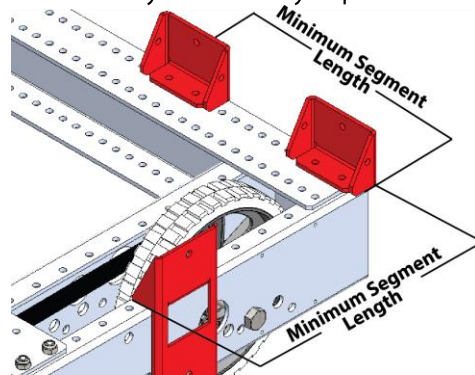
Step 5: Attach each bracket to the chassis frame using #10-32 x 0.625" SHCS (am-1007) and Nylock Nuts (am-1042). Each bracket should have two screws each securing the bracket to the top of each rail.

Step 6: Place the wood on the edge of the frame at the desired bumper height. Ensure bumpers height complies with all bumper rules. For 2018, when using 6" wheels the top edge of the wood planks can be aligned with the top edge of the side and front/corner brackets.
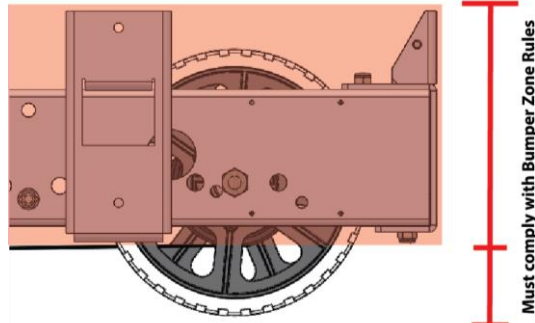
Step 7: Securely hold the planks and ensure the edges are flush with the side of the chassis. Mark the location where your holes should be. Then use a 13/64" drill bit to drill through the wood plank.
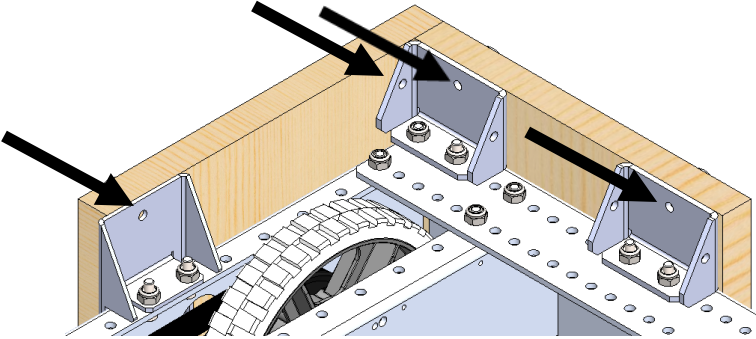
Tip: After drilling, it is helpful to label which bumper plank goes to each location on the chassis in order to easily re-attach later.

Step 8: Remove the planks from the chassis and drill out the 13/64" holes with a 7/32" drill bit. This will allow the tee nuts (am-1143) to fit inside the hole.

Step 9: Pound in the tee nuts into the outside faces of the bumper planks using a hammer. The face of the tee nut should be approximately flat with the wood.
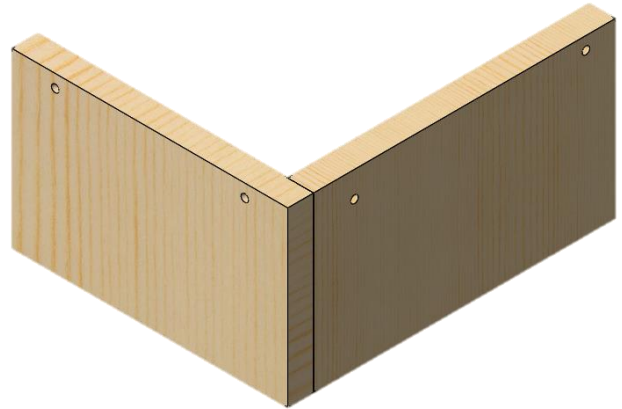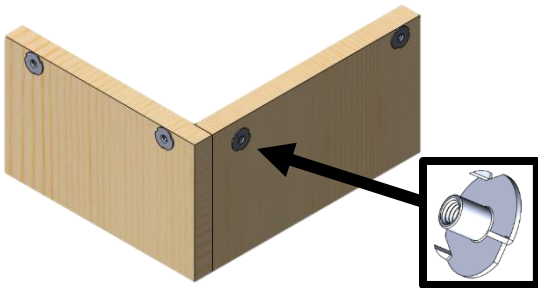

Step 10: Cut noodles to a length that matches the wood planks. Cut fabric large enough to wrap around noodles and wood with enough extra for stapling. If adding team numbers onto fabric it may be useful to do this before adding to bumper segments.

Step 11: Wrap fabric tightly around noodles. No noodles should be showing after wrapping. Staple fabric evenly along edge of bumper and trim any extra fabric. You will need to access the holes and hardware to attach bumpers frequently.

Repeat steps 4-11 for all bumper sets.

Step 12: Attach bumpers in the locations marked on the bumper planks with the thumb screws (am-1390) for easy removal.
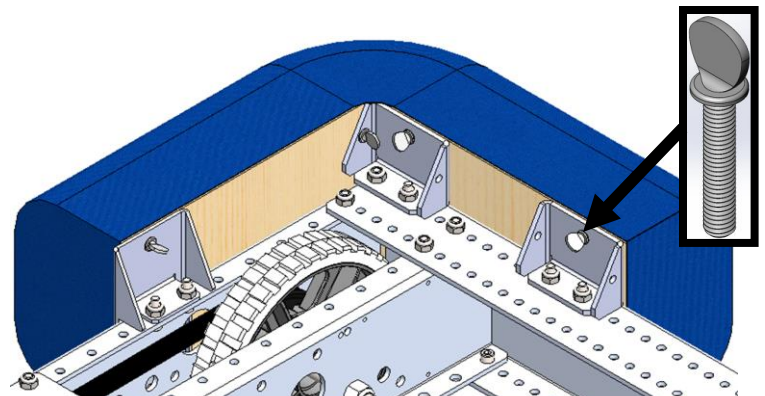
Tip: Alternatively you can use #10-32 x 1.00" SHCS (am-1056) to attach your bumpers to the robot frame.

AM14U3 Battery Tray Attachment

The Battery Tray fits into the end plate as shown below. Use 10-32 screws and Nylock nuts to hold in place. Tray can be placed anywhere along the end plate to accommodate bumper hardware, brackets, and other mechanisms.

Battery Holder (am-2941)

10-32 SHCS & Nuts
(am-1002/am-1063)

Ball Bungee
Cord(am-2719)

J-bolt (am-1325)

Battery Strap (am-2940)

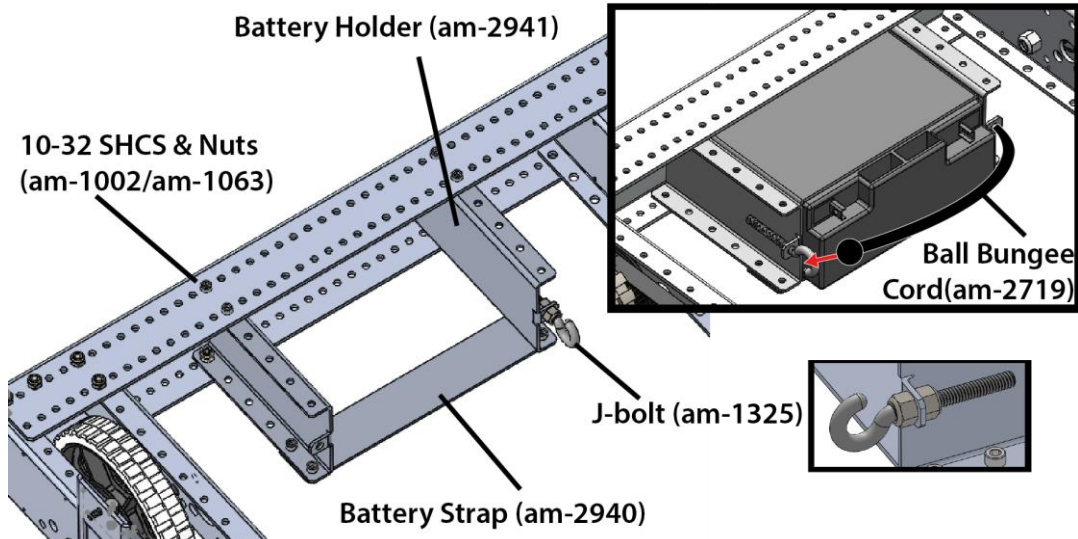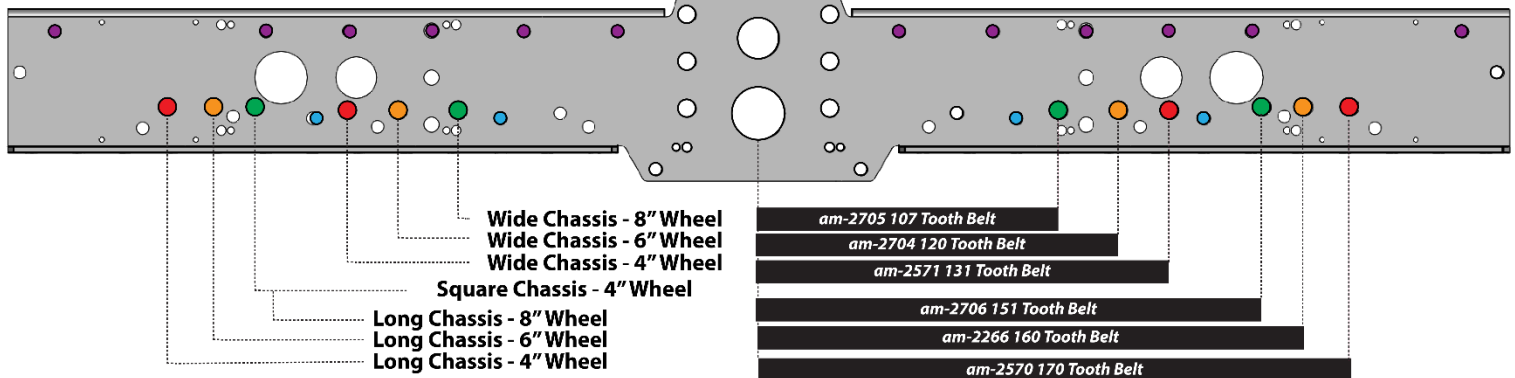**Tip:** Batteries may vary slightly in width. In order to ensure the batteries slide in and out easily, place the battery between the holder rails and tightening the 10-32 screws with the battery in place.

Additional Chassis Options

Wheel and Belt Option Chart

● Short Churro Standoffs   ● Long Cross Churro

Wide Chassis - 8" Wheel
Wide Chassis - 6" Wheel
Wide Chassis - 4" Wheel
Square Chassis - 4" Wheel
Long Chassis - 8" Wheel
Long Chassis - 6" Wheel
Long Chassis - 4" Wheel

am-2705 107 Tooth Belt
am-2704 120 Tooth Belt
am-2571 131 Tooth Belt
am-2706 151 Tooth Belt
am-2266 160 Tooth Belt
am-2570 170 Tooth Belt

Gear Ratio Chart

The AM14U3 drive chassis base kit features Toughbox Mini gearboxes.
Four additional gear ratios are available to change the chassis speed.

Ratio	CIM Gear	Lg. Cluster	Sm. Cluster	Lg. Output	AM14U3 Speed*
5.95:1	14T	50T	24T	40T	18.0 ft/sec
7.31:1	14T	50T	21T	43T	14.7 ft/sec
8.45:1	14T	50T	19T	45T	12.7 ft/sec
10.71:1**	14T	50T	16T	48T	10.0 ft/sec
12.75:1	14T	50T	14T	50T	8.4 ft/sec

*AM14U3 Speed is based on calculations using 6" wheels and 2 CIM motors per TB Mini running at 4100RPM, or 75% of free speed.

**10.71:1 Ratio is included in the 2018 Chassis Kit.

AndyMark

AM14U3

For more chassis options visit

AndyMark.com