



User Guide

Kit Gearbox for the 2009 *FIRST* Robotics Competition



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1. Overview

- 1. This gearbox is designed for use in the 2009 *FIRST* Robotics Competition (FRC).**
- 2. Each registered FRC team will receive two (2) Toughboxes in their Kit of Parts (KoP).**
- 3. The Toughbox is provided in kit form, with assembly required for usage. Full assembly instructions can be found later in this manual.**
- 4. Each Toughbox provided includes all parts to mount two 2.5” CIM Motors (provided in FRC KoP).**
- 5. Each Toughbox can use two of the 2.5” CIM Motors as input devices. Additional hardware can be purchased at www.andymark.biz.**
- 6. The design of the Toughbox is based off of the AndyMark “AM Gearbox”, which has been a proven design for FRC robots since 2006.**

2. Specifications

2.1. Materials

- 2.1.1. Gears: 4140 cold rolled steel**
- 2.1.2. Output Shaft: 4140 steel**
- 2.1.3. Small Hex Shaft: 1018 steel**
- 2.1.4. Motor Mount Plate: clear polycarbonate**
- 2.1.5. Shaft Plate: 6061 aluminum**
- 2.1.6. Extrusion Cover: 6061 aluminum (5"x5"x1.14" long)**
- 2.1.7. Output Shaft Spacers: PVC plastic**
- 2.1.8. Fasteners: zinc-plated steel**

2.2. Gear types

- 2.2.1. AGMA 6-8**
- 2.2.2. Cold formed gear stock**
- 2.2.3. 20 dp (diametrical pitch)**
- 2.2.4. 14.5 degree pressure angle**

2.3. Gear sizes

- 2.3.1. CIM Gear: 14 tooth (0.314" id w/ 2mm keyway)**
- 2.3.2. Large Cluster Gear: 50 tooth (3/8" hex bore)**
- 2.3.3. Small Cluster Gear: 14 tooth (3/8" hex bore)**
- 2.3.4. Large Output Gear: 50 tooth (1/2" hex bore)**

2.4. Gear ratios

- 2.4.1. 12.76:1 total**
 - 2.4.1.1. $50/14 * 50/14 = 12.755$**

2.5. Efficiency

- 2.5.1. 96% total**
 - 2.5.1.1. This assumes a 2% loss at each gear mesh**

2.6. Output shaft

- 2.6.1. 1/2" diameter steel shaft, with 1/8" wide keyway**
- 2.6.2. 1/4-20 x 1/2" deep threaded hole on end**
- 2.6.3. 1 machine key, 1 washer, and 1 1/4-20 screw are all provided**

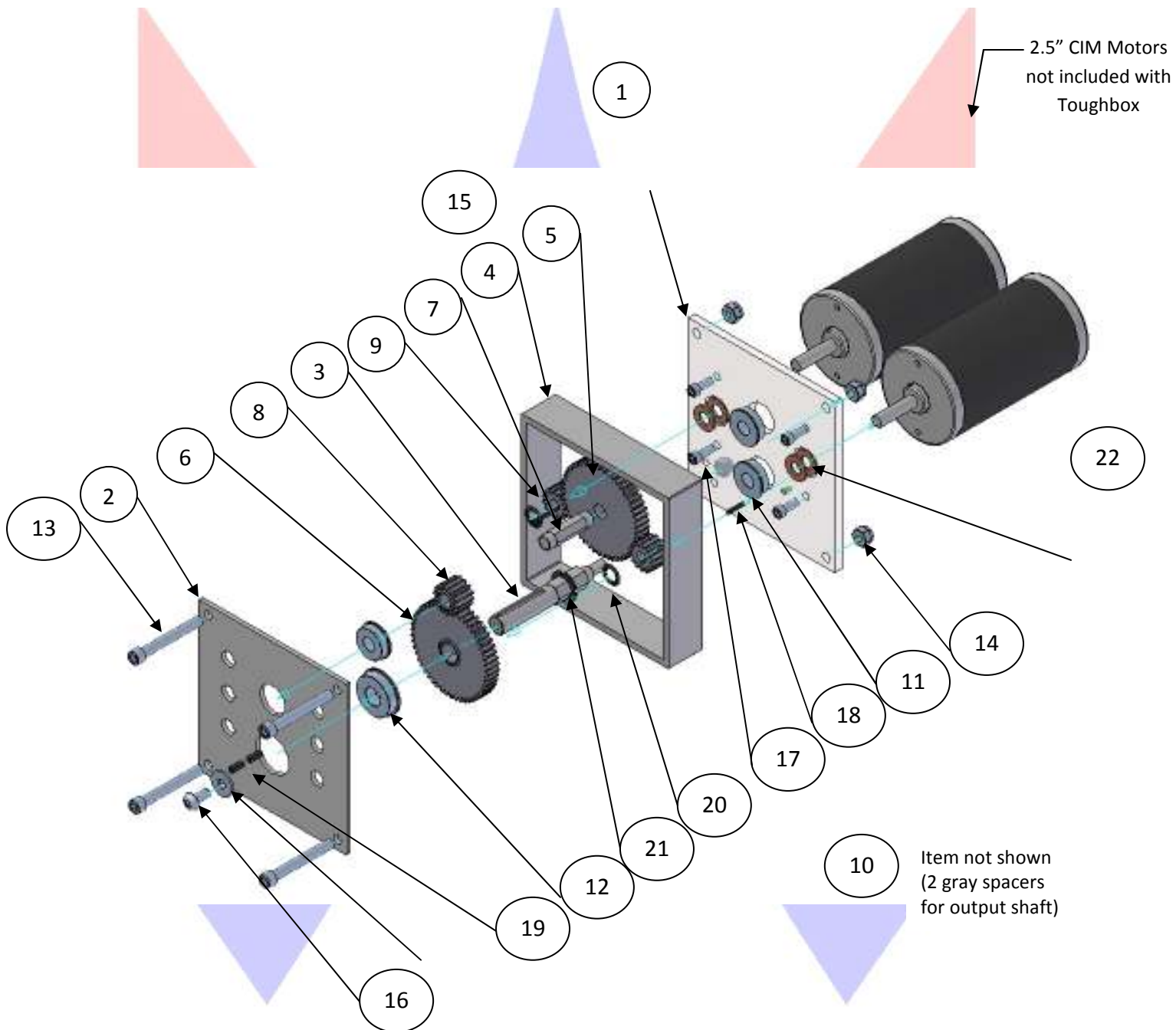
3. Bill of Material (BOM)



Item	Component	Qty	Part Source	Part Number
1	Mount Plate	1	AndyMark	am-0155
2	Shaft Plate	1	AndyMark	Toughbox_d02
3	Output Shaft	1	AndyMark	am-0153
4	Extrusion Cover	1	AndyMark	Toughbox_d04
5	Large Cluster Gear	1	AndyMark	am-0149
6	Large Output Gear	1	AndyMark	am-0150
7	Small Hex Shaft	1	AndyMark	am-0152
8	Small Cluster Gear	1	AndyMark	am-0151
9	CIM Gear	2	AndyMark	am-0034
10	Spacer	2	AndyMark	Toughbox_d10
11	FR6ZZ bearing	3	AndyMark	am-0028
12	FR8ZZ bearing	1	AndyMark	am-0030
13	1/4-20 x 2 shcs	4	MSC	67212001
14	1/4-20 nylock nut	4	MSC	87922035
15	1/4" Washer	1	MSC	2994887
16	1/4-20 x 1/2 bhcs	1	MSC	67563007
17	#10-32 x 1/2 shcs	4	MSC	9362336
18	2x2x14mm key	2	AndyMark	am-0032
19	1/8" machine key	2	AndyMark	am-0032
20	5/16 clip	2	AndyMark	am-0033
21	1/2" e-Klip	1	AndyMark	am-0206
22	5/16 washer	4	MSC	67491605

4. Exploded View

2009 AndyMark Toughbox – Exploded View



5. Part Pictures



Item 1, Mount Plate



Item 2, Shaft Plate



Item 3, Output Shaft



Item 4, Extrusion Cover



Item 5, Large Cluster Gear



Item 6, Large Output Gear



Item 7, Small Hex Shaft



Item 8, Small Cluster Gear



Item 9, CIM Gear



Item 10, Spacer



Item 11, FR6ZZ Bearing



Item 12, FR8ZZ Bearing



Item 13, 1/4-20 x 2" SHCS



Item 14, 1/4-20 Nylock Nut



Item 15, 1/4" id washer



Item 16, 1/4-20 x 1/2" BHCS



Item 17, #10-32 x 1/2" SHCS



Item 18, 2x2x14mm key



Item 19, 1/8x1/8x0.40 key



Item 20, 5/16" Clip



Item 21, 1/2" E-Klip



Item 22, 5/16" washer

6. Assembly Instructions

Tools needed:

5/16" allen wrench

3/16" allen wrench

7/16" wrench (or socket driver)

Small hammer



Assembly tools needed

1. **Ensure you have all parts listed in the BOM (pg. 5) and shown in Fig. 1.**



Fig. 1: Toughbox Parts

2. **Insert two of the 5/16" washers, the 2x2x14mm machine key, CIM Gear, and 5/16" clip onto CIM Motor shaft.**



Fig. 2: Assemble 2 washers, key, CIM gear, and clip

- 3. Press two of the FR6ZZ bearings into the Mount Plate. Use an arbor press, a strong push with a thumb, or light taps with a small hammer.**



Fig. 3: Press FR6ZZ bearings into Mount Plate

- 4. Press a FR6ZZ bearing into the 0.875" dia. middle hole of the Shaft Plate, and a FR8ZZ bearing into the 1.125" dia. middle hole of the same plate. Use same insertion method as step 3 above. As you insert the bearings, consider that the flanges will be on the inside of the gearbox. This may help you choose from which side to insert the bearings, for aesthetic reasons.**



Fig. 4: Press FR6ZZ bearing and FR8ZZ bearing into Shaft Plate

- 5. Mount motor to Mount Plate using #10-32 screws. DO NOT ADD Loctite or other thread locking material. This has already been applied to the screws (excess Loctite or other thread locking material will eat away the polycarbonate). Make sure that the bearing flanges are not on the same side as the motor.**



Fig. 5: Mount motor to Mount Plate using #10-32 screws.

- 6. Attach the 1/2" E-Klip into the groove on the Output Shaft. This can be done by starting the clip with fingers, then using a table to press the clip firmly into position.**



Fig. 6: Insert 1/2" E-Klip onto Output Shaft.

- 7. Place the Small Hex Shaft into the bearing that is closer to the motor pinion. Place the Large Cluster Gear (the one with the smaller hex hole) onto the Small Hex Shaft. Make sure the teeth of this gear mesh well with the CIM Gear. Also, be sure to place the gear so that the small boss (raised surface) around the hex hole is facing the bearing on the Mount Plate (see Fig. 7).**



Fig. 7: Insert small shaft into bearings and put the Large Cluster Gear onto this shaft.

- 8. Place the Output Shaft into the second bearing.**



Fig. 8: Place output shaft into bearing.

- 9. Place Small Cluster Gear (small gear with 3/8" hex hole) onto the Small Hex Shaft. Also, place Large Output Gear onto Output Shaft. Do this so that the boss on these gears are facing out. (The method of these small bosses contacting the inner races of the adjacent bearings reduces friction and the need for washers.)**



Fig. 9: Place Small Cluster Gear onto Small Hex Shaft. Place Large Output Gear onto Output Shaft. Apply moderate amount of grease* to gear meshes. Spin gears until all gear contact surfaces are covered with grease.

grease*: use general lithium grease or wheel bearing grease, just enough to cover the gear faces of this gear mesh.

- 10. Place the Extrusion Cover over the assembly as shown in Fig. 10.**



Fig. 10: Place Extrusion Cover over assembly as shown.

- 11. Place the Shaft Plate onto the Output Shaft so that the ½" id bearing (FR8ZZ) has its flange on the inside of the gearbox. As you slide the plate onto the shaft, you can align the smaller bearing onto the Small Hex Shaft. The Shaft Plate should slide all of the way so that the Extrusion Cover is sandwiched between the Mount Plate and Shaft Plate. There should be no gaps.**



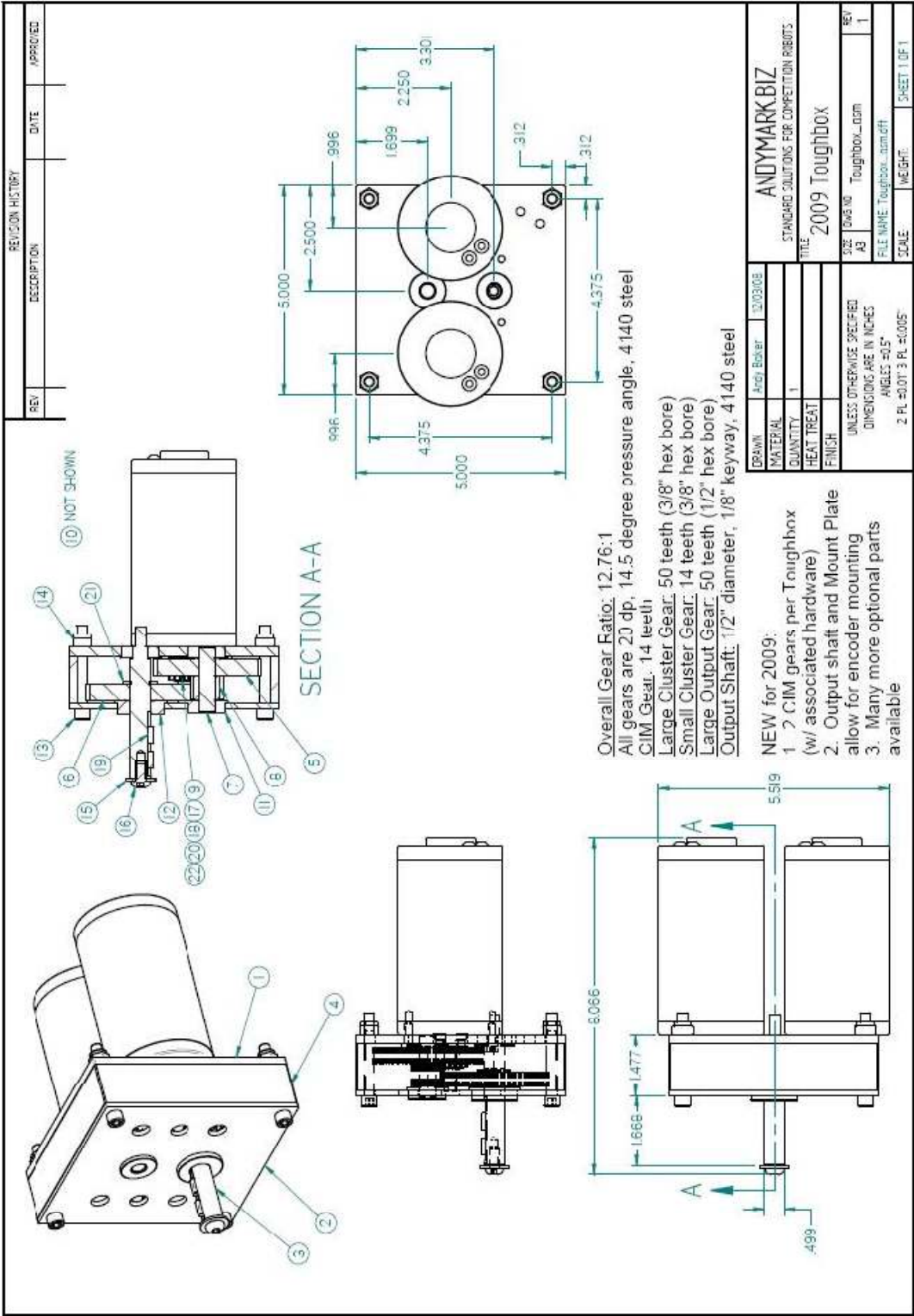
Fig. 11: Place Shaft Plate (with inserted bearings) over shafts.

- 12. Insert all ¼-20 x 2" Screws (4) into the holes on the Shaft Plate and through the 4 holes on the Mount Plate. Assemble the ¼-20 Nylock Nuts and tighten all with a 3/16" allen wrench and 7/16" wrench or socket.**



Fig. 12: Insert and tighten ¼-20 screws.

7. Layout Drawing (also available as .pdf on www.andymark.biz)



8. Installation Tips

Optional Motor Mount: The motor could be installed after the gearbox is assembled. Here are pictures for instruction:



Fig. 8.1: Insert motor shaft, with gear and fasteners installed, into Toughbox.



Fig. 8.2: Position Toughbox so motor is on top, insert #10-32x1/2" screw (item 17) from bottom, reaching up through gearbox with screw and 5/32" allen wrench.
Insert and tighten both motor mount screws

Also, 2 CIM motors can be mounted to the Toughbox. If you wish to do this, you will need to procure these parts:

14 tooth CIM Gear, 2x2x14mm machine key, 5/16" retaining clip, 5/16" washers, and #10-32x1/2" screws.

Reference Information

- **More information on the Toughbox gearboxes can be found at <http://www.andymark.biz/am-0145.html>. Additional Toughboxes can be purchased for \$88. CAD files (.stp version) are available at this same site.**
- **The Toughbox was designed by Andy Baker and Mark Koors of AndyMark, Inc. It is a new version of the AM Gearbox (<http://www.andymark.biz/am-0011.html>), which was a derivative of the 2005-2006 *FIRST* Robotics Kit Gearbox, originally designed by Paul Copioli of team 217. Therefore, the Toughbox is a 3rd generation design that is efficient and proven.**
- **90% of the Toughbox part content is made in the USA.**
- **A video of the Toughbox assembly can be seen on the AndyMark Toughbox page also.**