Robot Weight Watcher

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Team #33

Background

- This is my 5th Killerbee Robot (BuzzX-XIV)
- Every robot I have helped with has weight 119.9 pounds at some point in the season.
- Every robot except 2007 has had to go through weight reductions at some point (this one we knew would be close so we were extremely careful).
- I have never seen a hopelessly overweight bot. Some require more drastic measures than others.

Basic Steps on Weight Reduction

- PUT DOWN THE STEP DRILL, HOLE SAWS, and SAWZALLS
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  - I emphasize this as these are often “permanent and rash” attempts to make weight.

1. Step one is to understand how bad your problem is:
   - How many pounds do you have to loose?
   - How much time do you have (less than 1 hour, skip planning and start removing something)
2. Plan out your actions
   - Plan ahead of the event if you can so you can purchase materials and decide who will do what.
   - If you are new or out of ideas, ask for someone with experience to help. Some inspectors can give you ideas on who to talk to.
3. Attack dense materials first:
   - Attack Steel and Copper first as they are much more dense than AL

The following items will get their own pages because there are lots details.

4. Fasteners- What would PC do?
5. Large Panels- Thin FTW
6. Replacements- We can rebuild it faster, sleeker, lighter?
7. Lightning Holes-Pick up the drill (should be a last resort).
8. Remove systems-Use wrenches not SawZalls.

Fasteners

- You only need 1 thread past the nut for most fasteners to work.
- Nylock Jam nuts are thinner and lighter than lockwashers and regular Nylocks. Order a bunch from McMaster Carr before going.
- Why use ¼-20 when 10-24 will work?
- Button heads are lighter than Hex-heads and the allen key style look way cooler. Be careful using Phillips because they strip easy. Be careful using Robertson as many teams don't have compatible tools to share (sorry Canadians blame Henry Ford).
- Would PC just use a rivet?
  - Pop-Rivets are great for attaching many things and are a lot lighter bolts.
- Why use a fastener when velcro is just fine?
  - We use velcro to attach many of our body panels (as long as they are light and thin see other section).
  - Seriously it is FRC not Battle-Bots.

Large Panels- Thin FTW

I am amazed at the armor that some teams feel they need. News flash, this is FRC not Battle-Bots.

- Diamond Plate is only for simple underweight robots. If you have a simple underweight robot, great use Diamond plate.
- You do not need ¼" lexan for body panels.
  - 1/16 is plenty tough for almost every application. In fact we on Team 33 usually use 0.020" or 0.030" Polycarb for our panels. This stuff is really tough as long as you don't have sharp corners (then it may tear).
- Even light panels that are large can weigh a lot.
  - In 2007 we figured out how to make ramps for only 1 pound/square foot. Problem is that there was over 18 square feet of ramps plaus support structures and actuation.

Replacements

- Replace Steel Parts with Aluminum if you can. Aluminum is 1/3 the weight of steel.
- Replace 1/8th 1x1 inch Aluminum box with 1/16th wall 1x1 inch aluminum box. 50% weight reduction. Also good for ¼ pound/foot.
- If using box as a tension strut try using angle or some stringer from aircraft spruce (at 11 oz. per 12 foot, it doesn't get much lighter).
- If you welded some stuff, I have a solutions, but it isn't pretty
  - Cut out the square tubing and insert round if you can. This can be huge weight reductions.
  - 7/8 round will fit in 1/16th 1x1 box. If you use 049, then weight reduction will be approximately 7/8*3/4(round)*049/063=49% reduction

Lightening Holes

- Drilling holes is a lot of work and a lot of mess.
- Replacing 1/8th box with 1/16th box is a 50% reduction. Drilling 0.75” holes every inch is 0.75^2*pi/4 or about 27/64 of 1x1 removed. That means it is about a 40% reduction. In a 4 foot piece, it will require drilling 188 holes in order to save 0.8 pounds. Replacing it with 1/16th box would save 1 pound, and 1/16th angle would save 1.5 pounds.
- If you must, do it orderly.
- Have a corded drill handy as you will run through a lot of batteries.
- Have a tape and center punch ready to get the holes lined up.
- Have a person pre-drill the hole centers with a small bit.
- Cover or remove electronics. Shavings in the electronics is trouble, plus it is weight you are not loosing.

Remove systems-Use wrenches not SawZalls.

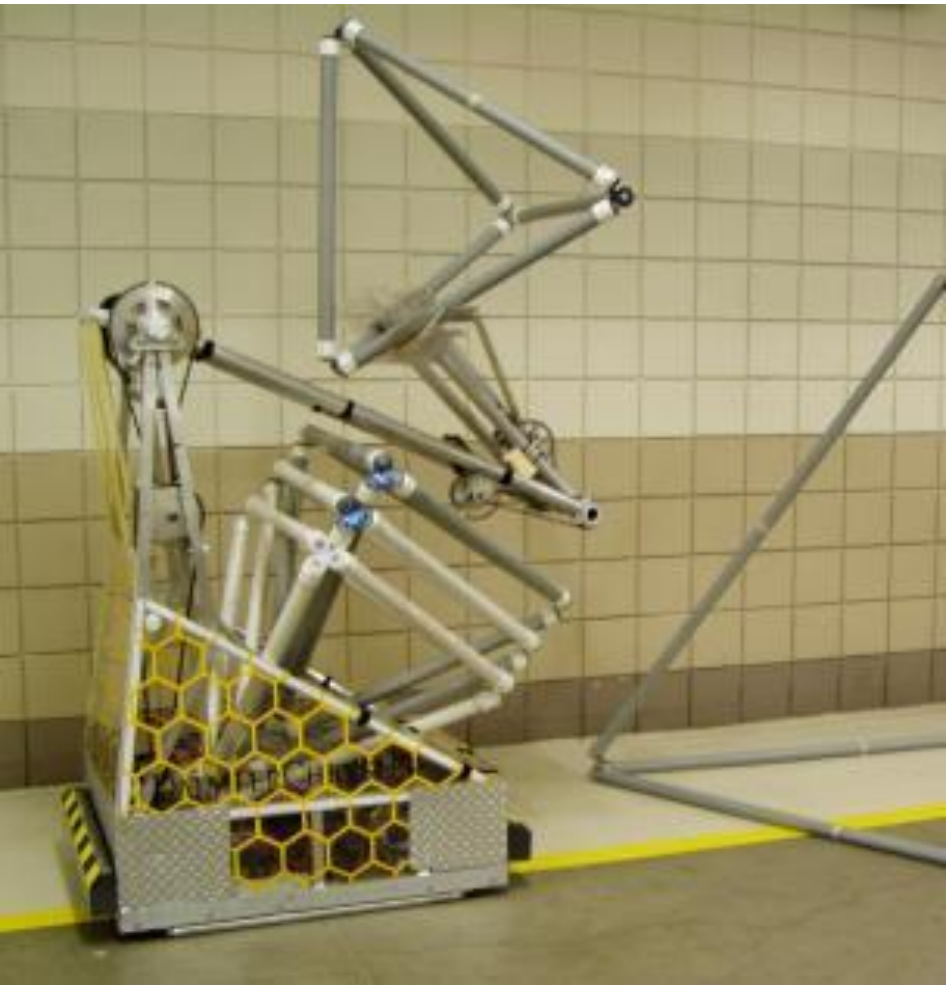
If you are very overweight sometimes it calls for more drastic measures:

- If you have a 4 motor drivetrain, can you get by with just 2?
- Do you have a non-functional mechanism that is not essential to the game?
- Do you have a single function mechanism that some other mechanism could also do?
- Can you remove a system lighten it up and then return it once it is lighter?

Common Killer Bee practices

- The Killerbees often try to do most if not all of the game functions.
- Because of this our bots are always pushing the weight limit.
- We like for our robots to be student built, so we keep within the scope of construction techniques that can be taught to HS students in a reasonable amount of time.
- When we have a student welder, we weld more. When we don't, we don't.
- Jim's sheet metal chassis designs have been easy to build and are very lightweight. If the panels are exposed, we generally use 063. If the panels are internal or behind bumpers, we use 050.
- We standardize fasteners so that almost every bolt on the robot uses the same tools (mostly 10-24 fasteners).
- We use button head Hex drive whenever possible because they are less likely to strip than phillip's, and are lighter and easier to get to than hex heads.
- We use locking Jam-nuts as they will not vibrate loose and are lighter than traditional lock-nuts.
- We try to use very little steel except for gears and sprockets and shafts.
- We use AndyMark parts when we can to save time. (Thanks for making the Aluminum Transmission plates!)

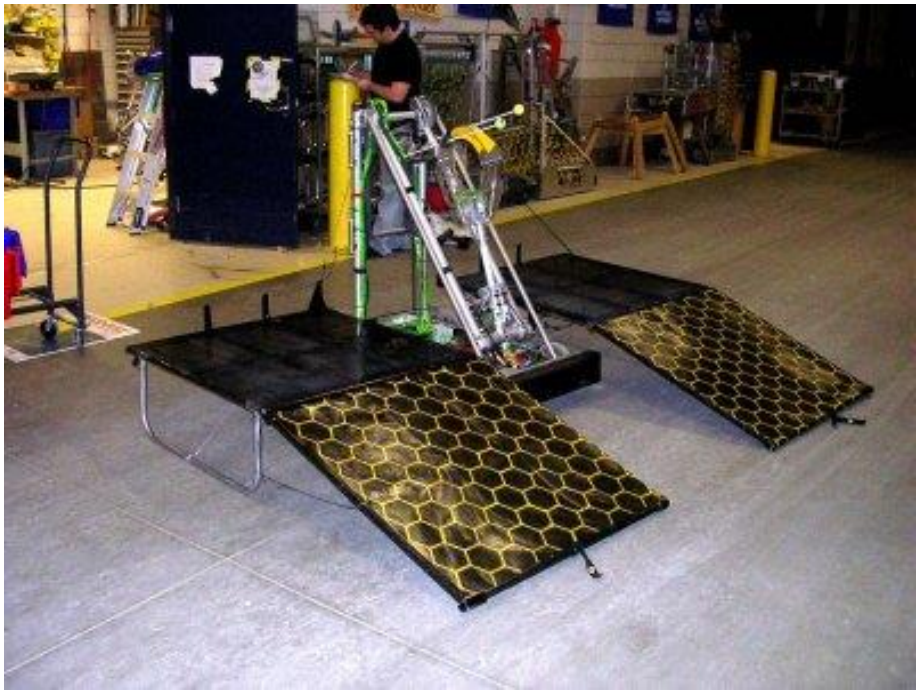
2005 Buzz X



- Originally marginally underweight.
- Crab-drive was too squirrelly so it was removed for skid steer option.
- Multiple Tetra manipulators were built.
- Lesson I: Have an easy interface to the game playing piece, because you may not like your first one.
- Lesson II: Crab drives are heavy and a ton of work.
- Lesson III: Welding is fairly permanent and slow.

2006 Buzz XI Great lengths to find weight.

- After the first competition weekend we found that our shooter had so much backspin, it would de-score balls.
- In order to go with a double roller shooter, we needed 2-3 pounds.
- We replaced the internal frame from 1x1 1/16 box to Round 035 wall saving 2.5 pounds.
- Do to solid planning we were able to swap out that frame without missing a single practice Thursday morning.
- We also found out that our revolving ball sorter was a giant hit-me sign so we wanted to add a parking brake system that required another 1.5 pounds.
- We then at our third competition replaced the outer frame with Round 035 and 1/16th angle. Loosing almost 2 pounds. And were able to add the brakes in.
- This structure was just barely strong enough and many stress cracks formed in the post season.

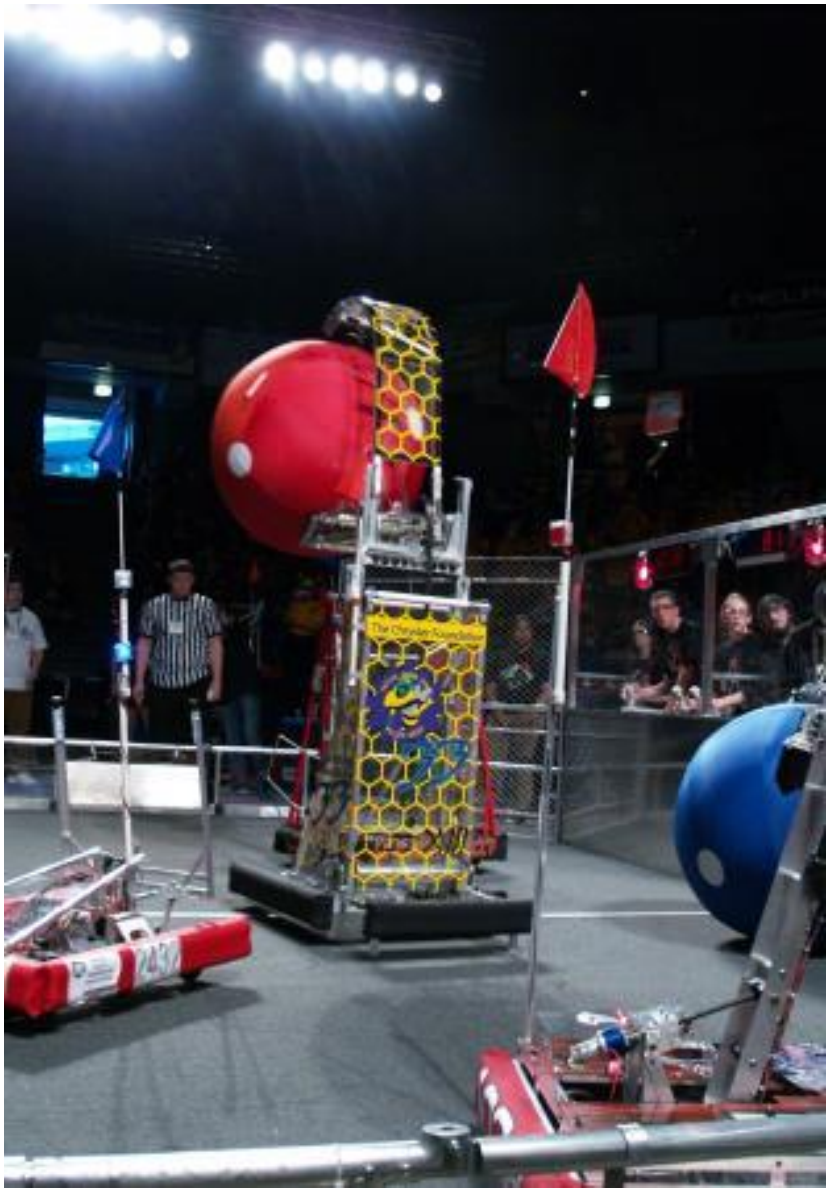


2007 Buzz XII

This is the only year I do not remember having to loose a weight at competition. This is because we knew we were in trouble from the start. With the giant ramps that we wanted, we knew that weight was going to be a huge issue.

- Almost all of the tubing on this robot is 035 wall aluminum.
- Thin wall aluminum is very difficult to weld.
- The welding process anneals the aluminum so react accordingly in your calculations.
- We stayed underweight (119.9 pounds) because we were obsessive from the start.
- I took a lot of flack for spending a Saturday morning evaluating which shoulder and elbow joints to use, but we saved 50 grams per joint which resulted in 0.4 pounds savings. Without it we would have been at 120.3 and not allowed to play.
- Building this light is not for the faint of heart. Our practice bot suffered a catastrophic metal fatigue failure after several hours of practice. Concerned, we had materials on hand to fix the real bot. It lasted until the final post season event (YES EXPO) where mid morning it suffered a simultaneous shoulder and tower metal fatigue failure. I consider this one of my greatest design successes as if was just enough to make it through competition.
- If we had the extra weight, we would have probably made a roller claw like 148 or 67, but there was just no where reasonable other than removing the ramps.

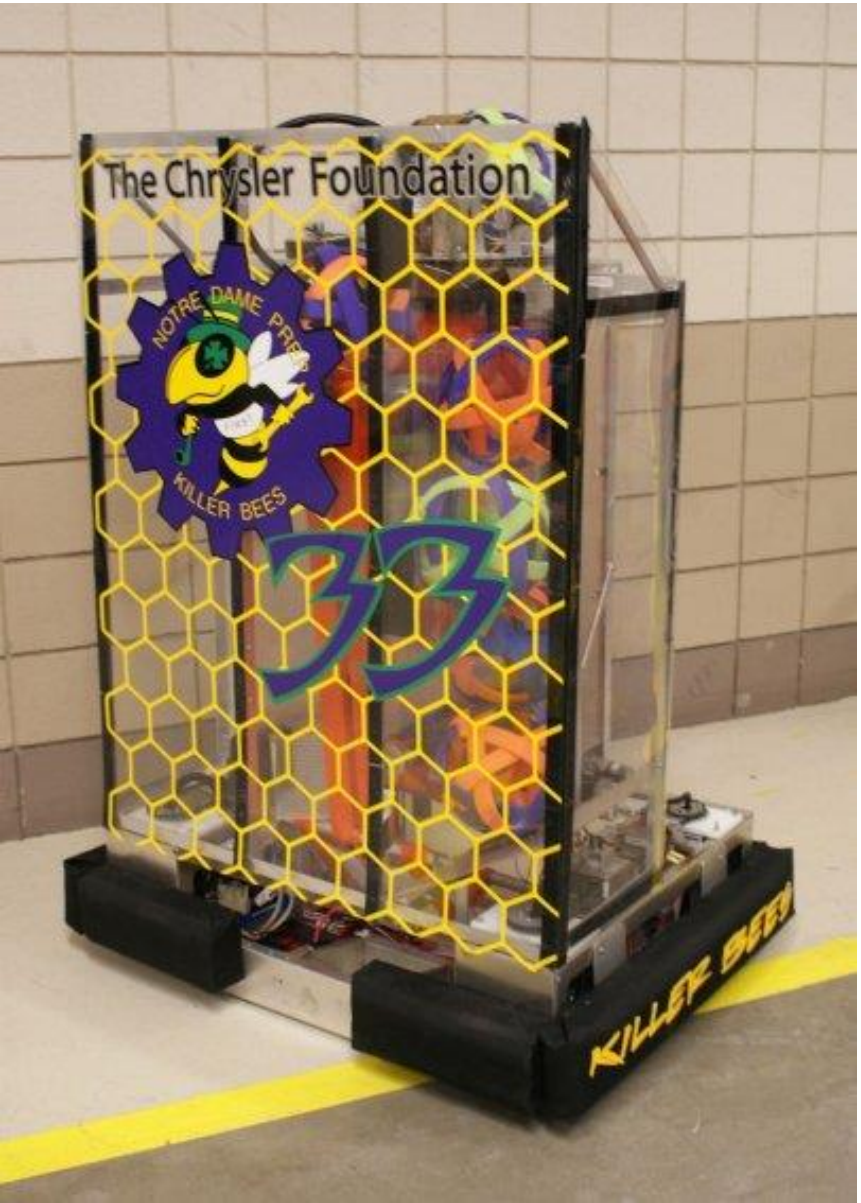
2008 Buzz XIII No way we will be 120 Lbs.



In 2008 we did the weight roll-up calculations and it only totaled 110 pounds.

- This gave us false confidence and we stopped trying to keep weight low.
- Several mechanisms that once built were not able to be changed, had added fat on them that could have been trimmed.
- The week before shipping we were 2 pounds over and still wanted to add more mechnisms.
- In order to save weight, we removed the pump and added accumulators.
- We rebuilt the platform out of Round 049 instead of Box 1.16th.
- This saved enough weight that we were able to add in a ball kicker and counterbalance bungee for the upper arm.

2009 Buzz XIV: Where did that last 20 pounds come from?



This year something rather bizarre happened that we are still trying to figure out. 1.5 weeks before ship we were at 103 pounds with “everything” included. The night before bagging, we were 9 pounds over??????

- First thing we did was remove the trailer hitch and a couple of the small bumpers up front. 3 pounds.
- Next we replaced the 1/8” angle uprights with 1/16” angle. 4 pounds.
- Lastly we figured out that instead of 2 motors we could use 1 and link the two parts together. Saving another 2 pounds.
- After critical review, we have several more weight savings ideas we will be implementing.