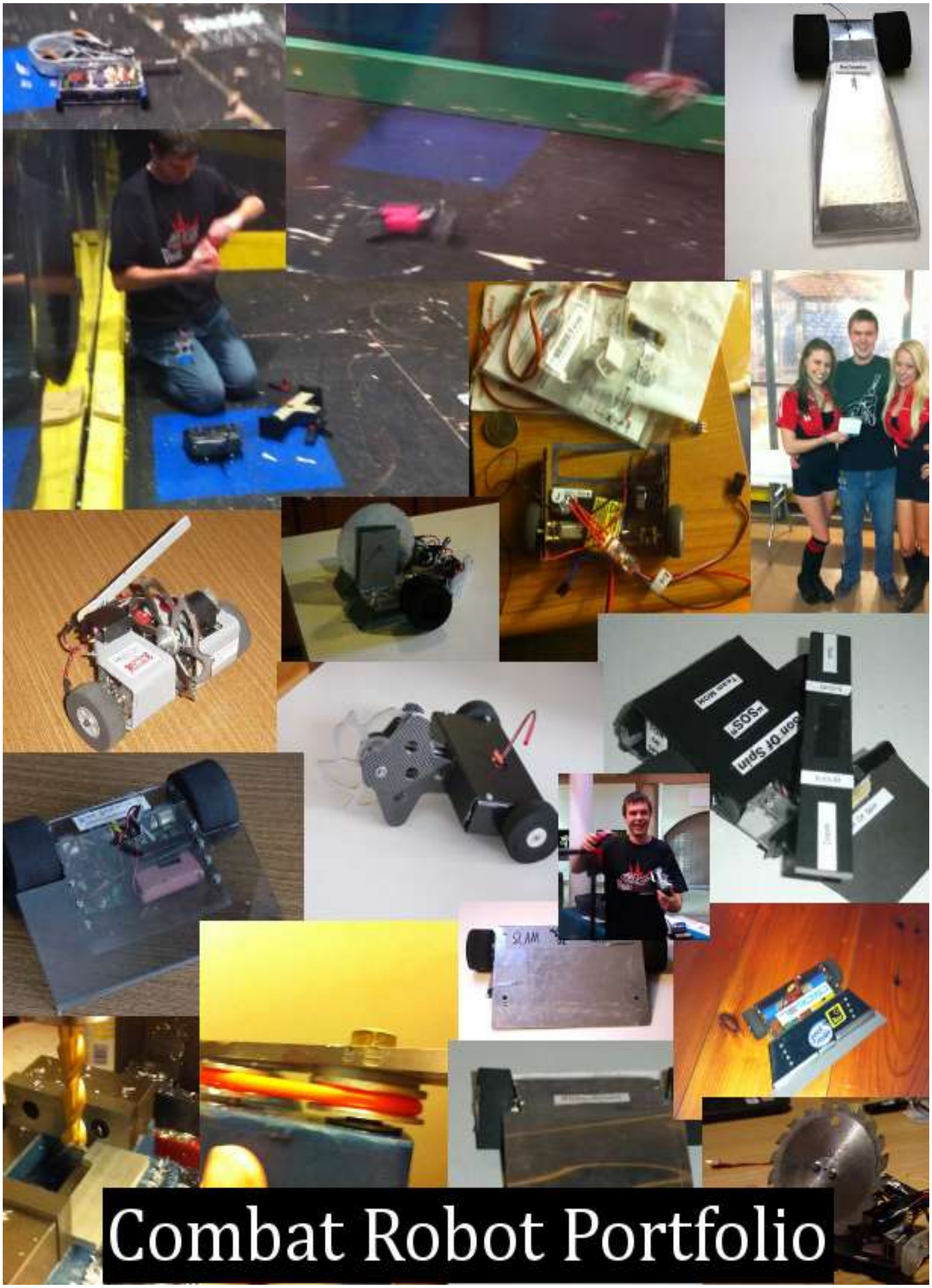


John Parsons

OVERVIEW

The fight I got into when I was eight was far from my last. Putting this chronology of my robots together reminded me of how far I have come and how much I have learned. My passion has been fueled by the constantly evolving challenge combat robotics provides: the perfect combination of engineering and physics.

My aim is to show you how much my engineering mind has grown in the time since I began building robots as a third grader. These robots are not kits. I buy raw materials to make the frames. I then buy motors and electronics, and figure out how to put the robots together on my own. The only way I know how to choose the right motor is by studying statistics and seeking advice from other builders. "Amatol" arrived on my doorstep as some sheets of polycarbonate and ABS plastic. "Coercion" began as a 1.5"-thick piece of high-impact UHMW plastic and a garolite fiberglass resin sheet. The original "Slam Sandwich" started as a piece of aluminum, a piece of polycarbonate, and a bottle of CA glue. I have tried nearly every robot design and made nearly every mistake, but if robotics has taught me anything, it is to expect the unexpected.

I fashion just about every mechanical part of my robots. I turn my own pulleys on a lathe. I mill the tops and sides on a tabletop CNC mill, drill and thread the screw holes and even melt my own super-strong urethane drive belts together. When something breaks, I have no one to blame but myself. Fixing my robots in the pit area has taught me to think clearly under pressure, because when a robot is in two pieces, its batteries are dead, a drive motor needs to be replaced and there are only twenty minutes until the next fight, panic is the last thing that will help.

I hope this portfolio reflects my passion in combat robotics and who I am as a person. I also hope you can tell I had a blast putting it together. The robots in it are the ones I consider most telling of the education I have received as an engineer – I have built many more! Do not worry if you know little about robotics or robotic combat. I have included the basic rules of robot war, information on some common designs, and information about some basic events. I realize this portfolio is a lot to read, so if you simply wish to view the most current robots, I recommend you look at the last four pages.

Combat Robotics 101

Basic Rules

- Robots are divided into weight classes. (150g fairyweight, 1lb antweight, 3lb beetleweight, 12lb hobbyweight, and many other, larger classes up to 390 lbs.)
- The object of the competition is to kill your opponent. You have two minutes to do so in 150g and 1lb classes and three minutes in all others.
- Robots are enclosed in an arena. The arena is usually 8'x8'x4' high for smaller robots and 16'x16'x8' high for larger ones. Good arenas are made of steel, have a sturdy, wooden floor and are surrounded by bullet-proof polycarbonate ¼" to ½" thick.
- If both robots are still functioning after the match ends, a panel of three judges decides who won the fight based on which robot controlled the match more. They consider damage, aggression, and strategy.
- Robots must be radio-controlled and electrically-operated. Projectile weapons, lasers, liquid weapons, radio jammers and robot-shocking devices are prohibited.
- A robot is guaranteed at least 20 minutes between fights, which is usually not even enough time to fully recharge a robot's battery, let alone fix major damage.
- Tournaments consist of either a round robin or double-elimination brackets.

Basic Concepts

- There are three basic types of robot: spinner, wedge, and flipper.
  - Spinners are designed to kill their opponents. They are real crowd-pleasers and are a blast to drive. They are also expensive and hard-to-maintain. Spinners do not often work for a full three-minute match. The idea of a spinner is to deliver as much kinetic energy as possible into a hapless opponent. Some specific types of spinners:
    - Drum / Eggbeater: a wide vertical spinner. Drums are round and eggbeaters are more rectangular.
    - Disc: a saw blade or other circular device. Most are vertically-oriented so impact will damage the opponent and throw it into the air.
    - Undercutter: a horizontal spinner located underneath a robot.
  - Wedges are designed to take the abuse from spinners until the spinners break themselves and then control the match with a superior drivetrain. Wedges are so-named because they usually have a surface that is low to the ground to get under the opponent. They are the most common design.
    - Some wedges are technically "bricks", which are robots designed to be tough but have no inclined surfaces. Bricks are the simplest and least effective design, but can do well in combat if built tough enough.
  - Flippers have a device designed to throw the other robot into the air or otherwise lift it off the ground.

EVENTS

INTERNATIONAL COMPETITIONS

- Motorama Robot Conflict: An annual robot competition held over three days in Harrisburg, Pennsylvania. About 100 robots (ranging in size from 150g to 30lbs) from all over the United States and Canada attend. It is the largest event on the East Coast.

NATIONAL COMPETITIONS

- Bot Blast: The second largest small robot (6lb and under) competition in the United States. It is held in Bloomsburg, Pennsylvania and builders from all over the United States attend.
- Franklin Institute Robot Conflict: A smaller, one-day, educational version of Motorama held at the Franklin Institute in Philadelphia.

REGIONAL COMPETITIONS

- House of NERC/House of Benson: The precursors to Franklin Institute Robot Conflict. These events were held in either New Jersey or Massachusetts from 2005-2008 and drew a respectable crowd of 10-20 robots.
- House of Gilleski/UConn Events: Held in 2004 and 2005, these events drew a crowd similar in size to House of NERC.
- Pound of Pain: A series of events held in Nashua, New Hampshire. Pound of Pain 6 is what really made me fall in love with robotic combat. These events drew about twenty to thirty robots.

Nor’easter (2004)

What it was: A 1lb antweight robot with a front flipper powered by a servo. It had a 1/32” aluminum body and the front was covered by a piece of 3/32” polycarbonate vacuum-formed to fit.

Why it’s special: Nor’easter was the first robot I ever contributed design ideas to, way back in early 2004 when I was 8 and 9.

Changes and improvements: None.

How it did: Considering I was 9 years old driving this robot against grown men, it did well. It went 2-2 at Motorama 2004 but did not place. It was retired after a bad fight at Pound of Pain 8 later that year.

Lessons learned:

- I underestimated how good spinning weapons would be at shearing off exposed wheels.
- I underestimated how much current the drive motors would use. I upgraded them and probably did not use the proper current when choosing a battery.
- Being nine years old, I overestimated the amount of torque that would be present at the end of the flipper. It was more of a lifter.
- I did not anticipate how great the frictional losses would be in a large plastic gearbox and should have used more grease.
- The gray double-sided tape appeared to adhere to aluminum and polycarbonate very well in large quantities.

Robo-Sushi (2004 – 2010)

What it was: A 150g fairyweight with a flashing wedge and two big drive motors. It got under most everything and out-pushed most everything as well.

Why it's special: Robo-Sushi was the first successful robot I ever built by myself. Pictured above is a later version that had an ABS baseplate; early versions were completely cardboard and the first competition version had a cardboard baseplate.

Changes and improvements: The cardboard baseplate became plastic and the balsa motor mount was replaced with actual motor mounts. Later versions got a plastic wedge that had sides and higher-performance motors.

How it did: Unbelievably well. It never won a competition, but it took second at Pound of Pain 8 (when I was 9), which qualified it for the RFL National Championship. It also placed second at Motorama 2006 and third in 2009 (as "Fright Blade"), among the other trophies it took home.

Lessons learned:

- 1/64" 6061 aluminum is too soft to be effective armor. 6061 aluminum has a yield strength of 16,000psi while 6AL-4V titanium has a yield strength of ten times that.
- Hot glue only adheres well to paper, not to nylon and brass. It did not hold the wheels on very well.
- Faster wedge robots seem to work better. Running 6v Copal 50:1 gearmotors on 14.4v seemed to be adequate; less than those specifications caused the robot to be too slow.

SON OF SPIN (2004 – 2005)

What it was: A 3lb beetleweight robot with a 1lb steel bar. The design idea was good but the execution was beyond poor – due to my age and building inexperience.

Why it's special: Looking back on it, the design is similar to my current beetleweight, Coercion. It also showed that I was capable of dreaming big, even if I couldn't build very well. It was held together almost entirely with superglue and zip ties (even the giant weapon motor).

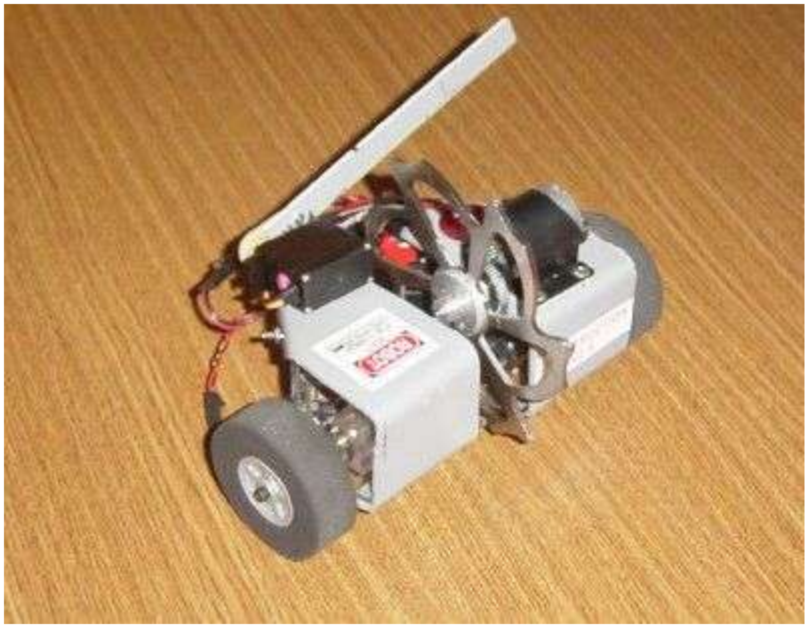
Changes and improvements: None. It was my first beetleweight and was never rebuilt.

How it did: It blew up in pre-event testing (the weapon speed controller fried and all of the super glue joints broke when the weapon struck the body) and never fought.

Lessons learned:

- One must be careful when picking a weapon controller. The website I purchased the 600-size motor stated the "max amps" were 18.8A but upon doing more research, stall current turned out to be 70A. The speed controller was only rated for 20A burst current.
- CA glue is more effective when there is more contact area. Many of the ABS pieces could have been folded to make the bond with the baseplate better.
- Weapon balancing is important. Being off by a little bit can throw off rotational momentum and cause the robot to shake or in Son of Spin's case, cause the baseplate to flex and the blade to strike the body.
- Providing constant down force on a wedge through the use of rubber bands helps to get under other robots.
- Putting cool labels on your robot serves only to distract you from improving it.

DISCSTRUCTION (2005 – 2007)



What it was: 1lb antweight with a vertical spinning disc. It was built out of folded ABS and polycarbonate. The original didn't have the self-righting arm that you can see at the back.

Why it's special: I built this robot with minimal assistance and it was my first effective 1lb antweight. The design carried on for many years and I am currently thinking about building a better version of it.

Changes and improvements: Later versions got a self-righting arm, had the motor mounts screwed in, and got little wedgelets on the front to keep the robot from tipping over.

How it did: Reasonably well. It took third place at House of Gilleski in 2005 but never placed again after that.

Lessons learned:

- I was young enough to not care about hole alignment that much. Instead of drilling holes on a drill press and hoping they aligned, a drill would have been a good idea. It would have reduced the tension in the top of the robot and made it better able to resist other forces.
- Open designs can let gunk into robots. Gunk can interfere with double-sided tape by reducing contact area.
- Copal 50:1 drive motor shafts are not supported well by the rest of the gearbox, and the gears are too small. The result is that they break when hit almost every time.
- Threadlocker is the single best way to improve robot reliability.

Slam Sandwich I, III, V (2005-2010)

What they were: A long-lived series of 1lb antweight wedge robots. From left to right, Slam Sandwich (SS), Slam Sandwich III (SSIII), and Slam Sandwich V (SSV). No images of version 2 exist and version 4 was accidentally skipped!

Why they're special: Building Slam Sandwiches made me good at building robots. You can see the huge progression in build quality. The first robot was glued and taped together, the second began to use screws, and the third was tough enough to hang with "Switchblade", the #2 robot in the country, for a full two-minute match.

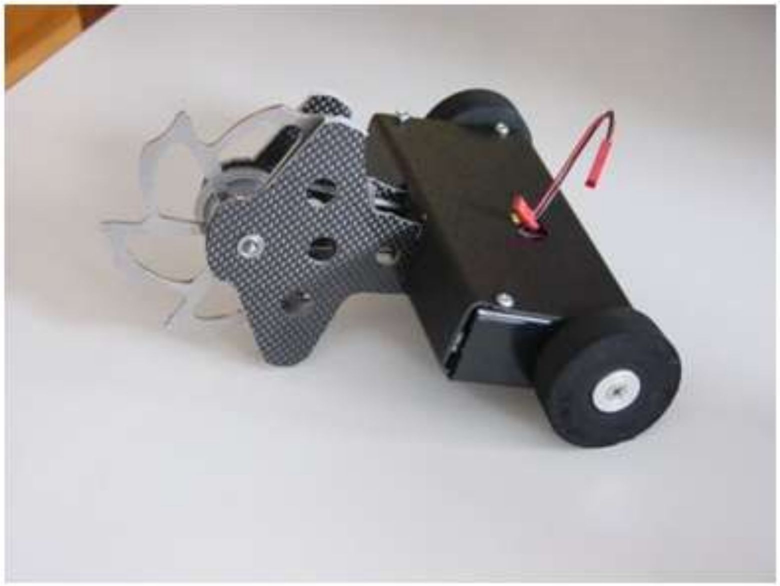
Changes and improvements: Numerous – from improved construction to better wheel protection to a better drivetrain. Note the duct tape in the first version, four screws in the wedge in the second, and eight larger ones in the third. SS had plastic gearboxes, SSIII had notoriously brittle Copal 50:1 gearmotors, and SSV had large, durable, 3lb beetleweight-sized B16 gearmotors. Wedge ground clearance was also decreased from SS to SSV.

How it did: Being my workhorse antweight for so long, it usually placed decently. It usually got 2-3 wins per two losses and occasionally finished in the top three. SS also has the distinction of beating an antweight from "Team MIT" at an event at UConn in 2004!

Lessons learned:

- The more screws, the more material holding your robot together and the stronger it will be. Larger screws also hold robots together better.
- If a wedge is off the ground at any point, it is ineffective. Wedges must be carefully ground to make contact with the floor all the way across.
- Polycarbonate is a good wedge material because of its high impact strength (13ft*lb/in IZOD notched impact) but is also very brittle – unlike UHMW, polycarbonate shatters or breaks instead of deforming.
- Polycarbonate also appears to be far superior to aluminum for robotic applications because of its lower density.

THE BELOVED SHARDY (2008-2011)



What it was: 1lb antweight with a vertical spinning disc. The vertical spinner had brittle (carbon fiber) weapon supports but the robot was effective.

Why it's special: Beloved Shardy was the first time I ever used pulley drive on one of my spinners. The Speed-280BB that drove it was also the last brushed weapon motor I used (or will use). It was the most effective antweight spinner I have personally built so far.

Changes and improvements: Few. The weapon supports were changed to be less brittle and some of the angle polycarbonate pieces that I made had to be replaced.

How it did: Quite well. It took first at Robot Event of Doom and a House of Benson event in Massachusetts.

Lessons learned:

- Vertical spinners are strongly affected by gyroscopic forces when turning due to the change in angular momentum. This causes one wheel to lift off the ground and is known as "gyro dancing". It negatively impacts maneuverability unless an expert is driving.
- Brushed motors are far less efficient and reliable than brushless ones. In the arena, brushless is far superior.
- The gear ratio on the blade was too high. It could have been decreased to 2:1 or even 3:2 to increase the kinetic energy of the saw blade.
- A higher-capacity battery would have been able to provide enough energy to run the weapon at full speed for longer.

LOLCAT (2011-PRESENT)

(No cats were harmed in the making of this robot!)

What it is: 150g fairyweight robot with an eggbeater weapon on the front. The original had aluminum sides and the current version has polycarbonate ones.

Why it's special: The current version of Lolcat is the first robot I ever built on a CNC mill completely by myself. Its design was inspired by a robot called Puppy Patter, and ever since I have been building robots, I have wanted a fairyweight eggbeater just like this one. It's my favorite robot of all time and only the second of its kind that I am aware of.

Changes and improvements: The latest version has bigger wheel guards to protect the wheels better (the original didn't have wheel guards and the Motorama 2012 version had poor ones) and a better weapon motor mount that is attached to both the top and the bottom. It also has new polycarbonate sides to save weight and allow for better radio reception. I have tried three different batteries and now believe I have found the best one.

How it does: It has placed in the top three at each event it has attended. It won second at Motorama 2011, third at Motorama 2012 and first at Bot Blast 2012.

Lessons learned:

- Aluminum sides combined with electric motor interference make for difficult, glitch-filled driving. The steel floor at Motorama also hurts radio reception.
- Wheel guards must be as far away as possible from wheels in order to have enough space to stop weapons before they get to the wheels.
- CA glue makes nylon brittle.

AMATOL (2011-2012)

What it is: Tough-as-nails 1lb antweight wedge designed to be a next-generation Slam Sandwich.

Why it's special: It's got 6 years of antweight wedge experience woven into it. It has more drive power than Coercion (a 3lb beetleweight) and is designed to fight spinners as well as other wedges. It is one of the fastest antweights in existence but is still very controllable. It's like a Porsche 911.

Changes and improvements: From Slam Sandwich, it is now put together with 6-32 machine screws, has a better wedge shape and has more powerful motors. The gray device on the front of the wedge is designed to get under other robots better.

How it does: It did well at Franklin Institute Robot Conflict 2011, placing third. Two unlucky breaks led to an early exit from Motorama 2012 and two more made it do poorly at Bot Blast 2012.

Lessons learned:

- No antweight or beetleweight-sized gearmotor can withstand a hit.
- Using software tuning in the controller to slow down turns leaves a robot with explosive straight-line speed but makes it very controllable, too.
- Decreasing the ground clearance on the wedge (with the gray attachment) is the difference between an easy win and a close judges' decision.
- Too much drive motor torque can cause the robot to "burn out" and actually make the robot accelerate more slowly because there is less friction present once the wheels begin spinning on the floor. Once the wheels grip, the robot shoots off.
- Rubber tires seem to provide better grip than the foam ones Amatol uses but a little skid in turns adds to the "fun-to-drive toy" factor that I love.

COERCION (2012-PRESENT)

What it is: 3lb beetleweight robot with a (balanced) 1lb S7 steel bar.

Why it's special: Coercion is a scaled-up version of an antweight undercutter I had in the works. Coercion has a one-piece UHMW milled frame (one of the few of its kind). Any robot that scares me as much as Coercion is near-and-dear to my heart.

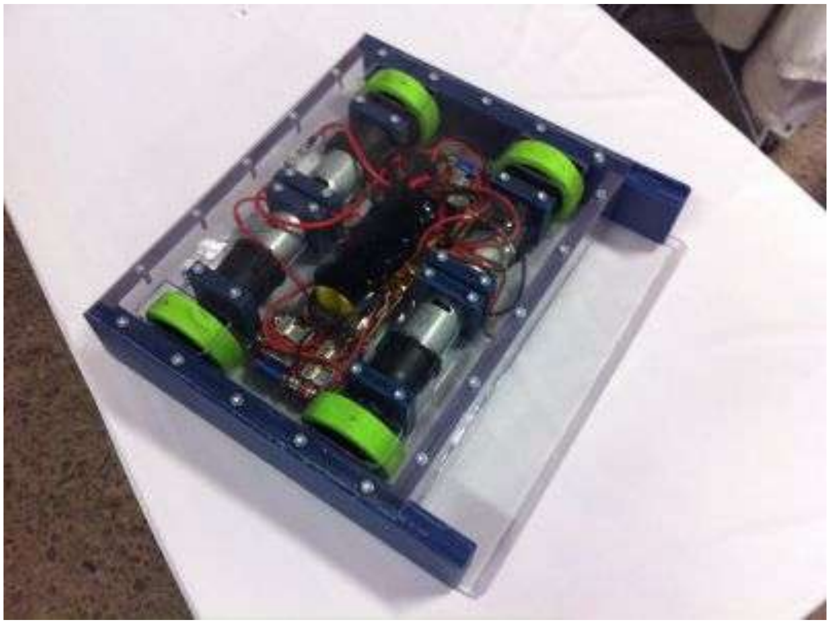
Changes and improvements: Since the image was taken, the battery voltage was decreased and the capacity was increased (to make the robot run cooler and longer). The weapon belt has been tightened and the weapon now rides on ball bearings. The wheel guards are now made out of sturdier polycarbonate. More ventilation holes have been drilled as well.

How it does: After fixing the weapon spin up problems it suffered from at Motorama 2012, Coercion managed to go a strong 2-2 at Bot Blast 2012.

Lessons learned:

- Ball bearings cause *much* less friction than UHMW bushings.
- Soft-starting (not starting with full power) a brushless motor can actually cause it to cog and stall for longer than normal, which can cause it to overheat (as opposed to starting it with full power, which creates more heat temporarily but motor cooling quickly takes care of it).
- Even S7 tool steel needs to be hardened to be effective. Unhardened S7 is too soft and dents easily in the 3lb beetleweight class. Lolcat's eggbeater is not hardened either but the stresses in the 150g fairyweight class are much smaller so it is barely even scratched.
- Reducing battery voltage is an effective way of reducing current consumption (as predicted by Ohm's Law)

TOUGH NUT (2012-PRESENT)



What it is: 12lb hobbyweight brick bot. Originally it was slated to have a front edge but (due to time) wound up with the small scoop device you can see, which we removed after it was damaged.

Why it's special: Tough Nut was probably the last joint venture between my father and I and was also our first hobbyweight. It competed at Motorama 2012 and took an impressive third against some great robots. It was one of the best father-son experiences I have ever had.

Changes and improvements: At Motorama, we added a 1/8" steel ram plate to what is the back in the picture then made the ram plate the front.

How it does: Tough Nut is way stronger than we predicted it would be. With a wedge, it will be a force to be reckoned with. It went 4-2 at Motorama 2012, beating four spinners and taking third.

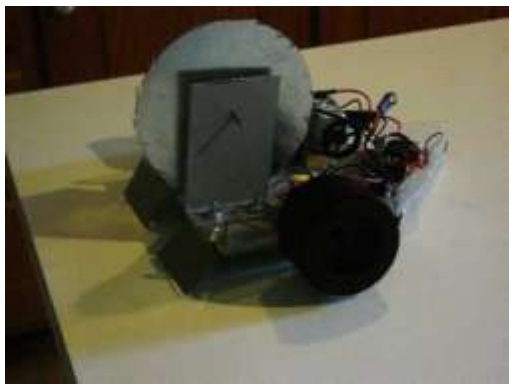
Lessons learned:

- Due to its light weight, strength, impact resistance, and ductility, UHMW is the ideal robot-building material.
- Wedges are far more effective than bricks. Some robots were able to get under Tough Nut and remove one or both sets of wheels from the floor, cutting its pushing power in half.
- Spinners bite the best on edges; driving straight into horizontal spinners reduces damage while giving them a corner can cause severe damage. Against Fiasco, one hit appeared to go through ¾" UHMW as well as the 1/8" steel ram plate.
- The plastite screws Tough Nut used were very good at holding in both polycarbonate and UHMW, two materials that do not hold screw threads very well due to their softness. They held on so well that the material around the screws gave way before the threads did!

Concept Robots

These robots never made it to the arena, but the ideas and lessons that went with them did.

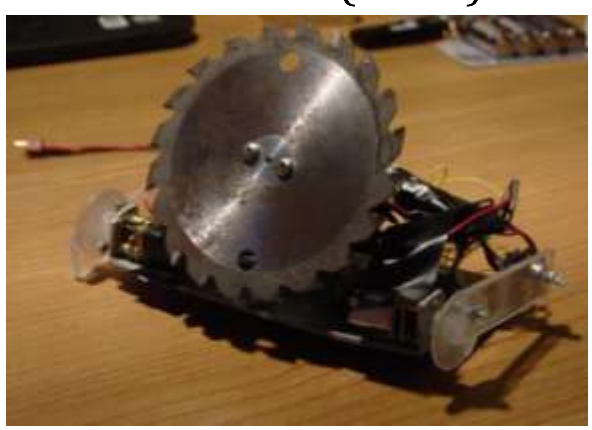
Gator (2004)



What it was: I built Gator when I was 9. It had a 1/16” thick aluminum saw blade and front titanium wedges. It used a plastic chain to spin the blade (needless to say it did not spin very well especially considering that the gear ratio was 1:1).

What it led to: Discstruction – its design is an improved version of Gator’s.

Robo-Nori (2008)



What it was: 150g fairyweight “shufflebot” that treaded the line between being a “walker” and being a wheeled robot. It used a simple cam system to move. It was not combat-ready but featured a sawblade weapon anyway. Its name is a play on “Robo-Sushi”.

What it led to: More fairyweight curiosity and eventually my favorite robot of all time, Lolcat.