

The Evolution of Attitude

● by Troy Mock

My venture into the three pound Beetleweight class began in 2009 when I was in the eighth grade. After many years of being a spectator at combat robot events, I saw the chassis of the Beetleweight vertical spinner Altitude on eBay, built by Kevin Barker of K2 and Terminal Velocity fame (**Figure 1**). I pulled the trigger, won the auction, and stepped into the violent yet thrilling world of three pound combat robots.

Included with the chassis and other proprietary parts were two 8" titanium discs and a substantially heavier and more intimidating waterjet cut spring steel blade. Unfortunately, the robot would be grossly overweight with the gleaming spring steel blade, so that disc would have to wait while I contemplated its future use.

To complete Attitude — my newly renamed robot — I bought the motors and electronics, and entered RoboGames 2010 — the largest robotics competition in the world, conveniently located a short distance from my home.

After three excitingly brutal matches, Attitude was out of the competition but ready for more carnage. During the Beetleweight rumble at the end of the competition, I bit off a little more than I could chew, discovering firsthand Attitude's inherent weakness: frame flex.

A vicious horizontal undercutter — after shredding apart my titanium front scoop and flinging it across the arena — got a good hit on my titanium blade and splayed the aluminum frame rails out enough so that the whole weapon assembly flew into the arena walls with tremendous velocity.

Consequently, my robot limped around the arena weaponless and shamed from the aftermath of that fateful encounter (**Figure 2**). While

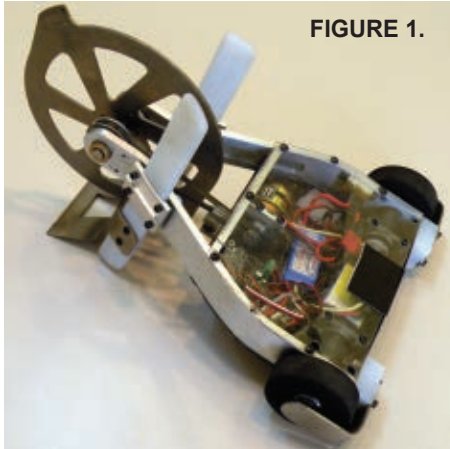


FIGURE 1.

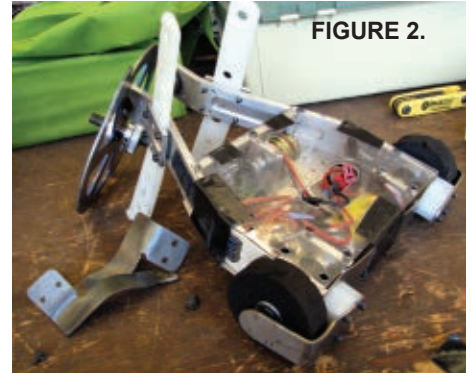


FIGURE 2.



FIGURE 3.

Attitude was able to inflict damage on its opponents, it lacked the jaw-dropping, arena-shaking punch of other Beetleweights that I so desired.

I utilized that original design of Attitude for close to two years, placing as high as second at Combots Cup VI and third at RoboGames 2011. Make no mistake, Attitude was able to shred into and even knock out a number of its opponents (**Figure 3**), but I wanted something more: for my fellow competitors to truly fear the raw power and destructive potential of Attitude.

Additionally, there were some inherent flaws that plagued the design. As I had found out at the first competition, the most important issue was frame flex. The central frame brace did not connect the two main frame rails that supported the weapon assembly; instead, the frame rails were joined solely by the top and bottom plates (**Figure 4**).

Coupled with a live shaft for the weapon disc and the use of thin flexible top and bottom plates, Attitude had a tendency to snap weapon belts in critical situations,

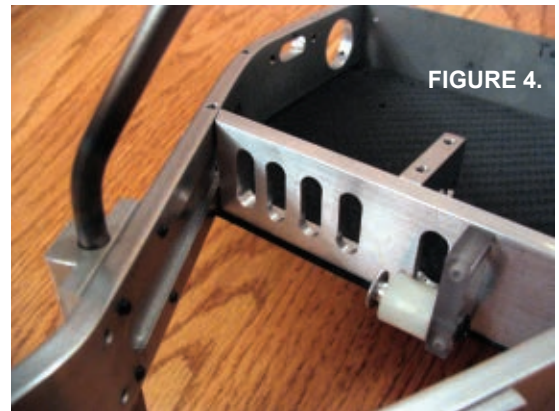


FIGURE 4.

such as in the gold medal championship match against the brutal drum of One Fierce Lawnboy at Combots Cup VI.

Without a functioning weapon, Attitude and its speedy but low torque drive motors and thin titanium armor were no match for the opponent, who systematically took apart my robot in a spectacular fashion.

For better or for worse, my intense fighting spirit prevented me from tapping out even as Attitude took hit after hit and received irreparable damage as revealed in

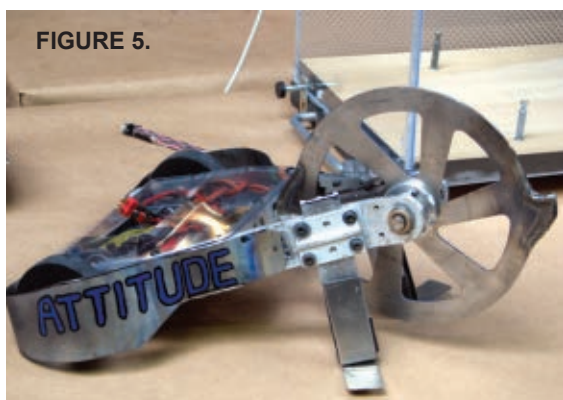


FIGURE 5.

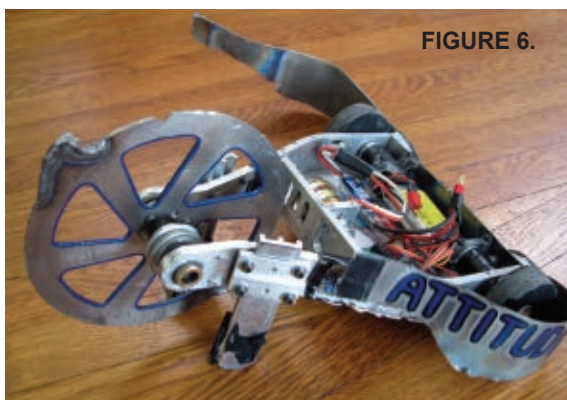


FIGURE 6.

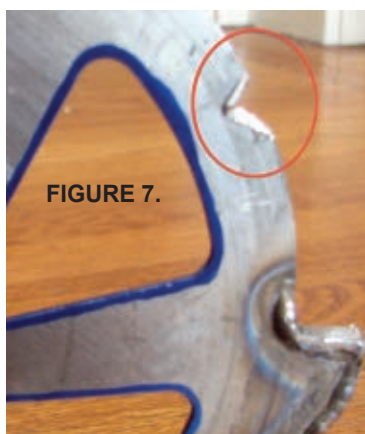


FIGURE 7.

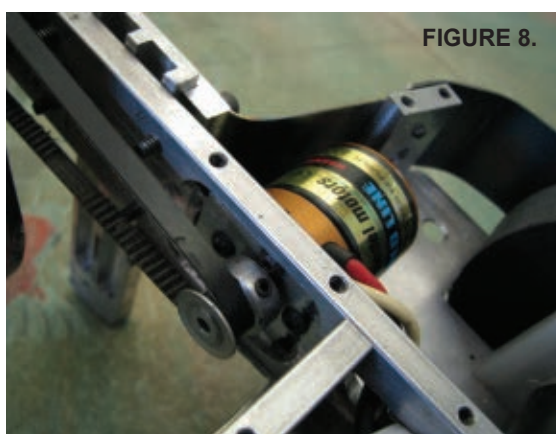


FIGURE 8.

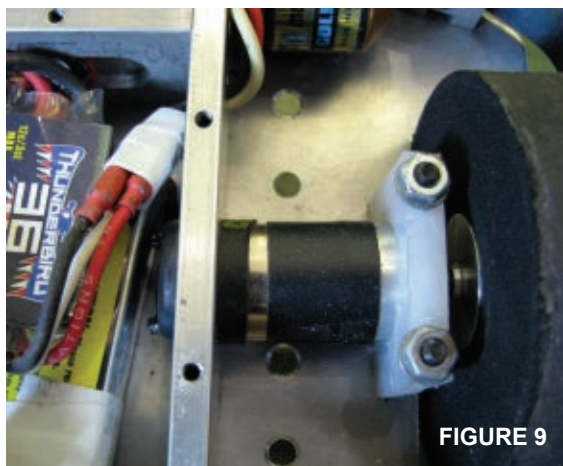


FIGURE 9

the before and after photos in **Figures 5** through **7**.

The level of engineering and design in the top Beetleweight contenders had continued to evolve, putting Attitude on the backburner in terms of destructive power. If I wanted to be competitive and succeed, I knew it was time to move to the next level in terms of my design and fabrication skills or become obsolete.

My goals for the rebuild were

simple: increased frame stiffness coupled with frame weight reduction to utilize a heavier weapon disc. It would be easy to imagine that lighter and stiffer do not correlate, but by forming a simpler stouter chassis, stiffness was substantially increased. Garolite and higher-grade aluminum were used as top and bottom plates to improve torsional stiffness. However, the live shaft from the previous

iteration was retained as it had given me no issues. With RoboGames 2012 rapidly approaching, I didn't want to rebuild the entire weapon system, as well as the rest of the robot.

To further reduce weight, I integrated the two main frame rails into the component layout as much as possible. Instead of having a separate weapon motor mount, the brushless Outrunner was directly bolted to the right frame rail. This allowed for a

shorter belt length and less weight (**Figure 8**). As seen in **Figure 8**, the frame rails were heavily milled for further weight reduction — as I later found out, perhaps too heavily milled.

For the drive motors, the motor

cans were press-fitted directly into precision holes in the frame rails (**Figure 9**). Also, I utilized the shortened aluminum weapon stays that kept the blade off the ground from a previous iteration. When inverted, Attitude's blade would strike the arena floor with enough force to bounce back on its right side.

Crowds tended to enjoy this maneuver as sparks flew and an obnoxious grinding clamor could be heard from afar as the robot ferociously bounced around the arena, trying to flip back over. Most importantly, by optimizing and integrating the frame, I was able to find weight for the intimidating spring steel blade I had been dreaming about for years. Version 2 of Attitude was finished in all of its glory with the help of my father in the early morning of April 20th — opening day of RoboGames 2012.

Completing the armor at 3 am and cutting the top cover right before the weigh-in of the competition, I (barely) had Attitude ready for battle (**Figure 10**). Admittedly, I spun up the pristine and knick-free spring steel blade for the first time during the safety check, and Attitude passed the weigh-in with a couple grams to spare.

I had unabashedly broken the famous law by Carlo Bertocchini, builder of Biohazard: "Finish your robot before you come to the competition!" However, luck was on my side that day, as Attitude did better than I could have ever imagined.

In its very first bout, Attitude's immense power prevailed. The opponent sailed across the arena again and again, each time with less armor and less courage to fight back. I cringed as the whir of Attitude's blade grew louder and louder, its Axi brushless motor whining to keep the teeth of the 8" steel blade spinning at a lofty 160 miles per hour.

In the following bouts, I grinned ear to ear as bright white titanium sparks and Lite Flite foam chunks showered the arena. The new blade was unstoppable as Attitude plowed through the competition right into the championship bout.

Facing up against the incredibly tough, well-driven Beetleweight wedge named Raptor 2.2 (**Figure 11**) and driven by fellow junior competitor Dawson Brown, Attitude had its hands full. Due to a narrower wheelbase and a blade 80% heavier than before, Attitude's ability to maneuver was significantly worse due to the gyroscopic effect of the huge spinning weapon.

In the previous matches, I was able to drive Attitude well enough to deliver knockout hits. However, against a skilled relentless driver and a nimble wedge, Attitude was unable to control the match and inflict the incapacitating damage necessary to win. I couldn't be disappointed with a second place finish, and coupled with my other bots I came home with an armful of medals.

As the next competition rapidly approached, I luckily had few changes to make. I identified Attitude's chief weakness at RoboGames: maneuverability. Aggressive wedges like Raptor 2.2 exacerbated this issue in the small Insect arena of RoboGames, and there was little I could do to remedy the issue without a major rebuild.

As I had discovered in previous matches against tough wedges, all I needed was one solid hit on the opponent's wedge that would skew and prevent the wedge from lying flat



FIGURE 10.

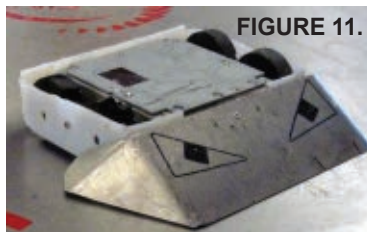


FIGURE 11.



FIGURE 12.

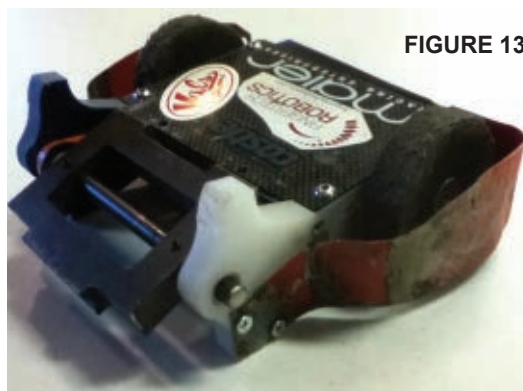


FIGURE 13.

on the ground, leaving my adversary vulnerable. The solution: small titanium wedglets that were hinged to the weapon stays (**Figure 12**).

This solution was ideal in theory because no matter the irregularities of the arena floor, the wedglets would remain flush and even pivot when the gyroscopic forces of turning caused Attitude to lift to one side. Also, after RoboGames, I noticed that the frame rails were slightly bent horizontally.

Although not extreme, this was caused by the perhaps overzealous deep channel milling to save weight, and the abusive hits from various horizontal spinners. There was not much I could do, so I kept a watchful eye on the frame rails to see if they bent any further in the upcoming competition.

I learned two important lessons at the following competition — Sonoma Ant Wars 2012. Attitude's spring steel blade was incredibly powerful, but it wasn't as wondrous as I had hoped. These two lessons were realized in a single match against a malicious Beetleweight with a solid S7 steel eggbeater (**Figure 14**).

With both of our blades revved up to full speed, the bots collided with deafening results. The arena shook and it took a few seconds to realize

what happened: Attitude had knocked the entire eggbeater out of the frame of its opponent! However, something was awry.

After that fateful hit, it was unusually difficult for Attitude's blade to catch and throw the weaponless opponent. Upon closer inspection after the match, the issue became clear: Attitude's spring steel blade was missing a tooth (**Figure 14**)! Against such a hard material as S7 tool steel, the thin spring steel blade simply disintegrated upon impact. Also, the measly supported .02" titanium armor on Attitude tore easily and provided little protection for the delicate electronics.

Although Attitude came home undefeated, I knew that a new blade and tougher armor would have to be constructed to be able to fight again.

As a pattern suggested, two upgrades were needed for RoboGames 2013: a new blade and better armor. The latter was achieved

FIGURE 14.



with thicker titanium and more brackets to securely mount the armor to the baseplate. There was not such a simple solution for the weapon.

I knew that the thickness of the blade would need to be increased to survive hits that would destroy the previous spring steel disc. However, the 8" diameter would need to be maintained to fit the design of the frame, and there was no extra weight for a thicker and more resilient weapon. This left only one option: an optimized asymmetrical blade made from hardened .125" 4130 chromoly steel.

Using free design software to find the center of gravity of the asymmetric shape and after machining the blade myself on various metalworking tools, I sent it to the heat treater for hardening (**Figure 15**).

Figure 15 shows the new blade overlaid on the previous spring steel disc; it is interesting to note the degree of asymmetry necessary for the increased blade thickness while

FIGURE 15.



maintaining the same weight.

In perspective, the next competition — RoboGames 2013 — was a wakeup call. Although Attitude took home the bronze medal in the Beetleweight division, its inability to maneuver continued to be its Achilles heel. Once again, tough wedges skirted by and pushed Attitude around like a ragdoll. The asymmetric blade was not perfectly balanced and therefore, the small wedglets I had used successfully before vibrated and bounced along the arena, rendering them useless against wedges that remained flush against the arena floor.

Make no mistake; the new blade was able to send opponents flying and shred the titanium wedge of my rival Raptor 2.2 (**Figure 16**). (The long, thin cuts in Raptor 2.2's wedge were from Attitude's previous spring steel blade; the gouges were from the asymmetric blade).

Unfortunately, when inverted, my usual method of bouncing around the arena until Attitude righted was

absolutely brutal on the small timing belts and weapon motor due to the asymmetry of the blade. Due to such a large weapon and a high center of gravity, Attitude had the tendency to tip over and bounce around instead of attacking the opponent and being aggressive.

I began to realize that the mantra of "bigger heavier weapon is better" had failed me. There was no use in having a monster weapon if Attitude was unable to transfer that energy into the opponent.

The evolution of Attitude has been parallel with my own developing interests. Attitude's long career has spanned nearly a third of my life and has provided me with indispensable knowledge and enjoyment. It's bittersweet to see my robot — with its rusted blade and numerous medals — sit on my desk like an old relic (**Figure 17**). I would love to be travelling and fighting a revised Attitude on the East Coast and watch my latest competitive design clash with some of the most vicious Beetleweights in the world.

I know that the process of design, construction, and competition has given me invaluable tools as I begin to get ready for the next chapter in my life (college). Just as Attitude has continued to evolve and transform, so have my interests and goals for competing in the unique and addicting sport of combat robotics.

I look forward to exploring and pushing my own personal limits whether it is in design or fabrication, knowing that I have built a strong and steady base from my extensive endeavor with Attitude. **SV**

FIGURE 16.

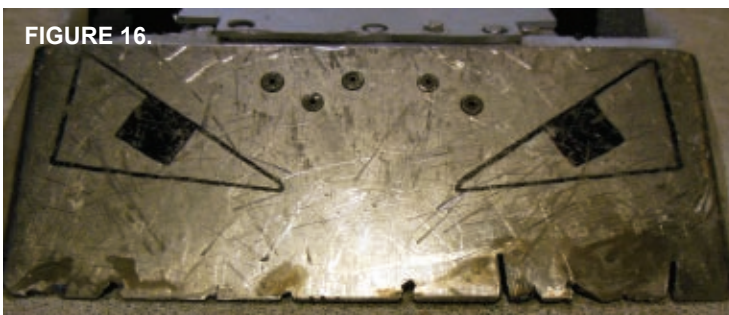


FIGURE 17.

