"The Great Big Decision"

CYBER BLUE – FRC 234
2013 FIRST Competition – Ultimate Ascent
Design Paper
11 December 2013

Intro

After the 2013 Boilermaker Regional, our team faced a difficult challenge and difficult decision. We had incorporated a unique design for the disc handling system on our robot and it was not performing at the level we felt we needed to be competitive at the upcoming Crossroads Regional and for the Championship event. We needed to make a choice of major modification and improvement to the design we had, or an even more major change to incorporate a totally new system that would require us to give up all of our functionality for floor pickup.

The team worked through a detailed process and plan to facilitate a decision. We then made a decision for a change and implemented it for the remainder of the season.

This paper will describe our initial design, the options evaluated, the factors we considered to make our decision and our final implementation. The paper will close with the results and impact of the change.

Initial Design

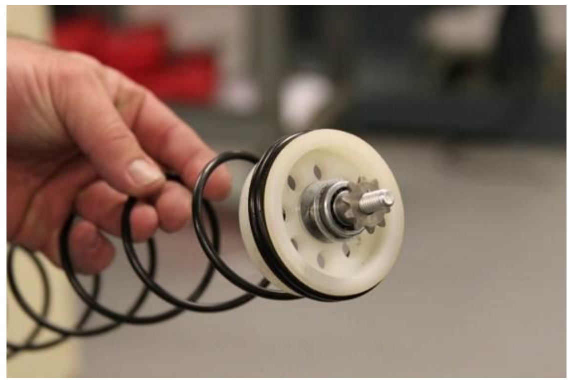
For our initial design, we decided it was important to be able to collect discs from the floor and be able to shoot from 2 or 3 distances with accuracy. We also believed the ability to go under the pyramid was important, so the height limit was less than 30". If needed, we would use our floor pick-up for loading at the human loader station.

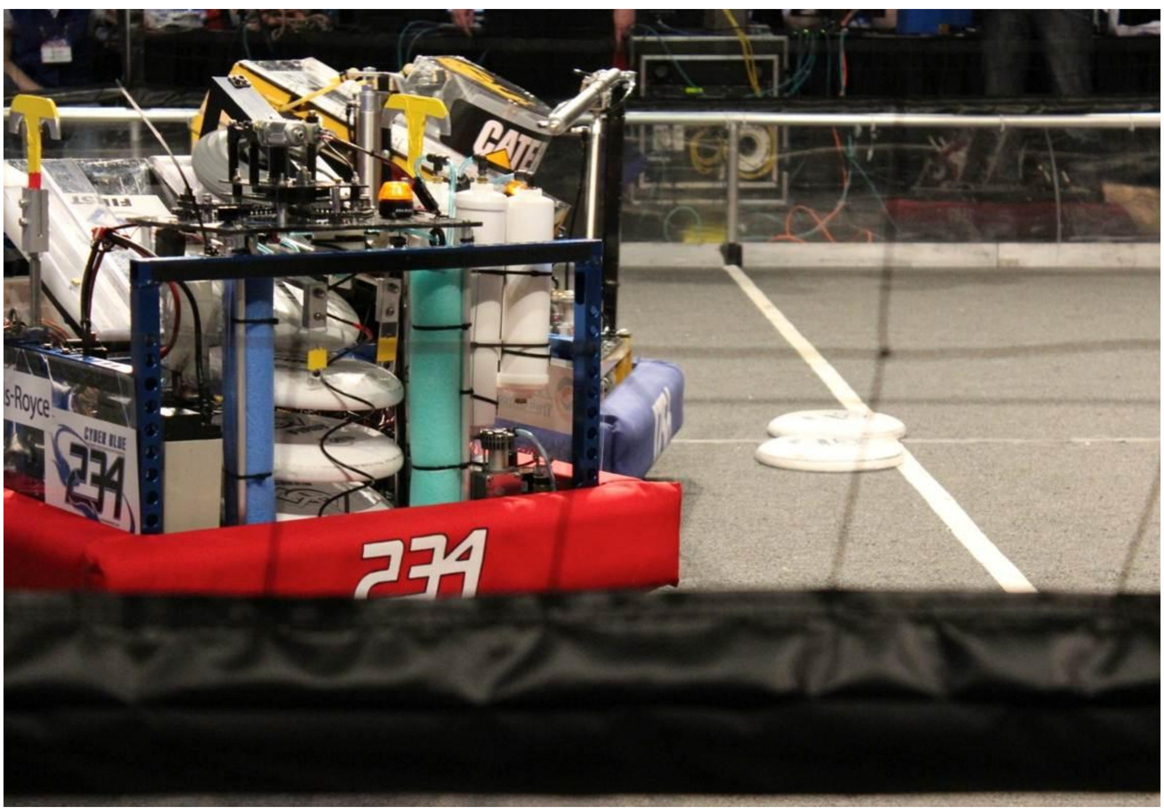
Our floor pick-up was a conveyor system with spinners on the front to pull in a disc and a conveyor to move it to the rear coil system that would raise it to the shooter input. Sensors limited the number of discs being brought in at one time. This system worked well in practice and in matches.

The disc management system was modeled after a vending machine. Three coils, similar to what is used in a vending machine, were used to raise the discs from the entrance of the conveyor up to the shooter input. The coils were driven by a single motor to be "timed" to keep the disc level. Sensors allowed the disc to move up one level at a time, so that there was room for another disc below, until 4 discs were inside the coil system. When four discs were in the coils, the control system locked out the ability to collect additional discs.

When it was time to shoot, the coils would rotate to advance a disc into the shooter input. A pneumatic cylinder would push the disc into the shooter wheels, where it would exit the shooter. The control then advanced another disc up, so it was ready to shoot. This was repeated until all discs were shot.


Doritos
Baked
Lays
Sun Chips
CRUNCH
Extra

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Design in Competition

In competition, we encountered two issues that needed to be addressed before our next event. It was sometimes difficult to collect discs, and required good alignment of the robot to the disc. We believed this could be addressed with some minor modifications to the spinners on the front that helped pull the discs into the conveyor and more practice with the drive team.
The conveyor itself worked well. Discs were moved to the coils and pushed into them so they could be raised up to the shooter intake.

On occasion, when we were shooting discs or driving, a disc would come out of the coils and become angled or even vertical (they were carried in a horizontal orientation). Once this happened, we were unable to raise other discs and could not continue to score. We would convert to "defense" and try to defend other scoring robots and then move to the tower for a 10 point climb.

Despite the challenges with the coil system, we ended up ranked number three after qualification matches and led the number two alliance. Our alliance ended up as Finalists; however, we were still unhappy with the robots performance. We took several photos of the robot, removed some parts, and took several measurements to be used as we made plans.

When we returned to our school, we knew we needed to make some tough decisions on what to do before the next competition.

Options

Our team believed we had three options: Make no change at all (the robot had performed and we averaged xx discs per match); Work to understand why the discs would fall in the coil system and improve / modify the coil system to work better; Make a major change to the robot for disc collection i.e. change the basic inner workings of the robot.

The Discussion

There was significant discussion on the best action to take and there were risks and potential benefits to whatever option we selected. The discussion started with just the students. The initial meeting was for students to discuss and debate the options we faced and make a recommendation for the team. This discussion ended with strong support for either improving the existing design, or changing to a different system. No one wanted to stay with the existing design with no changes and there was not an overwhelming level of support for one of the other choices above the other.

An option was to "do nothing" major and keep practicing with our prototype robot to improve driver performance and shooting accuracy. This option would require little additional work from most of the team members. As a group, we agreed that this was not a true option for us and that we would take steps needed and put in the extra work required to improve the capability of the robot.

After the student discussions and additional discussion time with mentors, some of the pros and cons of both ideas were discussed and captured. These are in the tables below.

KEEP / MODIFY COIL LIFT (Existing Design)				
Pro's		**Con's**		Risks
Floor Pick Up		Must Improve Floor Pick Up System		Auton Loading - May Get More Difficult
Minimal Impact on Design		Hard to Load for Auton		
More Practice Time		Timing of Coils		
Experience with Coils		Upside Down Discs		
Auton Option for More Discs		Coils Bend		
Unique		Slower		
		More Complex		
		Can't Add Mini-CIMS to Drive (space)		
		Parts Were From a New Sponsor		
		Don't Fully Understand Why Didn't Work Well		

SWITCH TO "BUCKET" HOPPER				
Pro's		**Con's**		**Risks**
Likely Easier to Load		Unproven (by us)		Unproven By Us
Consistent Load		Unfamiliar		Integration with Existing Robot
Faster Load		Major Robot Changes		
Faster Shooting (Disc Drop)		Limits to Feeder Station		
Upside Down Disc - Eject		No Floor PickUp		
Potential for Fast Full Court		Looks Like Other Robots		
Simpler		Unsure of Human Load Accuracy		
Opens Space for 3rd CIM on Drive		Requires Team Info Updates (Judge Books, Spec Data)		
Lighter (15 pounds)		Time Required for Changes		
More Feeder Options		Requires Dedicated Re-Build at Next Event		

Evaluation

We concluded that there were compelling reasons to choose either of these options, and there were risks associated with both.

Stay with Coils - For the coil system, we knew what we had and it had performed pretty well, but not at the level we had wanted or felt was needed. Some of the team members believed that with some effort we could understand the issues with the design, and then make some modifications and adjustments to improve the performance. This option allowed us to keep the floor pick up and only make changes to one system, the coils. A strong argument for this option was that it was unique, and that we had invested a lot of time and effort into it and we needed to make it work. A big challenge was that we did not really know why discs would fall out of the coils and several adjustments during the competition had not improved this system significantly.

Change to a Hopper System – We did not know exactly what the new design would be, but we observed other teams using hoppers and collectors that were successful. Our shooter was dependable and accurate, so we knew that we needed a system that could feed into that system. A negative of this option was that we would lose our floor pick-up capability and we did not know the challenges that we might face with a hopper system.

Decision 1

Since the group was divided between these two options, the first decision was to take three days to develop and evaluate both options. One group focused on adding a hopper, determining how it fit on the robot and how we could move the discs into the shooter. A second group worked on options to improve the coil system and address the issues we had with it. We then agreed to come back together, discuss and evaluate both options and the progress made, and then make a single decision on how to proceed as a team. Once that decision was made, all team effort would focus on that design option.

Accelerated Design/Prototype/Improvement Work

Coils – The group working the coils worked to improve the rigidity of the coils and to find ways to keep the discs in the coils. This included an option of using 4 coils instead of 3 and of using retainer bars or dense foam to help capture the discs. The group was never able to completely understand why some disc loads would travel to the shooter effortlessly, while others would quickly fall vertical and cause us to lose the ability to shoot discs.

Hopper – The hopper group looked at designs being used by other teams and at the available space on our existing robot. Modifications were made to our prototype shooter frame and a hopper (the top portion of a plastic bucket) was fabricated to hold the discs. A cut was made in the front of the bucket for discs to exit into the shooter and a pneumatic cylinder was added to push the discs into the shooter wheels. Since this design would require human player loading, the hopper elevation and placement was evaluated at the loading station slots to determine if we could load effectively. The team determined that the back of the robot would need modifications (removal of material) to allow for loading.

Decision 2

Then it was “Day Three” and we needed to make a decision and get the whole team working on implementing and perfecting whichever decision we chose. We had the benefit of a prototype robot, so for either option we had a good opportunity for implementing and improving our design and getting it ready for the next competition.

A second listing of pros and cons of each design option was created and it captured any new information based on the work from the past three days of activity. This update is below.

The general conclusion for not updating the coil system option was that the reasons for the issues with the existing system were not fully understood, and there were still significant risks that a new and improved designed coil system would still not perform at the level we needed. A significant level of work would be needed to create an effective design and implement it into the robot.

The general conclusion for a change to the hopper design was that the idea looked very promising and that the systems would fit onto our existing robot with some minor modifications. Our shooter would not need to be changed. We would lose the floor pick-up capability, but human player loading looked to be faster and more reliable. We had also noticed that the number of discs on the playing field was smaller than we expected and would likely get even smaller as the season progressed. Driving to each disc could be much slower than the human loader option.

KEEP / MODIFY COIL LIFT (Existing Design) - UPDATED				
Pro's		**Con's**		Risks
Floor Pick Up		Cannot Fuly Understand Issues with 3 or 4 Coils		Auton Loading - May Get More Difficult
		Challenges with Timing of Coils		May Never Get it Right
More Practice Time		Floor Pick-Up Requires More Change		
		Fewer Discs on Floor as Teams Improve		
Auton Option for More Discs		Coil Design Requires Significant Change		
Unique		Slower		

SWITCH TO "BUCKET" HOPPER - UPDATED				
Pro's		**Con's**		**Risks**
Loading Easy - Fits to Loader Station with Minor Mods		Bucket Circularity Critical		Dedcated Build Time at Next Event
Consistent Load		Still Requires Perfecting		Integration with Existing Robot
Faster Load		Less Practice Time		
Faster Shooting (Disc Drop)		Must Design Intake Ramp		
Upside Down Disc - Eject		No Floor PickUp		
Potential for Fast Full Court		Looks Like Other Robots		
Simpler		Requires Dedicated Re-Build at Next Event		
Opens Space for 3rd CIM on Drive				
Lighter (10 pounds)				
Can add more Air Reserviors				

Conclusion

The team made the decision to change to the hopper system. Once this decision was made, the whole team began working to implement the changes. This included additional prototyping and testing to create a strong hopper, effective system for pushing the discs into the shooter, and a fast, reliable way for the human player to load. Additionally, once this was designed and prototyped, we needed pieces, parts and a plan for how to make and install the changes onto our robot after we arrived at our next competition.

Implementation

The final implementation was to incorporate a plastic bucket hopper and a short pneumatic to push discs into the shooter wheels. The rear bar of the robot had to be lowered 1-1/2 inches for disc loading at the human player loading station. Lexan guides were made to help funnel the discs to fall into the bucket.

To address the risk of a disc getting stuck in the hopper or being upside down (we could not push an upside down disc into the shooter) we added an “eject” button that would push a full load of discs out of the hopper and onto the ground. This proved to be very useful in competitions.

We created a “surgery” plan of what needed to come off, be modified and be installed on our robot the morning of our competition. After we arrived, the team quickly began work to incorporate the changes.

Results

The shooter and overall robot performance at the next event was significantly improved. The total number of discs scored per match went from 3.5 to 15.5. Our OPR increased from 29 to 63 and our calculated contribution to winning margin increased from 17 to 41. Just as important, we were significantly more consistent in our scoring capability. We ended ranked number two and were selected by the number one team. This alliance went on to win the event. We experienced very few issues with loading or shooting discs.

The photos below show the loading station interface and the final integration of the new hopper onto the existing robot structure.

<u>Final Test</u>

The final "test" of the decision was the impact on the competition performance from making the change.

The data below is our own scouting data from each event. BMR is the Boilermaker Regional and CRD is the Crossroads Regional. Summary Tables and Plots follow.

Autonomous Performance –
Our Autonomous Performance at BMR (12 Qualifying Matches) was a 2.4 Average, with a range from 0 to 3 disc s scored. For CRD (10 Qualifying Matches), we were consistent at 3 discs. This represents an increase of 0.6 discs per match.

TeleOp Performance –
Our TeleOp Performance at BMR was 1.1, with a range of 0 – 3 discs scored. For CRD, our average increased to 12.5 discs, with a range of 7 – 17. This represents an increase of 11.4 discs per match.

Total Score Contribution –
Our Total Score Contribution at BMR averaged 17.8 disc points and 26.1 total points per match. Our total points scored were a 313 point contribution of our total alliance score of 691. This equates to a contribution of 45%.

Our Total Score Contribution at CRD averaged 55.5 disc points and 63.5 total points per match. Our total points scored were a 635 point contribution of our total alliance score of 1135. This equates to a contribution of 56%.

It is interesting to note that while our individual scoring increased over 120% (26.1 to 63.5), our contribution percent increased only from 45% to 56%. This indicates that the overall level of play was increasing and it was important that we made changes to improve our level of play.

Conclusions

The discussions, evaluations and decision actions had a positive impact on the team. During the discussion on options, everyone had an option to offer their views and concerns. By taking the time to further evaluate the two options, we were able to answer questions about both choices and then make a more informed decision. In many ways, the emotion of the discussion, the urgency of the work and the work required to implement the changes was a true 'coming together' point for the team. There was a considerable "emotional attachment" to the original design – it was unique, we had put a significant level of effort into it, and it worked part of the time. There was concern that changing would indicate we were "wrong" in our original design. We believe we took a good system design and made it into a better system design.

Regardless of everyone's personal views during our discussion, testing and evaluation times, once a decision was made on the change we would implement, everyone worked together to design, develop and implement the selected system to make it the best it could be.

Close

The decision to make a major change to the robot is not an easy one. Any change involves risk and the new solution could have created more issues that were unforeseen to us while we were making our decisions. In hindsight, the team made the right choice, and also made the choice in the right way. By involving everyone, using knowledge and technical skills to make a data driven decision and not an emotion driven decision, we made a good, but difficult, decision.

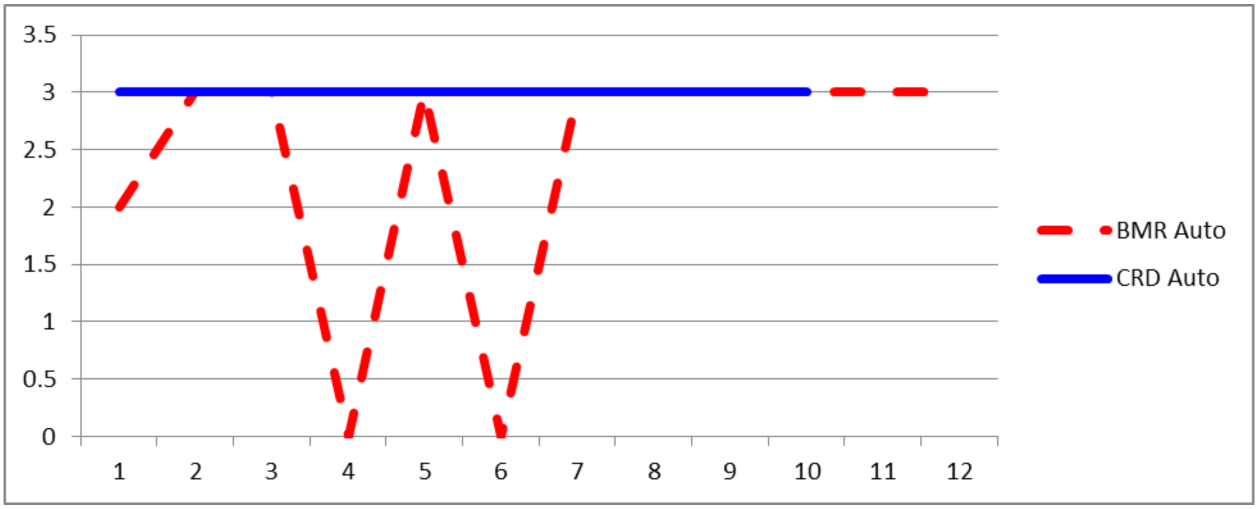
Additional Material

The following pages contain –

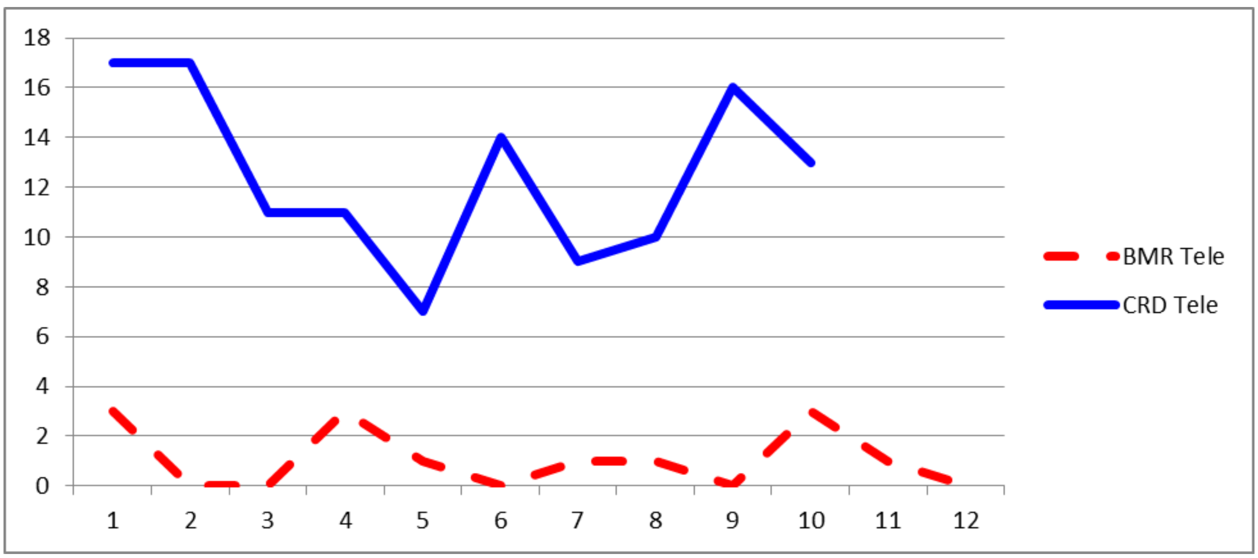
Robot Performance Data - Boilermaker Regional (BMR)
Robot Performance Data - Crossroads Regional (CRD)
Autonomous Performance Plot – BMR and CRD
TeleOp Performance Data Plot – BMR and CRD
Photos – Coil Design in Action
Photos – Hopper Design in Action

BOILERMAKER REGIONAL - FIRST EVENT						
	BMR	BMR	Disc Score	Total Score	Total Match	234 - %
	Auto	Tele				
1	2	3	21	31	62	0.50
2	3	0	18	28	60	0.47
3	3	0	18	18	44	0.41
4	0	3	9	19	29	0.66
5	3	1	21	31	31	1.00
6	0	0	0	10	19	0.53
7	3	1	21	31	95	0.33
8	3	1	21	21	24	0.88
9	3	0	18	28	113	0.25
10	3	3	27	37	87	0.43
11	3	1	21	31	75	0.41
12	3	0	18	28	52	0.54
TOTAL			213	313	691	0.45
AVG	2.4	1.1	17.8	26.1		

CROSSROADS REGIONAL - SECOND EVENT						
	CRD	CRD	Disc Score	Total Score	Total Match	234 - %
	Auto	Tele				
1	3	17	69	79	117	0.68
2	3	17	69	79	83	0.95
3	3	11	51	61	120	0.51
4	3	11	51	51	111	0.46
5	3	7	39	39	107	0.36
6	3	14	60	70	81	0.86
7	3	9	45	55	55	1.00
8	3	10	48	58	138	0.42
9	3	16	66	76	181	0.42
10	3	13	57	67	142	0.47
TOTAL			555	635	1135	0.56
AVG	3	12.5	55.5	63.5		



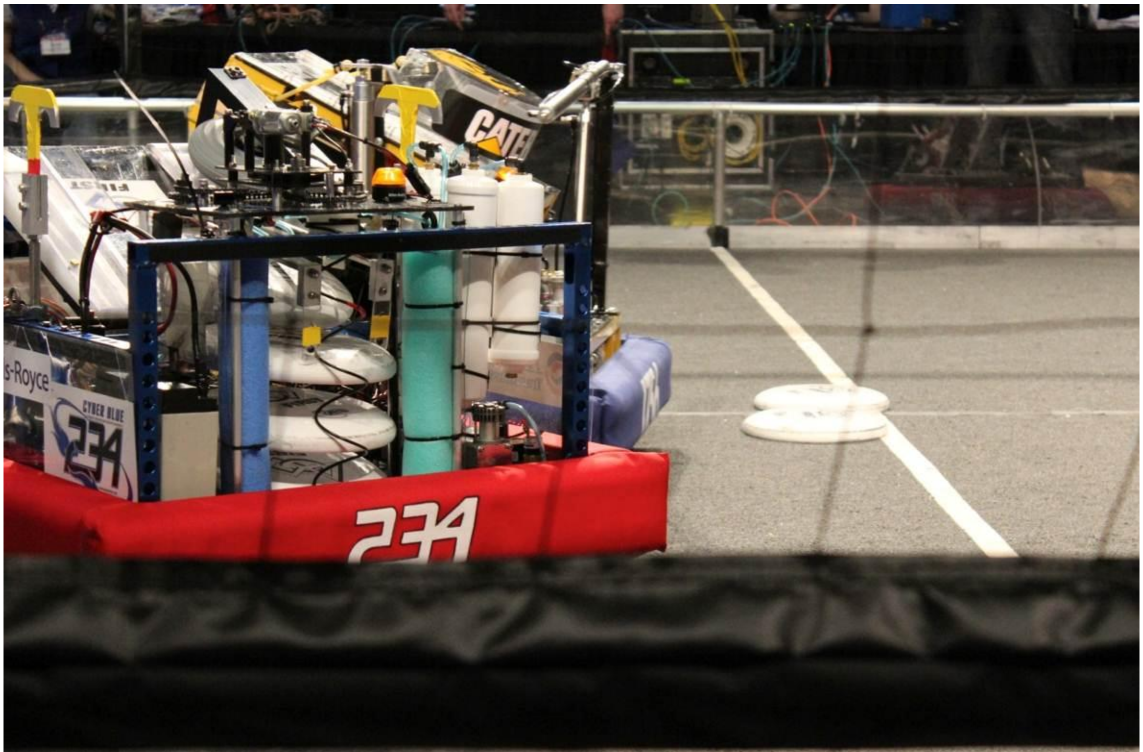
PLOT 1 – Autonomous Score Per Match – BMR AND CRD Events



PLOT 2 – TeleOp Score Per March – BMR and CRD Events

Photos

The first two photos below show the original design (coils) with discs in place and ready to shoot. The second two photos show the change to the robot with the addition of the hopper.

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