Prologue:

I found reviewing this document before posting it very interesting. A number of the things I worried about never became problems. A number of things I didn't worry about became issues. I look back now and laugh at some of the questions I had before I truly understood the game. I hope you enjoy this as much as I enjoyed writing it. It was actually quite a bit of fun and I looked forward to the end of each day when I could sit down and record my thoughts in a semi-organized fashion.

Team 1718 Controls Mentor Build Season Journal

<u>1/7/12</u>

Kickoff. The game is interesting. We sat down today and spent most of the day understanding the rules. There are very few rules, and that's encouraging. Early rules questions that were brought up that may be critical to the game later:

1. Can you use a device that touches the ground to balance your alliance ramp?
2. Can you block the baskets by getting on top the fender and extending blockers under them? My gut says no. Let's see if anyone asks.
3. Can you park your robot in your corner to corral balls that have been scored to play ball-denial?

Clearly defense is being discouraged, because the other team can force you to draw penalties if you drive too close to their lane, ramp, or key. It would still appear that a robot to clean up the garbage under the basket will be critical. Even though the GDC is discouraging defense, it seems like ball control / hoarding will be a viable strategy to slow the other team down if they've got top notch scorers. Auton is important. Coopertition will be critical in qualification matches.

Will balls be thrown through the feeder slot? Many people expected tubes last year to not be thrown. So let's look at last year. Why were tubes thrown last year rather than held? The answer to that question will probably answer what will happen this year… I'm betting they'll be thrown.

We'll start strategy tomorrow.

<u>1/8/12</u>

I helped build some of the more basic field elements today. Craig had already picked up the material and ripped it, so assembly went quickly. Seeing how small the bump really is was very educational. The bump will definitely be faster than ramps, especially with larger wheels. We'll consider pneumatic wheels to lower landing shock.

We played a couple games in the gym on the basketball court. Dimensions aren't really too far off the real game, so it worked well. NBA players hit 40-50% of their shots. We definitely do not have anyone who belongs in the NBA. Robots will probably do better from the key, but is it really worth stopping there? Why not just drive up? There may be some defense, but shooting will be much easier….Driving up will block the vision target (if vision is effective this year) so a mechanical aiming device (like the line-up devices for the mini-bot poles last year) may be effective. It seems like you could user the lower vision target to line up on the bottom to shoot in the top if you were a close-only shooter.

Robot placement during a match will depend on how balls get thrown in-bound. If balls are thrown, then 2 robots in the offensive zone and one in defensive zone seems appropriate. If balls are not thrown, then 1 robot on defense, 1 traversing the field for balls, and the last playing cleanup in the offensive zone would seem to make sense. I'm going to sit down and do a time study for each, including lost balls and defense being played. I really want to know the answer to how this game is going to come together. The difference here is bridge utilization. Will they be busy? Focus on using the bump?

Hybrid – a good team is going to put their balls in and get more from the bridge, and put those in too. How do we make sure we only get 3 additional autonomous balls if there are more than that on the bridge? That's a toughie. Perhaps we just push that down…. We'll have time to pick the balls up before the other team moves to our zone.

<u>1/9/12</u>
Build site meetings went well today. We listed every aspect we thought was important to the game this year then sorted them into needs, wants, and "perhaps".

Needs (Must Have)			New Ranking	
1	Reliable Drive-Train	12	12	
2	Auton Scoring	10	11	
3	Shooting Consistency	9	10	
4	Maneuverability	9	9	
	never-more than 3 balls	9	8	
	Targeting System	9	7	
	Top basket shooter	8	6	
	Picking floor balls fast	9	5	
	Steady on the ramp (Drive-train)	9	4	
	Cross Bump quickly	8	3	
	Pushing Power	8	2	
	Cross Ramps quickly	8	1	
Want (Should Have)				
2	Three robot balance	8	11	
	Retrieve/control more balls (auton)	7	10	
1	Defense	8	9	
3	Multi-directional shooting	8	8	
4	Shooting long Distance	7	7	
	Coordinated shooting(auton)	7	6	
	Steady on the ramp (Balancing mechanism)	7	5	
	Shoot from lane	7	4	
	Speed	6	3	
	Feeding other teams	7	2	
	Shooting Short	7	1	
Like (May help)				
	Human Scoring (endgame)	3	8	
1	Three-level shooting	5	7	
	Hybrid auton	4	6	
3	Score more Balls(auton)	5	5	
4	Take balls from feeder	5	4	
2	Dunking	5	3	
	Collect missed shots (auton)	3	2	
	Picking up from both sides	3	1	

Weighted Objective Matrix

Weighted Objective Matrices worked really well to sort out chassis orientation and wheels. No surprise, pneumatic tires won out the day. That will be a learning experience though. How much air pressure? Will we hop? 8 inch wheels are nicer than 6 inches for the bump though.

<u>1/10/12</u>
We broke into small groups today and each designed a robot. Then the team members presented them to the group as a whole, and we distilled out ideas we liked. A pro/con list helped narrow that down. Still need to discuss turret. That worries me a bit – 09's turret shook the camera like crazy and made vision difficult. Bearings and components made on a CNC will help. I'm scared of vision – our sodium shop lights made the retro-reflective terrible last year so we didn't use it (it wasn't necessary). Hopefully the ability to do shape recognition in conjunction will help. It's suggested to use small flashlights to light it up. Field setup will start tomorrow, and I'll have the controls guys get a vision target up.

I checked the CAD on the '09 bot and it looks like it will fire basketballs with minor modifications. I'll pull it out of mothballs tomorrow and check. It will make a nice training bot for the drivers for the first couple weeks if it works.

The '09 bot is tested with the new balls…

The bridge is here for the field…. And it doesn't balance nearly like they claim it should. Craig is ticked, because we made it to print. Double checked it… on to improvising. Perhaps we'll use surgical tubing to get the balance correct. Ours is much less stable than the ones in the videos using the battery test. Dear FIRST – stop measuring lumber cuts to the hundredth of an inch.

Our controls list continues to grow. The kids need to learn velocity PID control to control the ball launcher accurately, finish the text scripting system they've puttered around with for hybrid, and get a vision test station running. The new laptop for the driver station is a definite plus. No more carting a full size desktop to the field! I wonder if normal encoders will work at the speeds we're talking about? Rough calculations on Chief Delphi said 40 feet / second. A 6 inch wheel is 18 in diameter, 1.5 feet, so about 28 revs per second. Note: Check standard encoder specs. How can we attach an encoder to P90's? We won't need encoder resolution for that speed…..an endless turn potentiometer might work. Off to Digi-Key to read specs on them. 28 rps = 1650+ rpm. Internet is down. I'll come back to this.

It’s so tough keeping the kids involved. Focus is tough in these long design meetings. The younger ones tend to get drowned out by the voices of experience, but we need full team buy in on the robot. We were pretty successful today – having the smaller robot design groups helps the younger kids to feel more comfortable speaking up. We’re 4 days ahead of last year. I’ll probably be sorry I said that come tomorrow.

We’ve hammered out more specifics on the bot design:

Ball Launcher		Spinning Wheels	
Pro	**Con**	**Pro**	**Con**
Distance	Accuracy	Slight turret/aiming	
Easily serviced	Routine maitenance	Simple	Less accurate
Some experience	More difficult to feed	More controlled shooting	

Pro-Con list for some of our potential design directions.

<u>1/11/12</u>
The field is 90% built. We’re going to set up a camera and start programming the vision a bit. We’ll play with some different ring lights. Greg from NI posted a set from SuperbrightLEDs that seem likely to work well, as well as a nice whitepaper. We need the vision targets finished first.

We reviewed basic Newtonian physics with the mechanical so they can learn the basics and determine shooter speeds, RPM, etc. I worked ahead and it looks like an FP through a DeWalt gets us in the right ballpark. Perhaps we’ll look at using timing belts to reduce vibration and weight.

I need to dust off the picture-write VI that we posted to CD 3 years ago so we can take pictures of the targets at each end of the field during a practice match to better tune the camera to each field.

The pneumatic tires look promising, but we hate the routing of the valve stem. It makes having dual sprockets a dicey proposition if you want to adjust air pressure. It also worries me how far the sprockets are offset from the hub – we’ve had bolt breakage issues before in situations like this.

We’ve determined maximum distance to shoot is from just beyond half court. I question even doing that accurately. Balancing on the ramp with multiple robots is very difficult. I hope people are thinking about a way to stop their bot from rolling, like drop down brakes. We’ve been talking about a low crawler gear so we can push the other robots up the ramp. I’m a bit concerned about how slippery the poly-carb is going to be. If we had more experience with treads, this just might be a game to consider them. They’re tough to get right though, and we’re not going to learn them during a competition season.

The kitbot is moving slowly. We should have it mostly together by the end of Friday so we can drive a bit and get used to the weight distribution. We need to get these pneumatic tires tested soon. Turning is still a question mark.

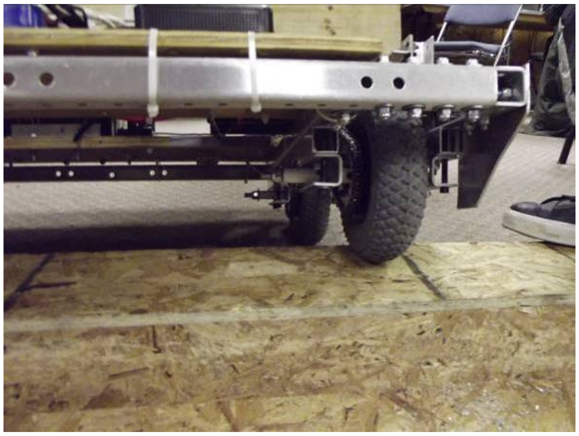
1/12/12

Velocity PID's! Thank you Jared, from Miss Daisy on Delphi! PID's for position are easy. PID's for velocity are a bit harder. He did a very nice derivation on Delphi that helped me write our first velocity PID. I wish I had stumbled across that post when we were working on traction control in 2009. We'll definitely need this for accurate shooting.

1/13/12

Friday the 13th. It wasn't a bad day… The kitbot is done and moving. We got to see what 6" pneumatic wheels do when they hit the bump at speed. Of course, we may have a solution to that in a wedge that allows us to slide the wheels up to the same level as the bump (at full speed I hope).

In true Friday the 13th style, something bad had to happen. Our new D-link for the robot got toasted when the power polarity was wired in reverse. We cannibalized the 2011 one for now, and put a new one on order.



The kitbot at full weight with pneumatic wheels and front lead-ins. Too bad it didn't turn well.

1/14/12

We spent a lot of time focusing on the ramp today. Possible solutions to the three robot conundrum:

1. Turn the front ¾ of your robot into a ramp. Problem: angle of the incline is close to tipping other robots, driving with another on top of you will be very hard, the bridge swinging may lead to disaster in this configuration.
2. Drop a plate 14" out from the front of your robot and let another robot drive on it. This may allow you to stick the front end of your robot off the end of the ramp. Perhaps we can lower an L-bracket and stick it under their bumper or frame to stabilize us.
3. Use sensors to watch when you drive the front of your robot up to the end, and automatically fire pneumatic brakes down onto the bridge. Brakes look like they will be a must-have anyway so the drivers don't have to try to keep the bot motionless.
4. A bar that will help tip the bridge once you're on it.
5. A hook to grab the robot behind you to steady your own robot.

Our best success came from putting the robots nose to tail. The back robot pushes, and the front robot stops the group once they're on the ramp.

Here is some of the basic math we used to start ballparking things:

Calculating Required Ball Release Speed

Target Height: 120 inches
Top Basket: 98 inches

Release Height: 50 inches
Release Angle: 45 degrees

Distance: 360 inches

1) **distance_final = distance_initial + velocity_initial*time+1/2*acceleration*time ^2**

120	=	50	+	Vy_I	* time + 1/2 *	g	* time ^ 2	

2) **Velocity = Distance / Time**

Vx =	360	/	time	
Vx	=	Vy		
Vy=	360	/	time	

3) **Velocity * cos(45) = Vx**

Substitute the Result of 2) into the Result of 1)

120	=	50	+	360	+ 1/2 * g * time ^ 2
70	=	360	+ 1/2 * g * time ^ 2		
-290	=	1/2 * g * time ^ 2			
-580	=	g * time ^ 2			
1.501035	=	time ^ 2			
time	=	1.225167	seconds		

Using the time, we can calculate Vx and Vy (the same since it was launched at 45 degrees)

Vx =	360	/	1.225167
Vx =	293.8374 inches / second		

Using 3), we can find the initial required velocity

Velocity	*	cos(45)	=	293.8374
Velocity	**=**	**415.5488 inches / second**		
or				
Velocity	**=**	**34.62907 feet / second**		

Basic Calculations for Shooter

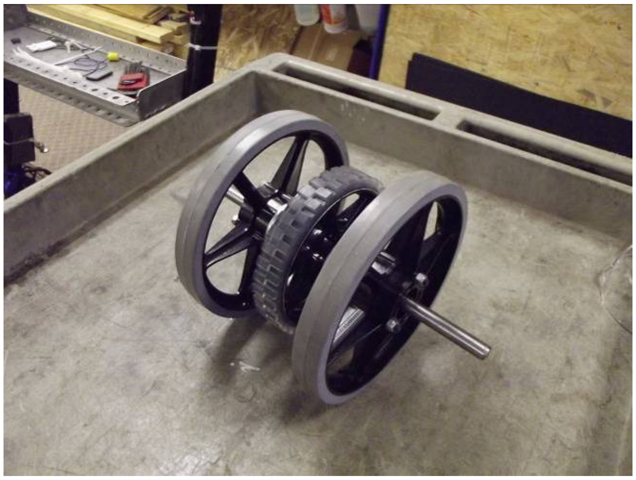
I'm growing worried about weight. 4 CIMs to drive, 2 fish to shoot, 2 Banebots for vertical conveyors, Banebots for horizontal (or AM FP-like 550 to avoid Banebots), AM PG71 for turret and another for cowl movement. That's 11 motors already, and we haven't talked about the balancing / grip mechanism for the ramp. Add in sensors and lights for ball information and we're talking 2 digital side cars and a whole heap of transmission weight. A bit of math that we did on the shooter:

Launcher	
Required Linear Velocity:	415.5488 inches/second
Wheel Size (dia):	6 inches
Roller/Wheels:	2
Circumference:	18.84956 inches
Rev / Second:	22.04555 rps
RPM:	1322.733

That's with powered wheels top and bottom. Double the required speed if you have wheels only on the bottom of your launcher. Backspin will be very important – it will give you an error margin for hitting the target. If you have enough backspin, hitting anywhere above the basket should result in a score.

The question of height has not been answered yet. How short can we be? I've been avoiding it, but I think it's time to put pen to paper and start hacking out some of the CAD. Just to make myself feel better.

The kids are building a modular shooter that allows them to modify compression easily. They're also discussing different wheel configurations and sizes. One configuration seems to be winning out – it's two eight inch wheels on the outsides to guide the ball to the center, then a six inch wheel there that does the actual work.



Pi's shooter. The center wheel was changed to non-treaded later.

<u>1/15/12</u>
It's Sunday, and I'm uploading the website as we speak. We have a new web team who have been working hard to get up to speed. Unfortunately Ford locks down their corporate system pretty well, and access to FTP ports is a definite non-starter, so all our uploads have to be done from elsewhere.

There is so much content to create! The basic framework is done. We made a lot of progress in the off season, but the amount of information in FRC is a bit daunting.

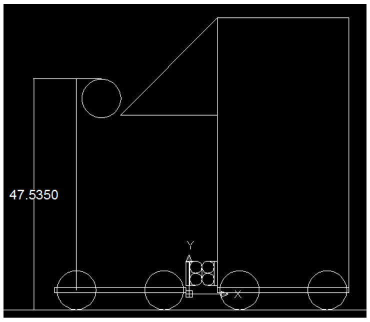
I spent some time creating the competition code template in LabVIEW and adding in some of our standard things. We spent the preseason creating a scripting system for autonomous, as well as a text file input for all our constants. Never again will we be stuck at world champs trying to download code on the field. From now it's update a constant or two and double-click our automated FTP script to dump them to the robot. The robot will auto-check those files for updates every time the code comes out of enabled or is started up.

<u>1/16/12</u>

MLK day, but we still had a meeting. I had to leave early due to personal issues, but it sounds like the team made some good progress. Prototyping started hot and heavy. We joked about 22 motors, but right now we stand at 13. Unlucky? We'll see. With some careful thought we figured we can fit the motors on a single digital sidecar between the relays and the victors.

I saw an email today about our kitbot suffering an 'accident'. I probably don't want to know…

Two minutes of CAD tell me that we need to have the top of the ball at about 48" to shoot over a 60" bot using a 45 degree angle.



Pi robot height, designed to shoot over teammates in hybrid.

<u>1/17/12</u>
Another prototyping meeting missed.   I spent the day at home thinking and playing with the vision programs. I also updated some of the web pages.

On another note, how awesome is it when you have open access to the folks who create these systems for us? I had a question for Greg from NI, and had an answer (and an email from him at home) in an hour. Incredible.

I took the vision example out of the robot framework and set it up to allow me to load files from the hard-drive. This will come in handy when we get to the competitions. We can take pictures with the webcam on the field, then calibrate everything in the pits. It worked well in '09, even though we never used the camera system that year.

I also spent a couple hours today thinking through the ball problem. We want a wide ball pickup, but we don't want to take a penalty picking up too many balls. Our solution is to create a ball counting system that keeps track of the balls in our possession. One sensor in the vertical chute will allow us queue up 3 balls, but what happens when we have 2 balls in the vertical chute and two balls enter the front of the robot at the same time? I started looking at photosensors, but to detect 2 balls, you have to look downward at the floor. A sideways through-beam will only see one "break" if 2 enter at the same time. Unfortunately, looking down forces us to use a diffuse beam.   The majority of those sensors are bordering more expensive, and also have ranges under 2 inches. If we only catch the edge of the ball that goes by, it may be 3-4 inches away from the sensor (because of the curvature of the ball). Ultrasonic sensors have a nice wide beam, but most can't read close in. Then on a hunch I pulled up a Vex ultrasonic sensor after I ran out of Sharp IR rangefinder options. Bingo! The Vex reads from 1.5 inches out. That's perfect, and the beam is also wider than a laser or photo switch. Two downward facing ultrasonic sensors spaced so they can't really see the same ball is perfect. We'll ping them alternately to get around interference issues.

In the middle of this, my wife asked me if our burps contain methane in trace amounts. This is the danger of having a wife smarter than you: you end up on the internet reading about cow burps, and how 10 cows can heat a small house with their burps over the course of a year.   From the business mentor while proofreading: No kidding, that's how the barn was kept warm all winter with 50 cows inside!

I suspect we can use an ultrasonic sensor on the vertical conveyor too. I asked Craig to put in the order for 3 of them. If the tests pan out, we'll order another 5 for the practice bot and spares.

Tomorrow: create a proposed wiring scheme and start working on a control system. Automation is nice, but they'll need a way to adjust speed and cowl angle, and gamepads aren't suited to that. Perhaps there's another gamepad out there with a potentiometer dial or two on it. Time to check!

<u>1/18/12</u>
Well, the mechanical guys solved a problem for the controls team. They narrowed the ball entry to only 1 ball. We'll keep the ultrasonic sound sensor there for the ball counting system. We've never managed extensive automation before without issues. The kicker in 2010 was fairly complex. I encouraged the controls team to think about asking themselves how it can go wrong – list every way, then plan for it and correct for it now.

The 2010 bot suffers a fate worse than death as it's cannibalized for parts.

Motors! Yes, we have a lot of motors available this year. If only they were actually available. Of the 3 most powerful motors, only 1 is truly available: the CIM. The 775 has a horrible quality track record. The powerful fisher price is unavailable. The 550's are available, but I really want that extra 20 or 40 watts for the shooter that the FP's would provide.

1/19/12

Yesterday it was motors, today it was transmissions. All the Banebot transmissions utilizing the 5:1 material are out of stock until after competitions end. Currently, the long shafts for the Toughbox minis are out at AM. The CIM-Sim's are out as well. Are other teams thinking the same way we are? The CIM-Sims with 775's in them (very slight modification) are nearly the perfect ratio for consistent key shooting.

The chassis is starting to be welded, but the lack of a true CAD mentor this year is hurting.

On another note, we won't be using pneumatic wheels. Once we saw how poorly the wide bot turned with 4 pneumatic wheels at the corners, we tossed them. We'll go to Plaction wheels, but that makes going over the bump a bit harder with our current chassis design. We could go to 6 wheels and actuate the middle to go over the bump, but actuation would cut into our weight when we're already worried about it. 6 wheel Plaction it is, and we'll stick to the ramps.

1/21/12

We switched the kitbot wheels to Plaction and it handles beautifully as expected. That finalizes our drive base. It's fairly pedestrian, but it's solid and quick. As a bit of a departure from the norm, we're going back to using 35 chain this year. Last year, due to a weird set-up with 5 sprockets needing to be aligned, we lost our 25 chain in 4 different matches. That left a bad taste in mechanical's mouth. We've had rock solid 25 chain in the past when each run only touches 2 sprockets, but better safe than sorry. Perhaps we can sway them back to 25 next year.

1/23/12

More decisions solidified. Black Neoprene O-rings and polycord for the conveyors is a go for now. We'd like to switch to O-ring belts for durability and longevity, but I'm doubtful we'll be able to do it until after the robot is built. We usually have too many on-the-fly changes to buy belts at a fixed length.

We're use 1.5 inch PVC for the rollers. We'll put the front one under a 1' x 2' aluminum beam to protect it from impacts. We had some nasty luck with the 2009 bot getting it's roller broken.

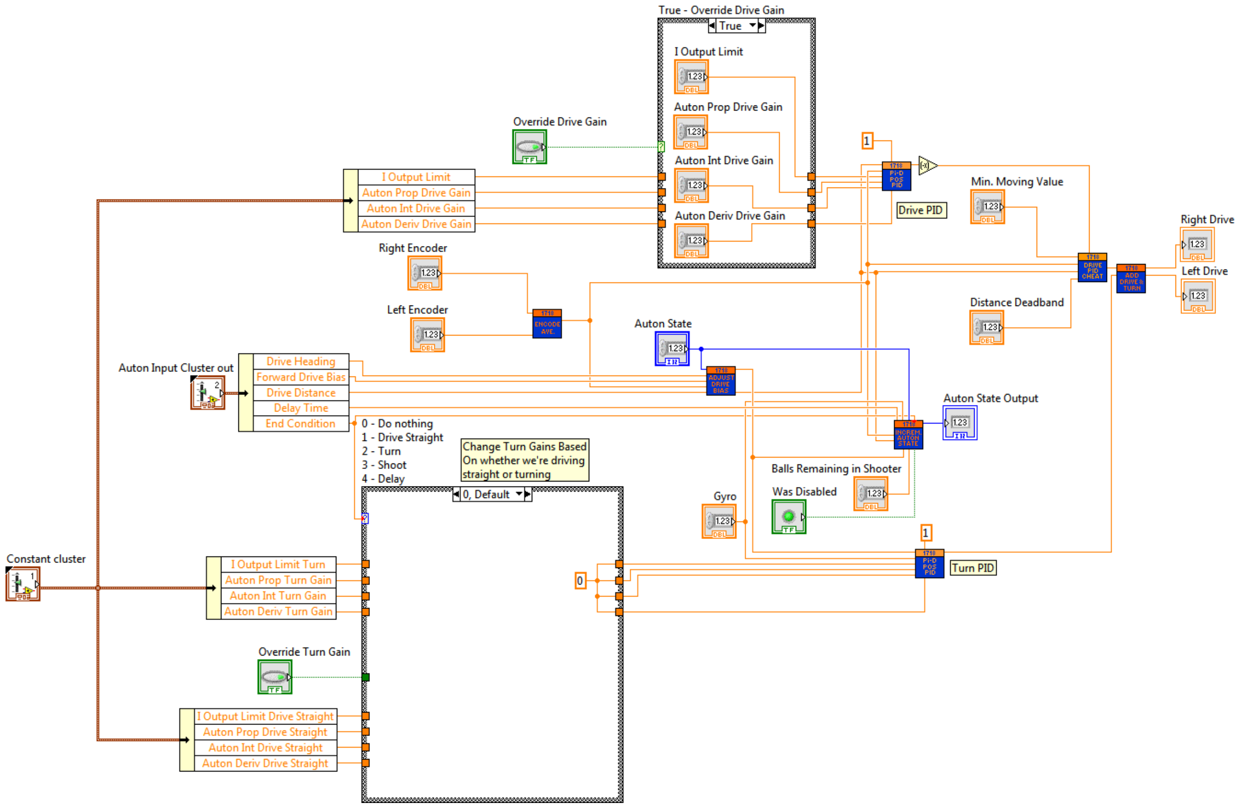
Last time we did rollers we did through-axles. They were heavy and were a bear to align and insert. This time we've got a neat idea to use 1/2" bolts with the threads turned off the last 2 inches. The roller bearings will run on the non-threaded part. That will make changing them out and servicing them much easier. (After-season note: we went with through axles again because we didn't have the machining time to make this dream a reality.)

We also got the Ultrasonics from Vex in and working. They are much more accurate than the MaxBotix sensors in analog mode, and work down to 1.5 inches accurately. They occasionally flake out and give a reading more than their maximum. I had the kids think about our useful ranges of measurement and then write a VI that averages the last 2 readings to filter noise, and throws out any value that's over what it could possibly be (10 inches to the floor with a sensor installed and pointing downward). It should work nicely. The conveyor code is done and we tested it using indicators.

1/25/12

Due to our CAD struggles we will be installing electrical components on the fly. We're not going to be able to lay out the electronics in 3D. The camera is up and running and we're playing with adjusting the vision. It locks on well enough, but it's pretty CPU intensive. I'm considering using white light to improve the contrast of the target, and then using grayscale image processing. Trying to use colors hits the CPU pretty hard, and we don't have the expertise to write a custom driver station communications system to send data back and forth.

The autonomous scripting system seems to work in LabVIEW. We'll need to test it on the kitbot. We also need to test the velocity PID. We can do that on the kitbot drivetrain. The kids need to get the gyro wired and in a project box ready to use. We'll need a second identical one for the practice bot.



Hybrid of 1718. So flexible this year, and never changed once after week 1.

I'm seeing some complaints about maxing out the CPU on the cRIO on Chief Delphi. We'll have to do a lot of optimizing. I remember putting the set-speeds in an if/then that checks if the speed was changed can lower CPU. What happens if a set-speed is not called for a loop?

<u>1/26/12</u>

Turn code is done. The base turret code is easy – PID loop connected to the camera center pixel. I don't like the method used to determine distance. We're dumping that in favor of using the height of the top target to find distance.

I've been thinking quite a bit about targeting. Are we really going to shoot from anything other than straight on? If we need to we'll need to aim off-center from the target. I've been thinking about this since the game was introduced.

Once we have a functioning velocity loop that can hold the shooter speed where we want it, we'll shoot at different speeds and record the distances. Put it into excel, pump out a polynomial trend line equation and we'll have our distance algorithm.

<u>1/28/12</u>
The base chassis showed up today welded. Wheels are on, transmissions are on, some chains are on. The chassis warped a bit during welding, but that's nothing a bit of determined bending won't fix. We discussed the comments about people having trouble rolling up on balls with their bumpers. We hadn't considered it, but a quick bit of CAD shows a sweet spot between allowing your bot to climb the ramp and not allowing a ball under a bumper. I wonder how many bots that cross the bump (so by necessity will likely have their bumper at or just above the diameter of the ball) will have issues driving onto balls? Come to think of it, probably not many. This isn't the multiple-ball game like '09. The menu for tomorrow is gyro function, CAD the bridge lowerator, make sure the turret is nearly done CAD wise, then make sure the kids are moving on building the rollers. They're pretty close to done on a lot of those items. I'll get some white LED rings ordered as well to test contrast versus color, and have the kids finish making the 3 other vision targets for the field.

<u>1/29/12</u>
Design change. The double front roller is gone, replaced by a single for weight and simplicity's sake. Controls is working on the changes, they really aren't bad. They're also working on the ultrasonic counters (still). The example works fine, but they're struggling to integrate it.

Mechanical is working on both the practice and comp bot at the same time. This seems to be a much better system than what we did last year where we built one robot then the other. These two robots are going to be far more similar.

We're on track to be done at the end of week 5, depending on the shooter transmission. The kids are building confidence (they're scared to commit things for fear of making mistakes) and it's cool to see it happening. I saw the bridge lowerator today in 3D for the first time and watched Michael animate it. Awesome.

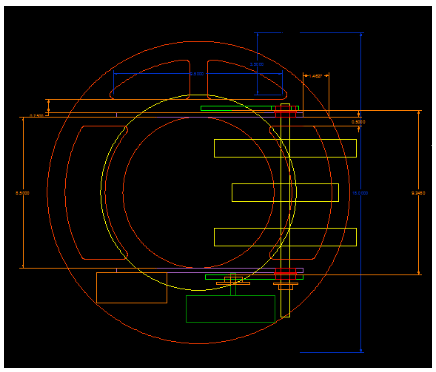
The web page is coming along well. We've got a few bugs, but I'm going to leave them until we're done adding content. The last week will be for running through the online compliance tools, and testing in every browser we can download to insure compatibility.

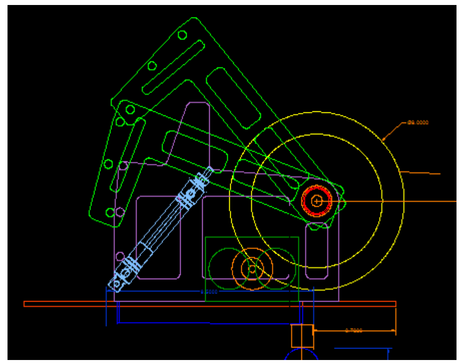
<u>2/1/12</u>
White LEDs worked pretty well today for the vision target. They are brighter than green, and using the white does result in a very nice contrast.

The kids have the ultrasonic sensors working and have programmed a counting mechanism. CIM-Sims are here. I wasn't as careful as I should have been on checking tolerances. Using the 775's in the CIM-

Sim negates the possibility of direct mounting an encoder to the transmission. The 775's are larger than the fish the transmission was made for. They also overlap the bearing, so I'll have to make spacers.

2/3/12
I took the 2D prints of the turret over to one of our CNC shops. He's not busy, so he thinks he'll have it programmed by Monday and cut by Wednesday. I spent some time doing more lightening work on the drawing.


Top View of 1718's Turret.

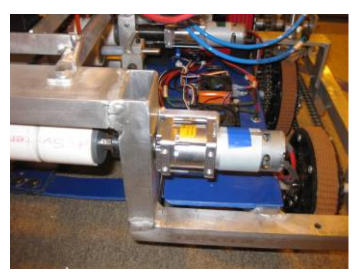

Side View of 1718's Turret.

Pneumatics! After a discussion about the hood design on the turret, we agreed a two position hood should be workable. That means pneumatic actuation, which thankfully gets rid of a motor up there. Including pneumatics there means we can use it to lower and raise the lowerator too. In addition, we can use it for our braking system for the bridge. That's three motors and controls gone. That will save weight, and the pneumatics is a much better fit because all three require linear motion and mechanical won't have to deal with cams and lever arms.

2/4/12
We had one of our rookie teams over today to work with us. Controls taught them programming and we helped them with their kitbot. We actually gave them our competition chain tensioners to get them up and going more quickly. We'll make more. They're coming back again next Sunday and want help on their bridge lowering mechanism. Do I dare tell the rookie team that ours isn't done yet either? Ha!

An order is placed for the material we need to make the front portion of the lowerator. We're considering dual path – ¾" thick poly-carb lightened where it needs to be, and ¾" polyethylene in case the poly-carb chips and proves to be too brittle. I want to pound this thing into our practice ramp to prove it can take a beating.

The vertical conveyor frame came in today. The kids worked hard with our mechanical lead Craig and got a big portion of the rollers and vertical tower done. The motors are all assembled to the P60 transmissions. We got lucky and it looks like our gear ratio estimates were dead on. We'll be able to direct drive the rollers. That will save weight on sprockets and chain runs.


Direct Driving the Front Roller

I noticed a discussion on chief Delphi about using the solenoid breakout to power LED's. That'll be a nice change from spikes.

I've been kicking around how to improve driving on the bridge. You have to constantly fight to keep the bot straight. We can fix that a couple ways. First, a crawl button that runs both drives with a PID loop at the same speed. Second, a gyro on its side that measures the robot tip angle and automatically applies drivetrain power to keep it in place. Third, a pneumatic break system that clamps the wheels, so when the driver isn't applying power the robot won't roll at all. I think we can tie this all together through controls and make the bridge a much easier place to be.

2/5/12

Today I ordered the cylinders for the hood, bridge lowerator, and brake system. I also ordered spare LEDs for the camera, potentiometers for the turret, and encoders for the shooter. I ordered additional CIM-Sim pinions because the tool room bored ours slightly oversized and I don't trust Loctite, along with the flanged bearings for the shooter.

I felt like we were doing well – right up until I talked to our outside machine shop. They won't be able to make our turret plate, side plates, and adjustable hood. So I scrambled around talking to some of our rookie and past rookie teams. They were nice enough to get me in touch with their CNC sources. However, the big breakthrough was when the Ford tool room agreed to throw it on their CNC. It's going to put us 3 days behind our 5 week finished-robot schedule. Darn it all.

Mechanical is off welding. Tomorrow's plan is ambitious. We need to get both robots completed wired and pneumatically piped. I'm going to dig through the code the kids have written and integrate it into one project while I look for any potential hang-ups. Everything works theoretically……

I keep looking back and wondering if we've missed something. Should we have worked on a balancing system that can push on the floor to help balance the bridge more quickly? Should we have gone with a catapult to remove ball inconsistency? Should we have gone with a long configuration and a front-loader or wide-roller? Will our wide configuration result in us tipping? Will the game end up requiring teams to go over the bump?

I guess this is a sign of how well designed this year's game is (so far). I really didn't have any of these questions in 2010 and 2011.

2/5/12 Addendum

I just opened the code and started looking through it and debugging. Imagine my surprise when the first sub-vi I had to open had the Eye of Sauron as an icon. Oh god, what have they done?

2/9/12

The electronics are fitting in nicely. Pneumatics are going to be here next week. That's unfortunate, as it means we'll be finishing up the robot with only a day or so of coding under our belt (on the actual robot). I'm a little upset that Bimba's 'free' cylinders are going to take 3.5 weeks to get here from the time we placed the order. It's good to know that they're that slow. In the future, I'll order a set from McMaster just to build the first one (they're stainless from McMaster, but who cares for the first build).

We've had our 2010 robot in the room using it as a dummy, making sure the camera code can lock on. We've checked most of our code, but not the stuff I'm integrating. That should be finished tonight around 2:00 a.m. Putting together our conveyor code, our turret code, our autonomous code, the scripting files, and the text files that are read in for all our constants will have to be debugged. We should be able to download code onto one robot this weekend, but it will be with no turret.

Machining on the turret pieces is progressing. It cost us 5 days when our first machine shop had problems. That's a tough 5 days to swallow. The turret plates will be done tonight, and we'll weld them either tonight or tomorrow.

The CIM-Sims make me a bit nervous. We modified them to put 775's in them. That included boring out the pinions (which were over bored by my tool room by accident and are now held on by Loctite and .001" shim stock), and turning down the shafts (which damaged the keyways). This is one of the most critical components on the robot, and they've been nothing but trouble – and we've only powered them up to break them in! Yikes. They sound like they're full of marbles.

3539 is moving along well. They borrowed our lead screws. No idea why. I'm interested to see what they'll use them for – perhaps manipulating hood position?

<u>2/11/12</u>
More good work. Wiring, wiring, wiring, and controls, controls, controls. A ton of work happening on mechanical too. I love this part of the build season. Parts coming in every day, and all the kids busy on everything you can imagine.

The web team started with 700+ errors. They're down to around 100. Wonderful work by them, and especially by Scags.

Mechanically, the turret will be machined tomorrow, then I need to drive it to Craig so he can do the welding.

Dean's list is tough this year. We have a lot of good students.

The Richmond rookie team stopped by again. Their kitbot was cruising around. We gave them some 35 chain sprockets to get them to 6 wheel drive. We also worked with them on a bridge lowering mechanism. We'll give them a couple CIMs next week since they're going to be primarily a defensive bot.

We're in a bit of a room crunch controls-wise. Not for the actual components. We're out of room on our digital side car for PWM's, Solenoids, and DI/O. I did some rearranging to fit everything. I had to move our ball counter light system that's going on the turret onto spikes instead of solenoids. I was enjoying the thought of not having to wire an additional two spikes and including the weight, but oh well.

We weighed the robot today. Everything is on except the turret, guarding, and pneumatics. We're 40 lbs. under. That sounds like a lot, until you add 5 pounds for the shooter motors and transmission, 3 pounds for the turret turner, approximately 15 pounds for all the turret components. Add in 5 pneumatic cylinders, the braking system…. Ack. Once again, we're going to be right at 120.

2/13/12

We designed the brake system today. The machining for the turret is done, so tomorrow we can either drill and tap it together or weld it. Mechanical will figure that out. The pneumatic solenoids are nearly mounted on the comp bot. The motor for turning the turret needs a mounting plate. The ultrasonic sensors have mounts, but I don't want to put them in place until we can test them out. I'd like to see if we can move the ball by a sensor at the max speed of the conveyor and map the profile of a ball, then use that profile to watch for balls. (Note – never found time for this during the season, thank goodness. It would have been overkill for something just meant to count balls).

Looking at the turret plate made us a bit nervous. We left an 8.5 center hole in it for the balls to pass through. The balls we have don't run more than 8 inches in diameter, but what if they do? After all, the tubes last year were a fiasco – we spent an entire elimination tournament unable to pick them up because the field officials decided to 'refill' them just before the elimination rounds and ended up drastically overfilling then. Even after complaining they still had some that wouldn't even go through the feeder slot. I hope we're not setting ourselves up for another problem here by hoping the tolerance on the balls will be less than +.5". We'll see.

The comp bot will be fully electrically tested before we bag it, but I suspect the majority of the development work is going to be done on the practice bot, then transferred over and tested during one of our unbag windows. We'll be meeting every day and continuing to work on the wiring. I'm still waiting on delivery of the 1 1/16" by 10" travel cylinders for the bridge lowerator. I don't think we're really waiting on anything else to arrive…. It all comes down to hard work to hit our target.

On another note, Chief Delphi had a bit of a buzz around whether you can park on the poly-carb under the bridge. I think they will rule against it. It doesn't seem to me to be in the 'spirit' of being on top of the bridge, which I assume is what the GDC wants. On the other hand, making a ruling this late in the season that could invalidate a team's design is pretty crummy. I'm torn on the issue. "Trolling" the bridge. Ha, I love it.

2/14/12

The brake brackets came in and were mounted and look good. Turret components are all finished and being tack welded – we should have something tomorrow. Website got another round of polish fixing grammar and typos again, along with getting it validated to WC3. Now we'll just continue to add content.

Team 1718's finished front page. Scags, our web lead, rocked this thing!

The Bulldogs stopped by.   They've decided to hold off on a turret for now so they can have a working robot. I think we'll have our turret done, but there are some problem areas that we may have to correct during open bag.

The Richmond rookie team was at our facility again today and probably will be through the end of the season. They don't have access to the tools we do, so they are making better progress working at our place. Their bridge-flipper downer is in pretty good shape, and I think we might even put a ball scoop on the robot before we're done. We'll see.

We're still waiting on the 'donated' Bimba cylinders. I ordered them the same day I ordered some that I paid for. 10 days ago. Just got the ones I paid for, and we're still waiting on the 'donation' ones. I can't say it gives me a warm fuzzy.

The ThunderChickens wiring mentor stopped by today. It's odd to be so close to other teams that we have kids on our team whose parents mentor other teams. I pumped him for info, but no luck =). I wonder whose team he has to cheer for when we play each other?

I still think we might be missing the boat on some sort of bridge stabilization device. We have numerous places we can take weight out of the robot right now, so if someone comes up with some sort of groundbreaking 'must have', we'll be able to adapt and possibly add it. Not being able to hook under the bridge (because that would be grappling) means that a lift mechanism has questionable utility. I think….

PS – bridge trolling is a no go. No surprise there, but there were a couple upset teams.

2/17/12

Wiring is mostly done. I hope to power the robot on tomorrow. We fired the shooter a couple times and it seems fairly consistent. We've got a hitch where the vertical conveyor passes the ball off to the turret shooter. We'll get that solved. Weight is at 111 pounds. We may need to do some cheeseholing. We've got a couple very beefy steel sprockets we can turn down too. We normally sit down and make a list of where we can lose weight, but I don't think we'll need to go that far.

If we can power up, we'll do all our standard motor tests, then get to work straight away on the conveyor logic verification. I'm anxious to see if we can count balls the way we want to.

We don't have the thin Lexan we'd like to have for the guarding. Originally we planned on using foamed PVC, but it's a touch heavier than Lexan. We have some corrugated poly-carb, but frankly it looks a little cruddy on the robot. Perhaps we can paint it.

I'd like to pull the air tanks and the rollers and get them painted, but there's no time. (Note: it's a good thing we never had time to do this. They were forcing teams to replace all painted pneumatic components because they consider them 'modified'. Come on FIRST, let's stop being ridiculous.)

On to the shooter performance. When we checked it today, we could shoot from the far side of the bump with consistency, but just barely running from a battery. That means in competition, we won't be doing it. Too many other battery draws. So we'll have to concentrate on making it accurate from the key.

2/20/12

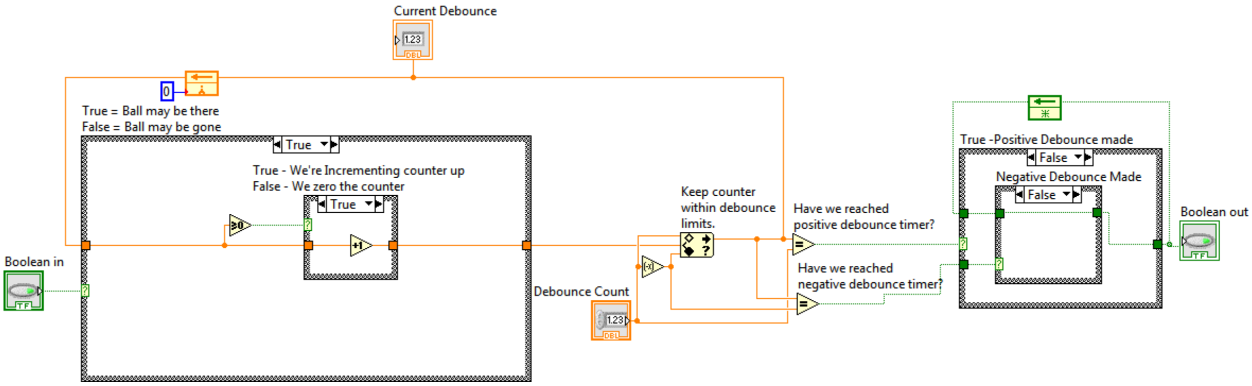
What a weekend. No sleep. The comp bot is moving now. All the electronics are working. The ultrasonic sensors were a headache to get going because they were plugged in both backwards and inverted. Pneumatics are functioning, turret is rotating, potentiometer is counting, and high speed encoder is working for shooter. Tomorrow we plan on going out and ramming the bridge lowerator into a bridge with people sitting on it. Let's see if it works or not before the first competition, shall we? We proved it in concept and tried a prototype, but I'm a little worried the angle of the pneumatics is only giving us a fraction of the force. The pneumatic mounts 4 inches above pivot, and we're contacting the bridge 12 inches from the pivot. The pneumatic cylinder is a $1\ ^{1}/_{16}$, or around $.5^2$ * pi, or ¾ square inch piston area. At 60 psi, that gives us 45 pounds * 4 inches / 12 inches, or 15 pounds pushing the bridge down.

We drove the robot around a bit today for the first time. We are extremely tail-heavy. That's completely our fault for not worrying about center of gravity. We worried about limiting height as much as we could, but we didn't pay attention to the front/back location of the turret, and now it appears to be biting us in the butt. We may move the battery forward to balance better.

We're right on the edge of weight, as usual. Tonight we weighted in at a petite 117 without guarding. Of course, we don't trust venue scales, so that is too close for comfort. Perhaps we'll go on a diet just in case. There are a few easy changes like steel gears we can lighten to save a pound or two.

We don't have sheet metal facilities or extensive machining capability. I would sell my soul for a water jet.

The counting system worked today. Our ultrasonic sensors combined with a de-bounce algorithm we wrote ourselves worked ridiculously well – far better than we had any right to expect. It now senses balls, indexes our vertical conveyor, keeps about 2 inches between each ball…. It's magic.



1718's simple de-bounce code.

We sorted a lot of the conveyor code out today. Some compromises forced us to remove the reverse ability on the conveyor – we had to attach some small pusher flaps to the rollers to move the balls between the two stages, and that means we can't back the conveyors up without tearing the straps off. Oh well – simplified programming and a simplified controller isn't a bad thing.

The first time I opened the conveyor code I found a Pokeball icon staring me in the face. Of course, I played along so I put a comment under it saying "Gotta catch 'em all!"

That reminds me, I need to order the board that 330's mentor posted from eStop Robotics that lets you plug in a pot easily to a USB port. I want to have a switch that has a simple adjustment – if the bot is shooting short in a match, then toggle switch the switch to add a small compensation, likewise if it is shooting long, they toggle switch the switch the other way. Perhaps that's wishful thinking – complicated controls schemes rarely work in the 2 minutes you have to score points. Bah – I'll order it anyway. If we don't use it now, we'll use it later.

<u>2/22/12</u>
I have to admit, this diary has helped me some to arrange my thoughts and remember what I had planned in the past. There's been a lot of progress over the last couple days, so much so that I haven't had time to update it. So, in no particular order…..

We tested moving the battery from the back of the robot to the front and it made a tremendous improvement. I just had a thought and fired an email off to the other mentors: our bumpers usually come in at 12 pounds or so. Why not bring them to the max 20 allowed by adding steel brackets instead of aluminum ones? That will help our COG. (Note – our final bumper weight was 19.3 lbs.)

The second thing we noticed is that our bridge lowerator wasn't doing the job. It tends to pop upwards when it hits the bridge. We have a couple of potential solutions. We can use surgical tubing to help hold it down. We can go to a bigger cylinder. We can go to a four-bar latching mechanism. We can reorient the cylinder positioning and attachment points to increase the down force on the lowerator.

The lowerator itself is an axe-shaped piece of white UHMW plastic. We hit it at a nasty angle last night, and it bent then sprung back. That's an unintended but very happy consequence of making it out of plastic.

Next - boy do I wish we had the weight to do a double-plated lowerator (one on each side of the robot). I wish it could serve dual function - ball funnel in hybrid when we lower the bridge, and bridge lowerator.

By the end of Worlds, our robots are beat to shreds. In 2010 during the Newton finals, most folks didn't know it but all three of our alliance robots were in bad shape. Our right toughbox had eaten itself. It was stalling the bot in turns, killing our maneuverability and speed and making it nearly impossible for the driver to aim the soccer balls. The CIMs after our 5 match 2 tie semifinal were so hot you couldn't touch them (mostly because of the drivetrain condition). Our pneumatic system had a leak - of all things to die, the pressure relief valve had sprung a leak from an extremely hard collision in the first finals match. The wings on our lift system were bent though still functional. We hate being broken on the field. So much so that we counted how many times we were broken in 2011, and still quote it. Robust, easily maintained systems are key to winning. Our drive train will NOT break this year.

I don't care for the angles I saw on our shooter. From beyond the bump, the 45 degree angle looked perfect. From a close distance, the 80 degree angle didn't look too bad. However, 45 at the key looked a bit ugly. The trajectory was too flat for my liking. That may necessitate a 3 position cylinder. I sure wish they had 3 position cylinders with the third position as a spring return. Hey Bimba, are you listening? Perhaps we'll decide we can't be accurate enough from beyond the bump. If not, then we can always adjust our 'far' angle to be for the key just by adding a hard stop.

We're running 2 inch compression on the balls. 2 Banebots 775's, though a CIM-Sim, then 23 tooth to 14 tooth sprocket. We are surprisingly consistent on angle and distance.

We did a 30 minute break in. The motors are all as cool as can be. Spacing the 775's away from the CIM-Sim plate added some much needed ventilation. The 550's on our conveyors are cool as well. The funny part is that the Banebots transmissions, 16:1 on the intake and 64:1 on the lift, are actually much hotter than the motors. That's some pretty horrible tolerancing (or profiling) on the gears. They're working though. (Note – by the end of the season these had broken in well and are silky smooth.)

The braking system works well. Because we are tippy right now, we 'slide' when the ramp tilts quickly from one side to the other. That may be fixed through our weight movement. The brakes are simple - two half-inch stroke cylinders push a 1x1" square of tread down on top of our drive wheels. You can still force the wheels to turn with the CIMs, but the wheels do not turn due to gravity when the robot is on the bridge. This is a nice compromise, because we know we won't break the brakes (ha) if they are engaged while we are driving full speed.

Our Pneumatic Brakes

Our sister team Romeo has been back and forth with us borrowing parts and talking. Last night they let us know they were struggling with the white LED rings. It seems that the vision was picking up the net (white) as well as the target. They are using Java, not LabVIEW. We'll have to watch this carefully. We tested and went with the white LED's because they are brighter and have better range than the green. We didn't see the robot locking on to the net at all - perhaps the pre-built LabVIEW vision is more robust than what they are doing in Java. I know it's certainly processor intensive.

A screenshot from Troy during a match using green LEDs.

2/26/12

The practice bot is wired and everything works.

We tested the bridge down device with another idea – a mechanical latch that works off another very short throw cylinder. It works wonders. The drawback is that we are lifting the front of our robot due to our COG in the back. It is what it is, but I'm disappointed. If I had my wants, we'd be redesigning with a lower COG, bridge flipper downer that collects balls, and a 6 wheel pneumatic drive. We'd never make weight unless we found someone who can do sheet metal for us, but it's a dream, right?

We can get over the bridge, but we aren't as fast as I'd like. The mechanical lead and I discussed today how we can go over the bump. Remove the middle wheel from each side, add skids to the underside of the bumpers, and we can do it. However, we've agreed to make that decision after we see the matches at Kettering. He maintains we won't need to cross the bump. He may be right for now due to the inaccuracy of many of the shooters out there. However, I suspect in the eliminations and especially at states and on Einstein, the accuracy will result in very few balls on the floor to pick up, necessitating trips over the bump. At least we have a plan: if we need to cross the bump, we'll be able to.

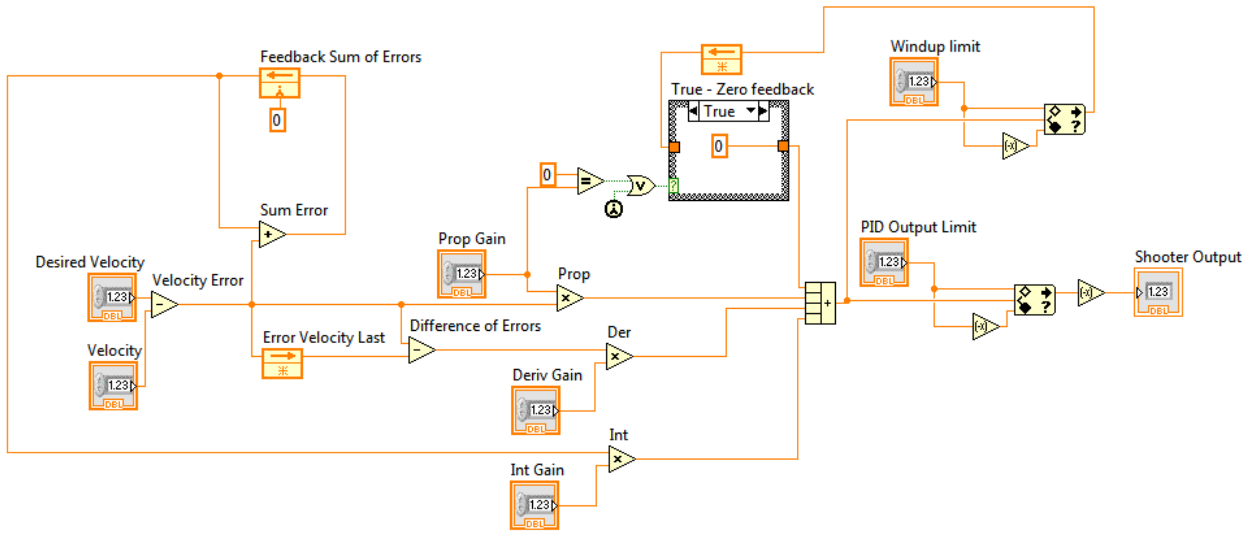
We got the turret turning quite well. We started linking up the vision to do tracking. At the lowest resolution we're getting 90-100 ms per loop in the vision processing .vi set to intensity. Setting it to color eats more time.

The loop time only really comes into play when you start trying to tune the PID loop. The camera lag results in overshooting your set point even when the proportional gain is set lower than I want it to be. For that reason, we looked at another approach. We looked at mapping the camera pixel location to a pot value. So when we took a picture and calculated where to go, it would be in terms of our potentiometer – we could just turn off the vision processing during the turn, then fire off one more camera shot to confirm we ended in the right position.

That has the drawback that if you're getting knocked around a bit (even by your alliance mates) your camera could end up being far off position.

By lowering the speed of the turret as it approaches the set point, you also decrease the camera lag. So we started decreasing the proportional gain, then limited the integral gain to +/- .1, which is enough to turn the turret. So the proportional gain dies off fairly close to the desired point, and the integral gain takes care of the rest just a touch slower. It's still a tiny bit slower than a correctly tuned PID loop would be if the camera didn't lag, but it's actually faster to the set point than our original 'normal' tuning of the loop with a high proportional gain and a lower integral gain.

2/27/12
Position PID's we get. Velocity, well… We spent 4 hours tonight playing with gains on our home brew velocity PID. We basically were stuck between two states: either the loop takes far too long to ramp up to the set point, or it oscillated wildly around the set point. The derivative portion was not acting as a damper, and we were frustrated. I returned back to it after work tonight, and made some changes to how we calculate the loop. Initially, we were normalizing just the D and I terms against the loop timing. This made them very small in comparison to the P component. By normalizing the P term as well, it was much easier to set the gains, and I managed to get it acting reasonably well. I'm still not happy about a 4 second spin up time, and now I'm regretting using 6 inch wheels. Too late to change now, we'll just have to find a novel way to spin up in advance. Perhaps we'll spin up using full throttle, then switch over to the PID within a certain range and allow it to maintain speed.



Team 1718's Final Velocity PID

We've got tomorrow off, then Wednesday we need to get the turret working again (we broke the PID….. or rather I found and fixed a programming error in our PID that broke our gains). Then we'll tune for the shooter. If there's time left, we'll go out and use set points to start hitting some baskets.

2/29/12

Got our first real drive time today. No shooting, except in manual mode. The “unbag” list on our whiteboard that we keep to schedule our open bag windows, keeps growing. Right now, the trajectory from the key is a bit too flat. The trajectory from the fender isn’t arced enough. We need something under the robot so the second we suck in a ball it’s off the floor. We need to modify the angle of the bridge putter-downer – right now the bridge is barely bumping into our bumper and hangs up a bit. The bot drives well, and is very un-tippy with the bumpers on. That’s good news. We played a bit with the tracking. The sodium lights on the production floor are horrible – they flicker through every color spectrum and show up like beacons on the intensity chart. I’m beginning to wonder if we shouldn’t be ready to use white or green lights, depending on venue. In larger venues with sodium arc lamps, intensity is going to be problematic. The best way to exit the ramp once you’re on it and straight is simply to floor the throttle and ‘Dukes of Hazard’ it. When we do so, we come off nice and flat and fast.

Because the bridge lowerator is allowing the bridge to hook on the bumper, I wasn’t able to test going over the bump.

Tomorrow we’ll do driving tests and operator tests. Saturday and Sunday, the controls team gets the robot to do all our tracking and distance and velocity PID work and get it running.

Next weekend we’ll hammer out hybrid. Frankly, once all the teleop stuff is working, hybrid will be fairly simple.

3/2/12

Driving tests went very well. We learned some more about the robot. It’s going to be necessary to put a plastic plate on the bottom so that we have the balls the second the front roller pulls them in. Our current system keeps the ball on the floor till it reaches the turret near the back of the robot. Our problems start when the drivers see the ball suck in the front end and immediately start to move. If they move backward, the robot sensor counts the ball as in the robot, but loses the ball. If they turn, it goes under our robot and we poop it out the back. If they drive forward, that ball jams against the one already in the vertical system. A plate will stop all of that, I suspect, and also get rid of the ½ second delay while the driver has to wait for the ball to index off the floor.

Prototype Under-plate on Practice Bot

We had to modify the shooting code. A couple of our manual functions had no delay before turning on the conveyors, and balls were getting to the shooter before it had spun up enough. This jammed the conveyor. We can’t reverse conveyor because of our pusher flaps on top. That’s bad, and we’re still working on a way to reverse it. Leading candidate is to chop out some of the top support bar to let the flaps spin in reverse.

We confirmed that keeping the turret mostly centered and having the driver line up while driving speeds the shooting process. We’ll refine that more now that we have our driver and gunner candidates.

Our code is very complicated, but I'll try to break it down simply. The driver handles the drive train, the brakes, and the bridge lowerator. The drive train code is very simple this year. We removed our victor linearization and all our other fancy code. Wide robots drive beautifully with no code intervention.

The brakes are a simple system. Two ½ throw pneumatic cylinders with square aluminum plates covered in tread. When activated, they push down on the top of the wheels. You don't want side loads on cylinders so I was going to put a regulator in line, but we found we didn't need to.

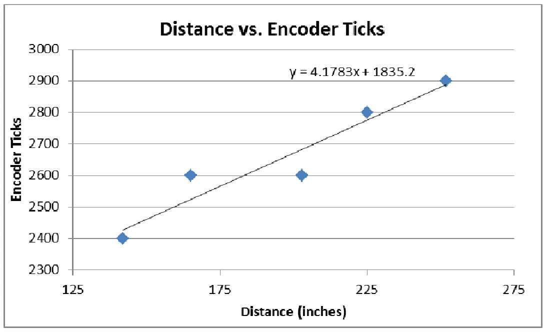
The bridge lowerator is finally working well. We have to make one more modification because it's not pushing the bridge low enough – it's about a ½ short of clearing the bumper. It's a wedge made out of polyethylene. It's actuated by a 1 $^{1}/_{16}$ pneumatic cylinder, and locked in place with a latch system actuated by a ¾" diameter ½" throw cylinder. It works very well, but it uses more air than I'd like. We went through a number of systems before arriving at this one. The leading candidate that we designed but did not build was a 4 bar linkage using a window motor that lowered the lowerator then "locked" it in place by virtue of going past center point. The pneumatic system was lighter since we already wanted it for hood actuation and brake actuation, and we were out of motor slots (at the time), so we went pneumatic. We have a problem to address here though – with the bridge lowerator only on one side, when we ram the bridge we turn sideways every time. That's creating some driving problems.

The operator has a slew of functions. Ideally, though, he only has 3 things he uses. He has a 'suck' button. We have ultrasonic sensors at the bottom and at the top of the conveyor that count the balls for our light system. The system indexes automatically. He has a left-right thumb joystick to fast-aim the turret, then a 'shoot' button that locks on, moves the turret on target exactly, spins the shooter up, then fires.

Spinning the wheels up can take a while. Therefore, once we have 3 balls, the turret spins up automatically to key-shooting speed. All these functions are controlled with a potentiometer on the turret, and a high-speed-encoder running on the chain to the shooter.

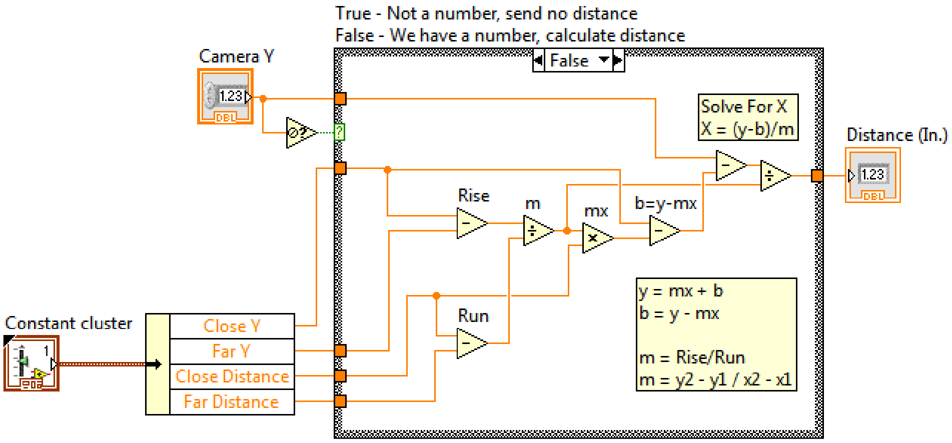
We also have manual modes. First, we have 3 buttons that spin the wheels up at a pwm command. When we were tuning the PID for the shooting speed and locked in at the perfect rate for a distance, we wrote that pwm value down. This gave us the right command to send to nail baskets without using any sensors. (We removed the pwm command later because it took so long to spin up it was unusable).

Our shooting speeds were all calculated experimentally. We plotted the speed required for the horizontal distance we needed to shoot in excel, then added a polynomial trend line and use that equation to determine speed for the distance the camera tells us we are at.



1718's formula to calculate desired encoder ticks/second.

The camera algorithm for distance supplied by NI works well unless you're to the side of the target. We've modified that algorithm to look at the vertical height by inferring it from the camera pixel. We take a distance measurement and pixel measurement up close, then far back. We turn these into the formula for a line, then feed in the camera pixel as a y coordinate to calculate the distance. The drawback is that we have to tune it to each robot. The benefit is we're accurate when we're to the side of the target.



Distance to target based on elevation, using a simple y=mx+b linear relationship.

We had a lot of trouble getting a PID we were happy with for shooting speed. We wrote custom velocity PID's that held the shooter to a very accurate speed, however they didn't ramp up quickly. Effective tuning fixed that.

We're using the default vision project stuck into our code. We only enable it when the gunner pushes the shoot command. At the same time, we disable a ton of other code (compressor, drive, etc) to free up CPU so we can do the processing on the cRIO. At the beginning of the season I complained about not getting lit vision targets. The program they've provided using the lighting they recommended works fairly well, but lit signs behind the targets cause havoc.

I'm increasingly worried about the bump and ramps. Many posts on Chief Delphi are suggesting that balls are getting stuck under the ramp on a fairly consistent basis. If we can only cross the ramps and 2 are jammed, fun will not be had.

<u>3/4/12</u>
It was quite a weekend. We got the velocity PID working. We had a couple of problems with windup, but after limiting that it's pretty happy. Distance works based on the height of the camera pixel. We're accurate within a couple inches – when the camera works.

There's the rub. Working out on our production floor we realized just how hard creating a robust tuning of the camera is. We had to retune it 3 times throughout the day. I suspect we'll leave the picture recording function active during matches and retune after every match to keep up with 'ambient' light changes in fields that have outside lighting present.

We watched many of the week-one Regionals. We've been talking on and off since week 2 about having a stabilizing arm touch the floor when on a bridge;   it certainly looked helpful on the several robots I saw using them.

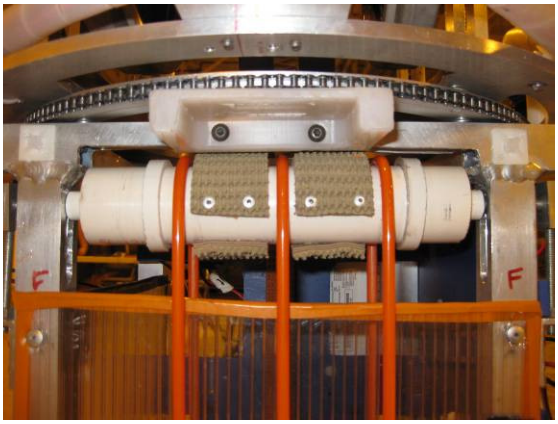
We modified the camera code and are using a de-bounce timer of all things. Because of the spotty vision, we wait till we see the same target in basically the same location 3 times, then transfer that angle to compare against a potentiometer, and stop looking at the camera. That addresses the issues we've had with balls in flight blocking our vision and causing the turret to turn away while shooting as well. We'll see if it's stable at competition.

<u>3/5/12</u>
Today was a good day for the mechanical team. They're changing our bridge lowerator significantly. The wedge system worked, but because we only had the weight for it on one side of the robot, we found it hard to lower the bridge because our robot would twist as we drove into the bridge, and the front of our bumper would go under the bridge (sort of counterproductive). The new one is a push-down system. Craig came in with a ready-made piece of bent aluminum, and they worked on fitting it to the machine. It should be pretty much functional by Wednesday.

The New Lowerator

We also chopped away a bit of the underside of the front turret crossbar. This let us raise our top roller that feeds into the turret. In turn, that removed a dead spot that was causing balls to occasionally get stuck. In addition, it means we can remove our 'flappers' from the top roller, and that means we can now reverse that roller if anything gets jammed.

While the robot was on its back getting its lobotomy, we added a light weight skid plate so we have the balls picked up off the floor the instant our front roller touches them. This fixed our jamming problem and will make ball pickup much quicker.



The upper roller gets raised.

We also moved our ultrasonic sensor on the bottom for ball detection one inch further forward. It was just far enough back that occasionally a ball coming in would stop before it reached the sensor. This happens because we have 2 conveyor systems, a front high speed system for sucking in and an inner slower system for indexing. The indexing conveyor doesn't run until the ultrasonic sees the ball, and in this case the ultrasonic was ½" away from seeing the ball when the ball stopped. So it would never get sucked into the indexing system.

We realized we've been shooting with only one 775 (no idea how long). The second 775 threw it's pinion. It's a little scary that we never even noticed, and had no trouble achieving the speeds we needed with just one. Perhaps we've found a potential for weight savings. I grabbed some .001" shim stock from my machine repairmen and we repressed the pinions. They're pretty tight now.

Now that most of the mechanical issues are fixed, we'll finish up our target system work tomorrow and hopefully hand the drive team a reasonably functional robot on Wednesday. (Minus hybrid –that's this weekend).

<u>3/7/12</u>
The changes we made yesterday were successful on the field. The balls pick up much better. They don't jam at the top of the conveyor when passing off to the shooter. We tuned the distance again (I'm not sure why it changed….), hopefully it stays stable between today and tomorrow. We calculated the distance formulas that convert to shooter speed, and then tried a couple shots. It looks like we nailed it. There are some bugs – occasionally it won't spin up, or it takes a while to lock on. I created an array of Booleans that step through our lock-on-and-shoot process. It actually takes a number of steps. Here they are:

1. Confirm we see a target for 3 loops
2. Sort for the highest target
3. Calculate distance to target from camera y pixel
4. Calculate required shooter velocity
5. Calculate turret potentiometer value from camera x pixel
6. Turn turret to position with a PID while spinning the shooter up
7. Check Velocity is correct (+/-10% speed…still not good) and turret (+/- 1.5 degrees)
8. Fire.

Tomorrow we'll be streamlining this system and see where the slowdowns are coming from. I'm betting it's step 1.

<u>3/8/12</u>
Did a lot of driving practice today. Our PID for velocity isn't quite tuned in, nor are our limits for shooting. We were 65-75% accurate in hybrid mode. Our spin up is also slower than we'd like. I adjusted the proportional upward and then adjusted the allowable windup in the overall term downward to compensate, but the loop started holding the velocity a bit higher than we want after that. We're also seeing some hiccups in the turret I don't like (and don't understand right now). We'll have to check the PID gains on that and see if we can improve it as well. We're not using any integral right now on the turret PID, just P and D. What bothers me is that the turret will settle at a very acceptable error, than a couple seconds later it will jerk off to one side or the other. I don't think our code is working to

lock in the desired value once we have the camera image – that's my only explanation as to why the turret acts like it's seeking new targets.

At some point in the programming we broke our ball counting system. The sensors are still working, but we obviously changed something that effected it because our light system is not illuminating.

The new bridge lowerator came in today and works wonderfully. We can lift the bridge, set the bridge down, and even use the lowerator as a jack to keep the bridge from tipping too far.

<u>3/9/12</u>
More code work and drive practice. The ball counter is fixed and working well. We changed our original plan on manual functions though. At first we thought we'd just test and assign a pwm value to each manual button in case everything broke. After testing it though, it takes so long to spin up it's not practical. We played with a system where we input full throttle for a certain period of time then went over to the pwm value, but it was still not consistent. We ended up using closed loop through the shooter encoder. Originally we were in the mindset of "what if everything breaks". Now we're in the mindset that trying to shoot with just pwm really isn't all that much better than not shooting much at all for us. The new manual system works well.

We found our jittery turret problem. Our 10-turn 10k potentiometer has a bit of noise. A simple 2 sample average fixed that entirely, and now we're locking on 99% of the time with no problem. Drive practice today had us shooting in full hybrid from all over the key at about a 75% accuracy rate. Not too shabby for now.

We're using a 5 sample moving average for our shooter encoder to remove some of the noise there as well. It lags $^{1}/_{10}$ of a second. That doesn't bother our system.

Tonight before I go to bed I'll need to create constants in our text file for a number of things we added. Turret offset, Camera height offset, etc.

Tomorrow, we start working on our autonomous scripting system for the first time. Our auton is going to be simple. We're going to drive to the bridge first and lower it. On the way back, we'll spin up our shooter wheels. We'll deploy our brakes and stop on the key, then begin firing in hybrid mode. We did it today in manual and it worked brilliantly. Having the turret rotate 270 degrees was definitely a good idea.

We'll have to add a couple more modes – we need to be able to suck while shooting so that we can have other robots feed us in hybrid. I hope we're one of the more accurate shooters on the field, which will hopefully lead to some high hybrid scores. I think we'll have to so that we can offset our major weakness of not crossing the bump.

In 2010, we chose not to cross the bump. However, we routinely proved that we could go through the tunnel just as fast as anyone could cross the bump. This is a bit different. Even the fastest bridge-crosser isn't as fast as a "Dukes of Hazzard" style robot crossing the bump. Later in 2010, when we started teaming up with talented robots, we became a middle and front court scoring machine. I see our role this year sizing up the same way. I'm hoping our accuracy rate leads to good robots that can cross the bump picking us (or vice versa). We'll do clean up in the O-zone while our second offensive robot runs to the human player and back to score. Our third robot will play defense by moving the balls from the opponents zone into ours, where we can grab them and score.

====Drive Straight==== / Drive Heading (3 digits)
0
Drive Distance (inches)
60
Forward Drive Bias (degrees)
0
Max Drive Speed (0-1)
1
Fire Shooter (1=On) (0=Off)
0
Shooter speed in manual (2600 shoots in manual)
0
Ramp Pusher Up (0) Down (1)
0
Suck On (1) Off (0)
0
Brakes On (1) Off (0)
0
Delay Time
0
==Drop Arm and Suck== / Drive Heading (3 digits)
0
Drive Distance (inches)
60
Forward Drive Bias (degrees)
0
Max Drive Speed (0-1)
1
Fire Shooter (1=On) (0=Off)
0
Shooter speed in manual (2600 shoots in manual)
0
Ramp Pusher Up (0) Down (1)
1
Suck On (1) Off (0)
1
Brakes On (1) Off (0)
0
Delay Time (ms)
3000

One of Team 1718's Hybrid Scripts

Fingers crossed that it works out something like that.

One of our sister teams, 2604, did well at Kettering. I felt good for them, and they played quite well. Tomorrow, our other sister team 3539 will compete. Next week, our sister team from Richmond will have their first event. Good luck to them all.

On a last note, our shooter slow downs are gone. We spin up in about 4 seconds with a good battery. Batteries are pretty key – we run them down in 6 minutes of hard play, but we start seeing shooter distance degrade after about 3-4 minutes. Hopefully we don't have any late match field-faults where they don't allow us to change batteries.

<u>3/11/12</u>
I get excited when I learn something new (or when something works the way it is supposed to). We've been having problems with the first shot from our shooter being very inconsistent. We've been watching the shooter encoder rates by eye trying to catch what the problem was but hadn't been able to nail it down.

Today we actually hooked up the encoder rate to a graph vs. milliseconds. We got a beautiful view of an underdamped velocity PID. On the initial ramp up, it overshoots the setpoint. On the way back down, it undershoots it, then finally returns. Our first ball was timed with the undershoot (just by luck). So we almost always undershot the first ball.

It was amazing to watch the system react as we slowly increased the derivative term to damp it back to where it should be. First the second blip (undershoot) slowly disappeared, then the first overshoot slowly decreased. It's working quite well now.

Hybrid modes work. Due to our current weight issues, we won't have a 'funnel' on the front of the robot, so we'll be able to get 1 ball at most from the bridge. However that might end up not being a big deal. A lot of the teams with the front end mechanism to lower the bridge and collect two balls shoot first to make sure they don't get 4 balls. Forcing them to go for the bridge first may be something they aren't prepared for. We'll see.

3/12/12

Open bag today and we managed 2 hours of very efficient work. That was probably our best open bag period ever. We finished what we had originally estimated to be 4 hours of work in 2. Part of that success can be blamed on our organizational system. The rest can be blamed on some very motivated team **me**mbers.

Prior to open bag, we create a list of everything that can be done. Then we split that list into tasks that can happen simultaneously, and put times against many of them. We lay out every single part, fastener, and tool that will be used in advance on a table in order. At any one time there are usually at least 6 team members with their hands in the robot working. Non-robot talk is not allowed, and we limited the total number of team members in the room at the time. We also insist tools be returned to the tool box immediately. It always impresses me how well our members work as a team in crunch time.

That leaves 4 hours tomorrow on the practice field. We'll take the robot down to the field and get everything set so that when we turn the robot on, we'll already have everything else up and running to connect and begin programming. I already have our work list stored in my head.

3/13/12

Wow. What a mess. We started out well today for our controls unbag. The turret tuned in nicely and is aiming well. We locked on with the camera fairly quickly, and were able to tune the camera distance easily.

We had some problems with the pneumatic system. At first I thought it was just one connection that had bad crimps – we redid that and it seemed fixed.

Then we ran into problems with our autonomous drive-a-distance code. For some reason (yet unknown to us) the robot took off in reverse at full speed. This was probably the 30th time we ran the code with no problem. I'd love to know what happened, as it happened twice before with the practice bot, confirming we have a code glitch somewhere. At first I thought it was encoder-count problems, but we reset the encoders when we enter disabled and when we enter hybrid.

I had my hand near the keyboard and immediately disabled the robot. Unfortunately, a full throttle to instant stop (vics in brake mode) flipped us right over on our back. It's the first time since 2007 we flipped a robot.

Of course, it landed on the camera, knocking all the tuning that we'd already done completely out of whack. When we set it back up right, everything appeared ok…. But neither our bridge lowerator or our brakes would work. 30 minutes of checking didn't solve the wiring problem other than to confirm there's a short AND an open circuit somewhere in those 6 pneumatic wires.

For 4 hours of out-of-bag work, we managed to:

- Confirm the turret tracks side to side.
- Confirm our shooter works fairly well.
- Bend the camera bracket.

- Break the solenoid wiring.

Yeah. Not exactly what I wanted. Thank goodness for the 5 hours we have on Thursday at the venue.

3/14/12

Happy Pi day. Trailer's packed. Scouting is debugged. OPR is ready. Advance crew is prepared. Weight will be close – we measure at 118.9 on the scale in the room. We need to add one final piece of guarding to prevent balls from being caught. We'll fix the solenoid wiring tomorrow at the venue, then do distance calibration, shooter speed calibration, then vision calibration. I hope we can fit it all in. An hybrid test before the competition starts would be nice too.

3/15/12

It's our first competition. Most of the bots here already have 1 comp under their belt. Our pneumatic system decided to continue being flakey. We ended up simply replacing the wiring of 2 of our solenoids completely. We weighed in with no issues. However, when they came over to check our robot, we found our bridge manipulator was 1 inch too long. How we managed that is beyond me. We measured the practice bot and it was legal. The only thing I can think of is that in our hurry during our last bag night the students installing it mixed up a dimension. No big deal, but we lost another 45 minutes remounting it and testing it. Then it was off to the practice field, where the camera just would NOT lock on. I got a field of red snow, and when I started changing color values I'm losing the targets no matter what. One of the students is a camera guru, and he had more success than I did. It still wasn't solid tracking though.

We had a plan to address some of that. I ordered larger ring LED lights that will go on over the smaller ones to help illuminate the target more thoroughly and evenly. The rest of the team was showing up later that night and bringing them with them (I air freighted them same day). However, we'd never managed to get the new camera system working well (2007 was our last successful year, and that was the CMU2). I asked the FTA and they told me that they'd be shutting down practice matches from 9:30 PM to 10:00 PM so teams can calibrate. We had no luck there either. The lights on the field combined with large LCD scoring screens behind the targets AND a large projector screen that cycled through the FIRST sponsors was wreaking absolute havoc with the system. They also had half the overhead field lights turned off on one end of the field, further complicating the issue.

I will give it to the West Michigan venue. This is the most professional, hard working, friendly crew I've ever had the fortune to meet. The FTA, field volunteers, and Field Supervisor were all incredibly approachable. They agreed to allow field calibration in the morning before matches, at lunch, and after the final matches of the day. Amazing how accommodating they are. West Michigan knows how to run an event.

Our bridge lowerator may be legal, but it barely puts the bridge down. We put on some serious surgical tubing, and now I can say that lowers the bridge with "Authori-tay" to quote Eric Cartman….

3/16/12

What a wonderful and horrible day. First, the wonderful: our gunner has an eagle eye. He spent the day in manual and is hitting nearly 75% of his shots. The horrible: the camera simply would not work.

We're taking camera shots every time we shoot the ball. We bring them back to the pits, and can simply not find a working camera setting that will allow us to track with all the lighting issues. Other teams are having similar issues. I know of only 1 team that is tracking well, but I can't claim to have talked to all of them.

We've got a good record, despite losing two matches. The kicker is the coopertition points – we've gotten them all. We made a decision that even if it's close, we're going to be going for the coop bridge rather than scoring. It's paid off and gotten us a #1 QS score… for now.

We're slowly working out bugs. The biggest issues we're seeing is on the transition from hybrid to teleop. We use the exact same code in teleop that we use in hybrid – the same turret .vi's, vision vi's, etc. We're finding places where the transition is less that clean – some hybrid values are getting sent over to teleop and causing all sorts of headaches. Arrays arriving with values still in them, variables still set to the hybrid values……This could have been found had we run practice matches using the driver station. Live and learn I suppose.

<u>3/17/12</u>
We've improved our camera targeting substantially. Or rather, we opened our eyes and tried what NI told us to do. We took an LED flashlight, turned it on, and put it right in the camera lens. We then logged in to the camera web interface and told it to hold white balance and exposure and saved it. We then changed the camera .vi to hold as well. The targets now pop like we're never seen before, and we don't have to recalibrate between the pits, the practice field, or either end of the comp field.

Unfortunately we got in to the semifinals and promptly flipped off the bridge. That smashed the camera mount, making our accuracy horrid. Despite shooting only 50%, we were in the lead in the second match too when…. You guessed it…. flipped off the bridge again. This time we a ball underneath us so we couldn't get up the bridge quickly enough as our partner drove up. Both flips hit the camera and turret hard. In fact, I'm ordering a new turret bearing just in case. We have a very stable robot, but when your partner starts driving up the bridge and you don't, you're pretty much out of luck. The bridges make fantastic levers.

<u>3/18/12</u>
All I can think about is how to improve. What if we change our bridge lowerator to an L shape that can slide under the robot in front of us? It has promise. I'll talk with the mechanical lead Monday. We have to spend some time cleaning up the comp code. We made a lot of on-the-fly changes and the code is pretty messy now.

<u>3/20/12</u>
I got a chance to watch some of our videos today from West Michigan, and some things stood out. First, we need to improve spin-up time on the shooter. 4-5 seconds till shooting is too long. The only way we can do that is by spinning it up in advance. We'll need to figure out a way to do that.

Next, our drivers requested a creeper mode for the bridge. I'm letting the kids figure it out right now. I think a simple PID for 3 inches should work, with a fairly large I term in case we're up against other robots.

Next, I ordered a 5 turn pot to replace our ten turn. I'm hoping that improves our resolution and removes a tiny bit of the noise we're still seeing. It may not be worth the time, but we'll give it a try.

<u>3/21/12</u>
We modified the code today so that when the fire button is pushed, the vertical conveyor indexes balls to the top while the camera is locking and the shooter is spinning up to speed. This will save us 1-2 seconds of firing time. We still need to look at spinning up sooner. Perhaps once we have 2 balls we'll spin up.

We spent time today talking with the kids about what they want to do to handle our current issues on the bridge. Specifically, we did a pair of face plants, one frontwards and one backwards. We can't really help our center of gravity, so we discussed what we might do with our lowerator to help. We're going to bend it a bit more so it hits the ground, then put a tab on the top so we can use it to steady bridges for other teams, and also use it to steady ourselves on the bridge.

<u>3/22/12</u>
Today we added some aluminum stand offs so if we tip backwards we won't pound the camera or the turret. We spent some time transitioning from hybrid to teleop and identified another bug where the hybrid program is not reloading after it's been run once. This could affect us if we run a hybrid then the match is stopped and we have to run it again. We'll fix that Saturday.

We also programmed the robot to spin up once it has 2 balls. This should be the last fix we need to minimize shoot-waiting time in the key. We'll try it out Saturday or Sunday when we debug all our hybrid modes.

Our old method of verifying shoot speed was to watch for a speed well above the requested set speed. This was because we have a bit of an overshoot on spin up. Rather than that, we implemented a de-bounce trigger with a range in the center of our desired speeds. This should get rid of our occasional overshoot because we're going to retune the shooter and lower the proportional gain, the integral windup limit, and increase the derivative gain so it's a little more accurate. This will affect spin up time, but that should be addressed by spinning up the wheels in advance.

<u>3/24/12</u>
We opened the bag today after crushing a few more logic bugs on the practice bot. We had to touch up the ultrasonic sensors at the entrance and exit of the ball chute. Then we tested our conveyor system – it indexes to the top and then stops until the shooter is up to speed. Success.

We have an inexplicable bug that keeps popping up. The vision .vi will simply stop running. Everything else functions, but if you click on the vision .vi or the period tasks .vi, they are not executing. I suspect this is happening because we are maxing out CPU. When we are testing vision, we force it on. Normally our vision only runs for 3-5 frames when the trigger is pulled. I suspect the cRIO is dropping those .vi's from execution to protect teleop. Annoying. (NI helped us solve this later – there was indeed a bug in their side of the code preventing a VI from reloading correctly).

Anyway, we implemented our new test for whether the shooter is at speed. We feed the actual speed into a range check against the desired speed and that result is fed into a de-bounce (has to be within range 5 consecutive times or 100ms) for us to shoot. If it's within +/-100 counts/interval it's good. For reference, we shoot when our counts are at around 2600 from the key. Way too much variation.

Next we got the spin-up working. When we were playing at West Michigan, we often saw that we were shooting with only 2 balls. So we modified our auto-spinup code so that it now spins up when we have 2 balls. This cut another couple seconds off.

Essentially, if we have 2 balls, we can pull up to the key and be shooting in under 2 seconds. We're very happy with that and I doubt we'll change it any more from here on in.

We modified our shoot while sucking code as well. What was happening was that our input conveyor was always spinning, even when our vertical conveyor wasn't indexing. We didn't have enough time before West Michigan to check how that would work, and we never did get it working just right. It causes big jams when it tries to stuff balls into the vertical conveyor and the vertical conveyor says 'heck no'. Now it only sucks when the vertical conveyor can move.

Next we modified our teleop indexing code. When the ball was indexing, we were stopping our front conveyor to prevent another ball from coming in and jamming. Occasionally our vertical conveyor didn't have a good enough grip and wouldn't pull the ball from the horizontal conveyor. This required manual intervention to fix (reversing the conveyors). Now, the horizontal conveyor runs at a greatly reduced speed when the vertical indexes to help feed the ball in. It seemed to work well.

Tomorrow we are unbagging the robot on the field, and controls will be the only folks there. This is the first time we've ever managed to have a solid enough robot that controls got to work on it this much between events. I hope it bodes well for our results in Troy. That competition is stacked with good bots.

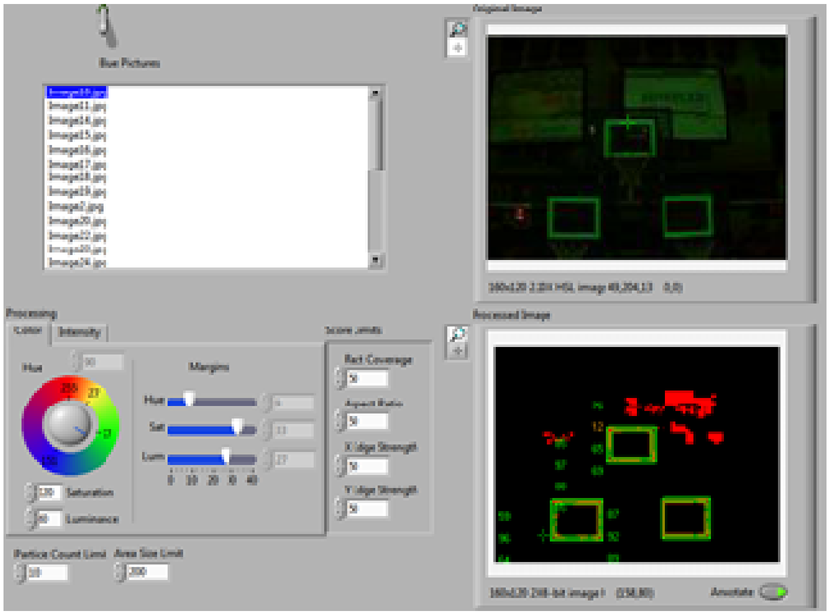
We finished up a camera jig that we used to check the camera position on both bots. Our camera is on a fairly lightweight mount, and it can't support the entire robot landing on it. The jig will help us get it back to the right angle and position should we have another mishap and end up horizontal.

Next steps are to tune distance, verify speeds and adjust slightly, then run through every hybrid we have to verify they are ready to go. I'm always scared to say that we're in good shape for fear of jinxing us, but I think we're going to do ok.

<u>3/27/12</u>
Good and bad work on Sunday. We lost a pinion on our shooter motor. We expected that, and have a spare transmission ready to go that's got pinions with correctly sized bores. In addition, we know that prolonged use of the shooter results in the turret fasteners backing their way out. We'll have to snug them down because the turret is a bit loose right now. We've also got a modified bridge lowerator to go on the robot once we get to the venue – it's got a stand-off so we can drop it on the floor and let the bridge come down on top of it to aid balancing during qualification matches (or eliminations if we're not going to balance). I would have liked more time playing with the shooter, but we'll have some time Thursday night and Saturday morning on the practice field to make sure our new algorithms for checking shooter speed don't create any new problems.

We had a lengthy discussion about the stinger as well. Right now, it's off the table. We all think we could do it, but the robot is performing well right now. We don't want to add something half-baked when we're already short on weight. As a result, what we are planning on at Troy is to spend in between the matches lightening the robot. We're swapping out some steel to aluminum, and we'll be removing a lot of unnecessary aluminum. All this work is going to happen high on the robot to help our COG. The side benefit is that if we decide we must have a stinger, we'll have the weight set aside to add one.

<u>3/30/12</u>
We had a very rough day. Of the matches we won today, only one of them was won because we dominated the field. The rest were a combination of luck, timing, etc. The vision is horrible. Period. Large projection screens directly behind the targets has left many of the teams completely unable to track, including us. It is what it is, but FIRST needs to rethink this whole vision thing. Simply put, the targets need to be internally lighted with LEDS through a diffuser, just like in 2006/7.



Dear FIRST and FiM – Don't put lit signs behind vision tagets!

It took a while to get manual running smoothly because we were focusing on auto-tracking so much. That's because auto-tracking worked so darn well at West Michigan. An hour spent on the comp field tuning got us exactly nothing. HOT tried a bunch of different colors but is seeing the exact same problem we are. The difference is that they were smart and went 100% manual, while we were stubborn and kept giving up points in matches trying to get tracking running and tuned in. Worlds is going to be even worse (if we make it to worlds).

<u>4/2/12</u>
Well, we're in the process of rewriting the vision code. Right now, we're only targeting off the top target. The new code looks for all the targets, and will accept a number of combinations. It works in this order:

1. Can it see all 4 targets – if yes, then shoot

2. Can it see the 2 middle targets – if yes, then shoot
3. Can it see the top and bottom targets – if yes, then shoot
4. Can it see the top target – if yes, then shoot
5. Can it see the bottom target – if yes, then shoot

I've been thinking about different combinations – for instance a top and a side target. That would require a bit more work because we would have to check that the targets are within a certain distance of each other and at a certain angle of each other to validate them. We'll hold off until we get the above system working.

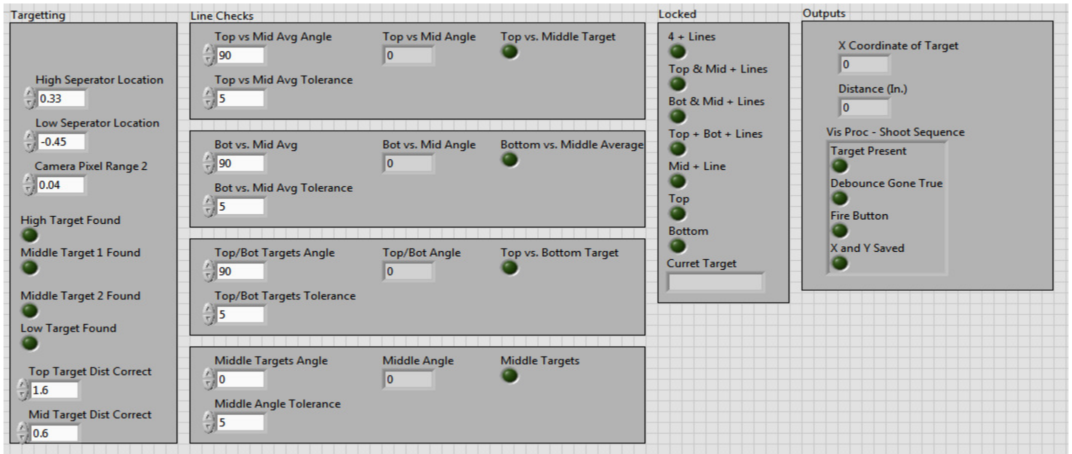
In addition, we added a maximum size requirement along with the built in minimum size that came in the NI code. This will help rule out the big screens and big conglomerations of things like blue / green / red banners behind the targets.

In all, I think it will be far more robust and more willing to ignore extraneous targets. In addition, we average the X value of the targets in all cases that we can lock on. Finally, we're switching over to the NI way of finding distance with this system, since the targets are at 3 different heights and we're not going to do a linear formula and calibrate for each – that would take too much time at the competitions.

We've also ordered new red and blue LED's so we have an assortment to try. Finally, we also ordered some 100mm proximity sensors to replace our ultrasonic sensors. The ultrasonic sensors have been working fairly well, but they cost us points twice when they thought 2 balls left and only 1 had, so they shut down hybrid early. The new sensors should be much more consistent, and we should be able to remove our de-bounce checks which will make them about a $^{2}/_{10}$ths of a second faster to allow balls to index.

<u>4/4/12</u>
We got new IR proximity sensors in for ball detection. They are far less prone to false-negatives than our ultrasonic sensors. The ultrasonics tended to have a nasty tendency to bounce their signal off the ball radius and not get a return. These new IR proximity sensors do not have that problem. We wired one up and it worked in our code as a direct replacement. We'll wire up the second one tomorrow and begin stress testing them.

Our new vision code is working well at finding targets. It degrades from 4 targets to 3 to 2 to 1 well. We also added some geometric checks to insure that the targets are located where they should be in relation to the other targets. The new code still has a few bugs – it occasionally is saving a flakey position value. We pulled the de-bounce for the x target location out of this code to speed it up. I put it back in tonight.



The front panel of our vision code.

We've seen a number of flukes where the second ball shoots right after the first. I think we need to tighten up our velocity tolerances a bit, because that second ball is just barely making it in. In addition, we've seen a handful of times where a ball dribbles out the front with no velocity on the shooter. I'm still not sure how that's happening. We've set aside tomorrow and all day Friday for trying to kill the last few bugs in the code.

<u>4-6-12</u>

The ball shooting appears to be fixed. We completely recalibrated all the distance algorithms, then we recalibrated speeds for all given distances. We're back to hitting 80-85% like we were before West Michigan (why doesn't it work on the comp field….?), and everything seems to be very stable. The code is clean and we've removed all the extraneous stuff. I'm optimistic for states coming up.

We got in some shore-A 40 ¼" rubber. We're thinking hard about making Plaction-Colsons for better bridge traction. We'll try it out before worlds if we go– no time before states.

<u>4-15-12</u>

That was a rough Michigan State Championship. Not just for us, but for many teams.

As far as our robot goes, the new vision targeting works well. Our modified CIM-Sim with 775's kept throwing the pinions, even with shim stock and lock tight. In addition, the constant transmission changes led to us having to change shooter gains constantly (each transmission acts slightly differently). On top of that, each time the transmission was pulled, the chain tension was different, leading to another slight change in behavior.

We were horrible in hybrid. We hit about half our shots. That needs to bump up majorly in time for worlds.

To top it off, the shooter truly has been bad. While we were tuning it at MSC, Mike Copioli stopped by and watched us. He asked about the large amount of variance we were seeing in out speed. Since we already know that 100 RPM equates to about 1.5 feet on our shooter (when running at about 2500 RPM), he was surprised we were allowing +/- 100 RPM variations with our PID control. He had me throttle the shooter up just using PWM without the PID control. The variation was still present. Why I didn't think of this much sooner I will never know. That means that the variation in steady state that we're seeing, and a large part of our accuracy problems (for distance) are directly related to the mechanical issues we have in our system.

New precision machined gearboxes were ordered last night. Jag's have been ordered for more linear control. New sprockets have been ordered that are lighter weight and will allow us to spin up faster. Monday I'll call each company and try to rush ship them. We're also going to look at a bang-bang controller for faster recovery after shoots. People have been talking about some success using them. I hope we can make ourselves competitive.

On another and even more important note, our rookie team the Blue Devils won State Rookie All-Star and are going to St. Louis with us. Go Blue Devils!

<u>4/17/12</u>
We spent a lot of time today working on the shooter. Specifically we are looking at the noise we're seeing on the encoder. We know part of it is from badly meshing gears on the drive transmission. However, we pulled the chain from the transmission and spun the shaft with a drill and still saw significant noise. The shooter bearings are smooth as silk and have no play. The shooter wheels, however, all have 5 degrees or so of play due to worn keys or worn keyways. I fired an email to mechanical and asked them to look at tying the wheels together or pin them all to the shaft.

We also found the encoder itself had developed a lot of shaft end-play resulting in noise. We put in a new encoder and it cleaned up significantly. Then we swapped it out (Bourns model) with a Grayhill model and it had an equal amount of noise remaining. This just confirms what we already knew: our mechanical system is very noisy. The pinning of the wheels (Wednesday), new transmissions (Thursday), new tuning (Friday) should allow for a full day tryout Saturday, then a check of all hybrid modes Sunday.

We also gave a shot to the bang-bang method of control rather than tuning since several teams had reported success. It spun up 1.5 seconds faster than our PID, but had 10-15% more steady state variation based on the data we graphed. We placed with the loop rate all the way up to forcing it at 5ms, but it didn't help much. Since we spin up our shooter when we grab the first ball, spin up time really isn't a factor. Spin up between balls is already fairly short. Accuracy is more important than speed, so we went back to PID.

We also tested today using a timed loop rather than a while-loop with a wait. This helped a very small bit. It might have been placebo effect though. Regardless, we played with the timing while watching the CPU. Setting the loop at 10ms raises our CPU by 6 to 7%. That shouldn't hurt us.

We also had the compressor kick on while we were working. The PID was maintaining the shooter at the time. We're not using VBus and Can, so the predictable happened. The shooter dropped a large amount of speed. That's fixed - the compressor is locked out now while were shooting.

We also noticed that the vision system continues to run after we have locked in a target. That's not needed, and vision pegs us at 100% CPU. The vision now shuts down the when it has locked on to a valid target. We'll test it Friday to confirm it doesn't have any negative effects.

These are all small incremental improvements in the robot. In the end it will all be overshadowed by game strategy and driver performance.

<u>4-24-12</u>
We're packed and ready to go. I'm anxious to see if we've managed to make any significant improvements to the bot. It's shooting at 75% now. Our biggest hurdle will be to insure we're consistent in hybrid. Our manual shooting in hybrid is good, but to be top tier we need to be able to snag those bridge balls and get one of them in as well.

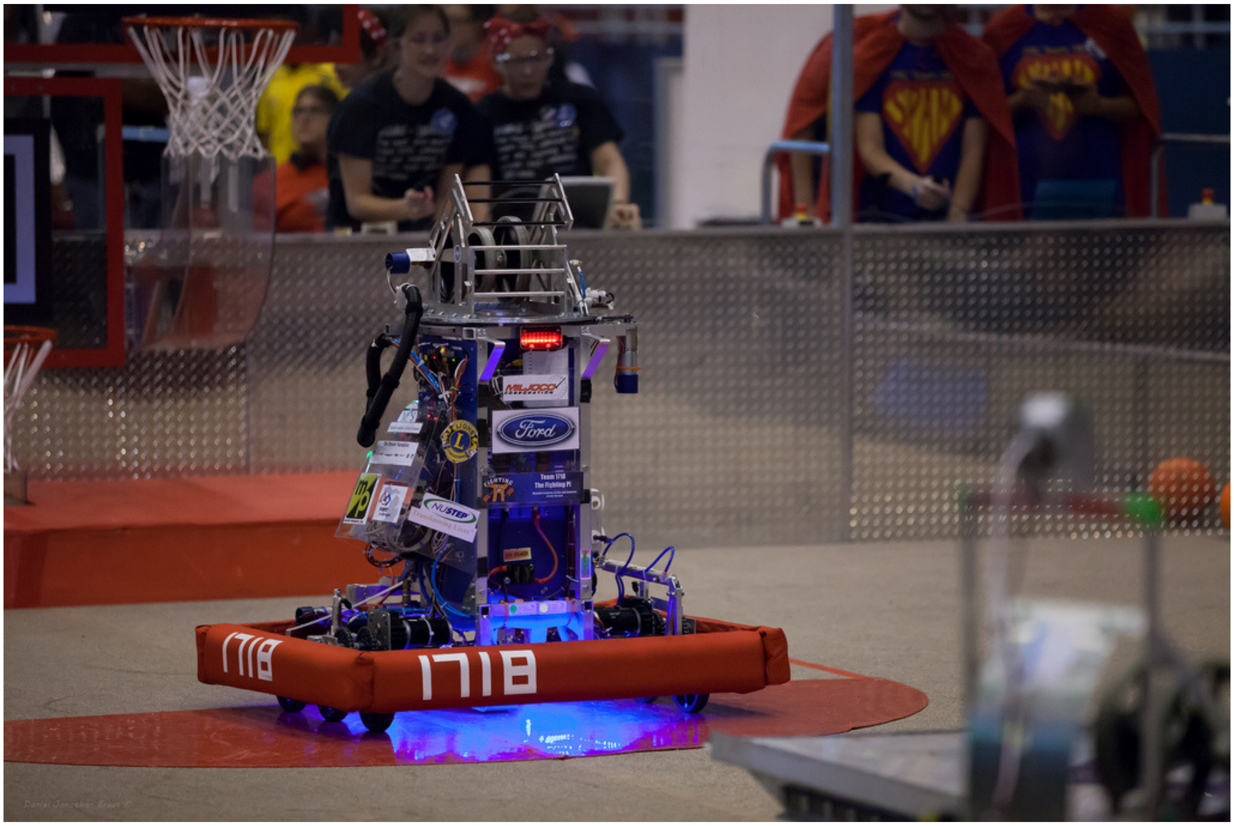
<u>4-28-12</u>
And it's over. I haven't updated this during Worlds. We've just been too busy. We started out with a horrid first match. Balls were going too short and too long, and the noise we were seeing from the encoder counting made the signal look horrible. The limits we had to set to enable shooting were wide open because of the noise.

Then, in our process of continual change to improve we made a change. We changed our while loop running at 30 ms with a wait statement into a timed loop of 30 ms. The signal smoothed out tremendously. Next, we put a 4 point moving average in front of the velocity PID to further smooth the encoder rate input. We stabilized even more. Finally, we added filtering in the form of a moving average + IIR filter (set to .25) in front of our enable shoot routine. We were now down the a variation of +/- 15 rpm.

We continued to struggle in the next match though with variation. During our first competition in West Michigan, we used the elevation of the top target to determine distance. This was extremely accurate. In order to increase the robustness of our vision code (because we were having trouble locking on in Troy) we rewrote the code to allow locking on to any combination of targets. However, this made it very difficult to do elevation (we'd have to calibrate to three different target heights). So we switched over to NI's supplied method of using target width. We noticed variation on the distances, from different targets, so we added correction factors in for the target depending on the height (because of lens curvature) and then we averaged the distance of all the targets we could see.

Sometimes this worked very well. Most of the time, it didn't, but we never traced our inaccuracy back to distance fluctuations from the camera. It was so stable in our workshop that the targeting locked on nearly perfectly near the end of the year, with no target size variation. It's different on the competition field.

Removing the distance calculations and putting in a single speed for key shooting increased our accuracy tremendously. We finally broke the 75% barrier and (ignore one bad match and we were at 84%), right up till eliminations when they changed out all the balls. We did beat the World Champion alliance in one match though.



See you all on the field next year.

Tom Line
Team 1718 Control Mentor