

Managing Luck

High Performance Processes
to Improve Your FRC Odds

"I'm a great believer in luck, and I find the harder I work, the more I have of it." - **Thomas Jefferson (US President)**



Who are we?

Chris Pinto

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Celt-X Team 5406

- 5 years old
- “Robodrome” stewards
- Lucky to have earned some medals, including a shiny one last year

But a lot of things haven't been perfect along the way. We've sprinkled some examples of lessons learned throughout this talk

FRC is Unpredictable

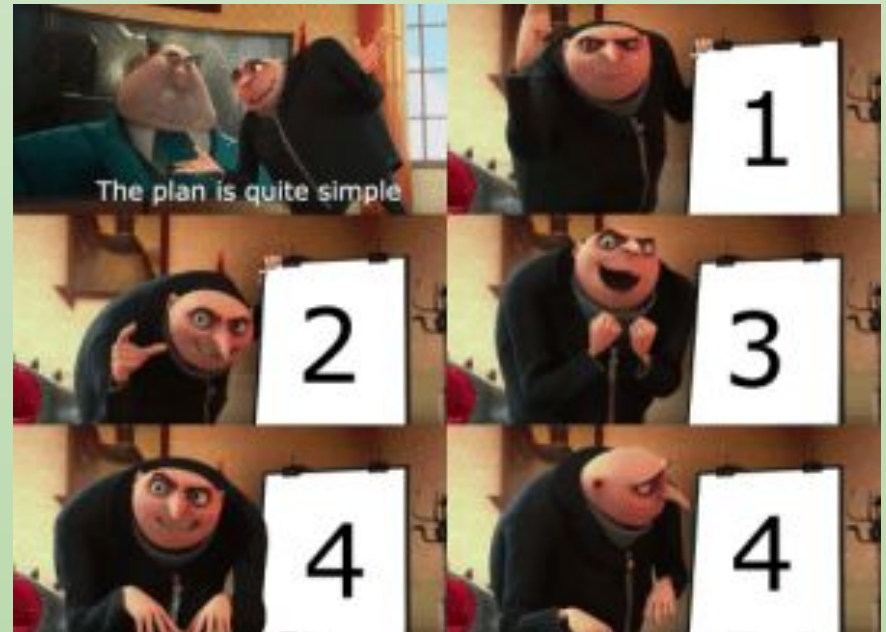
- Many people involved, each with limited info. Large turnover means it's hard to keep lessons learned for very long
- The hardest high school competition there is!
- Harder working competitors
- Short matches are an unforgiving way to test months of work
- Murphy's law has plenty of opportunity:

**“ANYTHING THAT CAN GO WRONG
WILL GO WRONG”**

But there are tools for taming luck

Celt-X's 4 part solution to foiling Murphy:

1. **Plan to Succeed** (set goals, be realistic about their needs and follow through)
2. **Plan for Failure** (prepare failsafes and backups because plans fail)
3. **Minimize Risk** ("high reliability" practices)
4. **Improve** (Learn what works and what doesn't. Do more of the former, stop doing the latter)



1. Plan to Succeed

“It does not do to leave a live dragon out of your calculations, if you live near one.” – **J.R.R. Tolkien, (author)**

Starting the Season - Goals and DRs

- This is covered better in other presentations
- Set goals at the beginning of the year. **Be reasonable.** - you don't have time to push every boundary
- Pick strategies that serve the goal
- Build a design requirements list to play those strategies. Peer review designs against requirements.
- Example: STEAMworks wasn't a fuel game

SSID: CeltX Lab
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<u>robot</u>		<u>pts/match</u>
BLT	20%	6
Super rookie	15%	20
average ontario	55%	32
elite ontario	7%	48
elite world	1%	

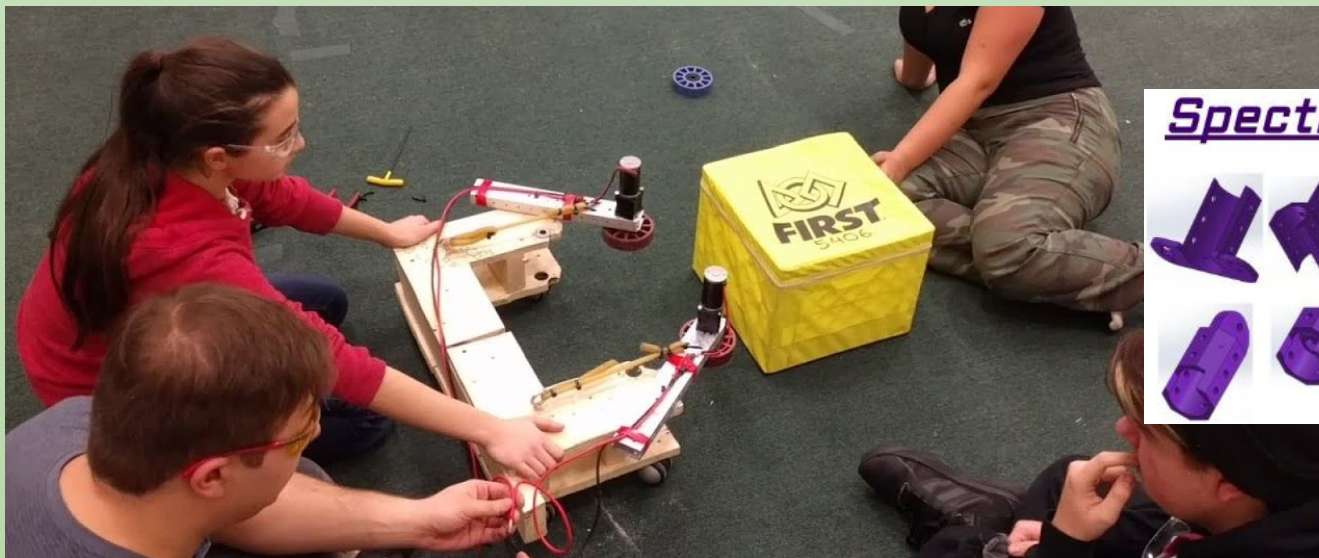
<u>avg match</u>	
50-80	
<u>Semis @ district event</u>	84-116
<u>Semis @ Ontario champs</u>	84-116
<u>finals @ Champs division</u>	120-150

120 pts
- 60 pts help
60 pts for us

Prototype

Don't just guess, test to be sure

- Takes time - concentrate on new unknowns (usually game pieces)
- Example: Topsy's intake and the shuttle valve
- Laser cutter is a great asset, but can do lots with COTS parts and lumber (see below) or PVC pipe.



Iterate

Don't Be Happy With Good Enough

- 2017 - Gear mechanism was after bag day
- 2018 - Ramp was after bag day
- 2019 - MANY revisions to our hatch mechanism
- **But be careful that time spent practicing wouldn't get better results!**



2. Prepare for Failure

“Luck is a matter of preparation meeting opportunity.” **Seneca the Younger (Roman Philosopher)**

Prepare for Failure

Good preparations can limit the consequence of a failure:

- Bring spare assemblies to competition
 - Example: 2017 climber
- Design for maintainability
 - Example: West Coast Drive chasses make wheel swaps easy
 - Neat and clean wiring, plumbing and labelling make diagnostics easier
- Train drive team and technician to respond quickly
 - Practice component swaps
 - Practice driving when broken!



Make Backup Plans

Have an easy backup plan for every hard or risky plan

Have good estimates of the time each will take

Watch the schedule like a hawk. Cut scope if you miss a deadline (this will be harder to do post-bag, so be extra vigilant)!

Examples:

- 2019 floor pickup and double climb.
- 2018 robot lift (came back to it after bag),
- 2016 climb (also after bag)
- 2015 can grabber scope cut



PLAN A: What I really want



PLAN B: What I can live with



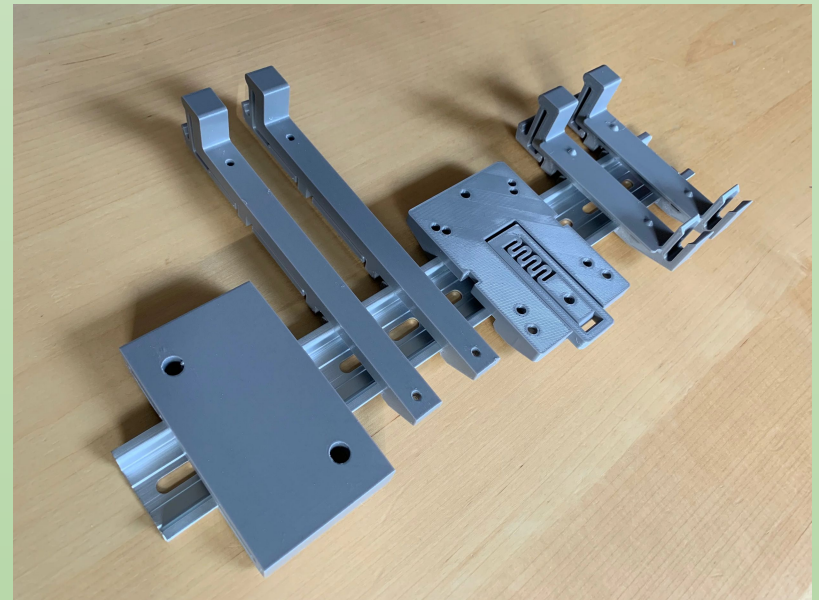
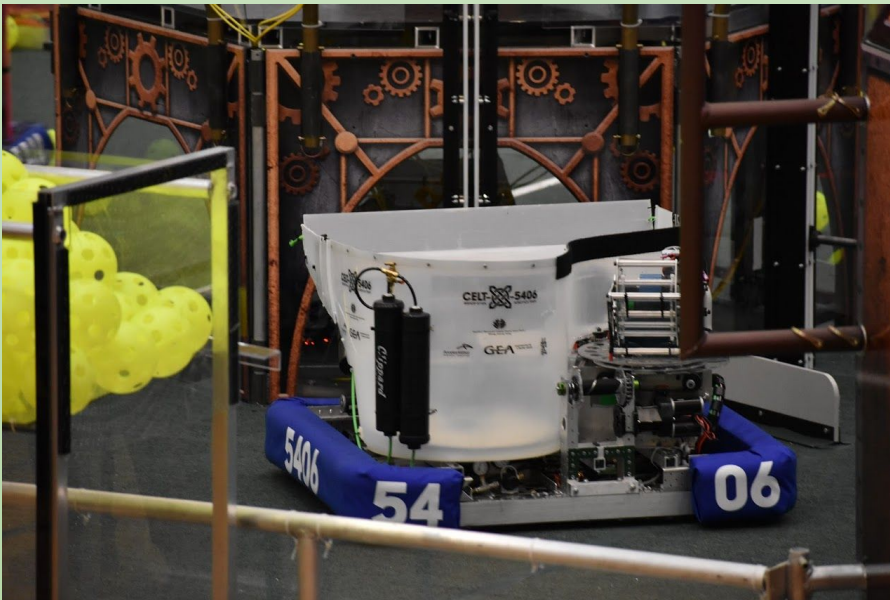
PLAN C: What I'll accept



PLAN D: Sell my soul!

Example: Replacing components in a hurry

- 2017 Solenoids were inaccessible (under the hopper). Of course they came unplugged after a fall from a climb
- OTOH, We have been mounting PDB and Talons under the belly pan in 2017, 2019. Highly recommended (with lexan cover of course)
- New 3D-Printed DIN Rail mounts in 2019 make electronic swaps stupid fast!



Example: Lost or Broken Driver Station

- In 2015 our donated driver station laptop kept crashing
- In 2016 the network card on our driver station (netbook) died in finals
- At Rah Cha Cha Ruckus (Rochester Off Season) 2016 we left the driver station on the bus
 - Bus driver left venue to go sleep
 - Luckily one parent had a car, but we almost didn't make our first match
- Now we bring a backup station and charging cord



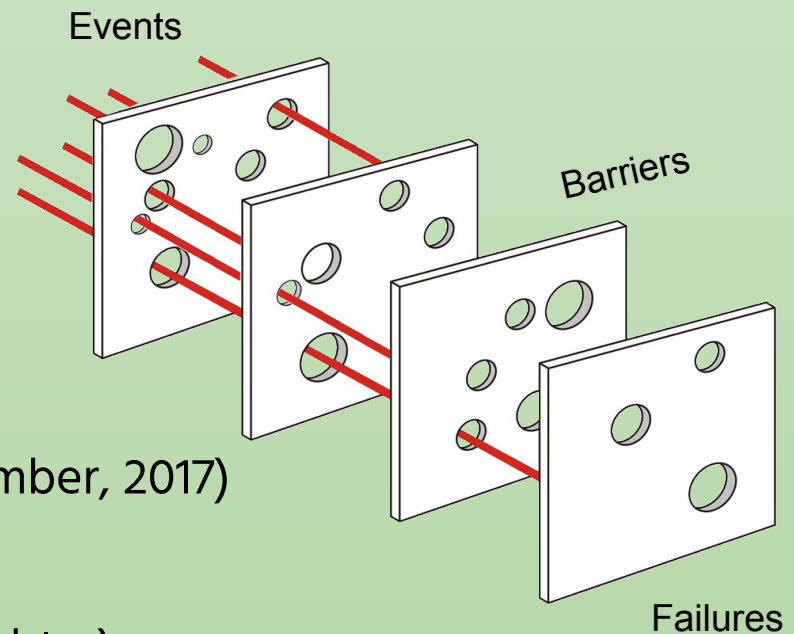
3. Minimize Risk

“The most misleading assumptions are the ones you don’t even know you’re making.” ~ **Douglas Adams (author)**

Strategies to Minimize Risk

In order:

- a. Eliminate the risk (change design, strategy or process).
 - i. Example: overbuilt mechanisms
 - ii. redundant components and strategies (eg. multi motor gearboxes)
Note follower controllers don't count: not independent
- b. Add physical barriers
 - i. Example: hard stops, guards
- c. Add symbolic/ procedural barriers
 - i. Example: training, checklists
- d. Learn the warning signals
 - i. monitor frequently if risk can't be eliminated or prevented (climber, 2017)
- e. All of the above (defense in depth)



(These are also techniques to improve safety btw)

Avoid “Error likely Situations”

Humans and robots are fallible. Can't rely on perfect performance.

- A failure is an error which didn't meet any barriers along the way

If it's easy to do wrong, it will be done wrong. Easy to do right, it will be done right

- Example: End Game “Key Combos” 2018, 2019.

Helpful to think about all of the robot or process Failure Modes and their Effects

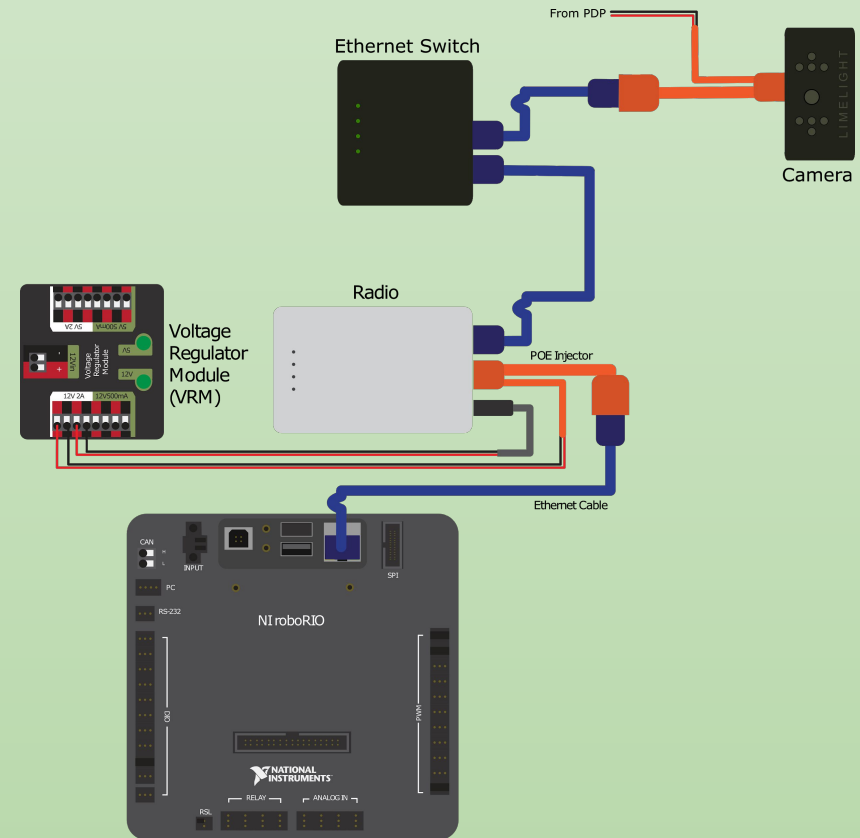
- When a failure does occur, think about all of the things that could have stopped it but didn't
“5 Why's”

Have a “Questioning Attitude” (be a pain in the ass)!



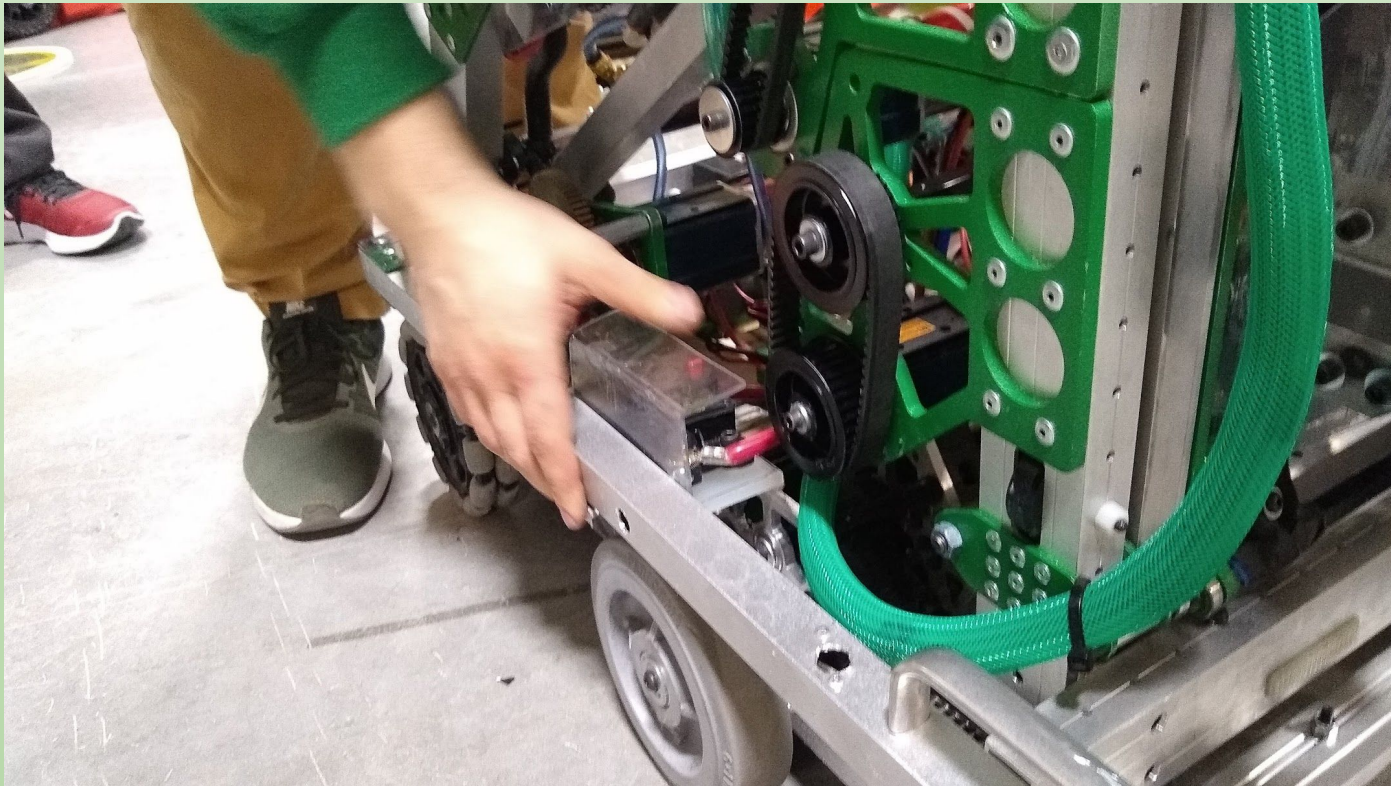
Example: Ethernet on the Robot

- Have to tether to test at competition
- Means unplugging Limelight/Axis Camera or Rio from Radio
 - Opportunity to forget to reconnect after testing
- If you add an Ethernet switch
 - *in the right place*, you can reduce opportunity for failure
 - Caution - the wrong place could increase risk since switch is another failure point!
- Use POE Injectors Too!



Example: Power Switch Guard

- Sometimes barriers actually increase risk (2019 Ontario Division Finals). Think carefully and test thoroughly!!



Use Checklists to Prevent Errors

- Checklists are widely used in aviation, medical and nuclear industries
- Go through step by step (write them down, call them out) ensures no steps are forgotten

Examples:

1. Packing List
2. Pit Checklist
3. System Check !!
 - Run *every* operator/driver function before a match
 - Also check after every repair or code upload - as early as possible to catch errors!



Can't Win Them All, But Do Everything to Try!

You only have 10 short qual. matches at a competition.

Wins, especially upsets, are born outside the playing field. (this could be another whole presentation)

- Pre scouting, especially later in the season
- Roving Repair Team
- Rock solid drive team strategy meetings
 - Bring visual aids. Learn names, build trust, shake hands on the plan
- Communication between scouts, DT, and pit team.
 - Briefs and debriefs.
 - Dead robot list.
 - Live scouting data.
- Ensure drive team looks over partner robots after setup
 - We usually look over robots for things like a battery not strapped in or an exposed main breaker (alliance partner was powered off at Mac, 2017)
 - Holtzman (2056 coach) is always the last to leave the field :)

Example: 2018 RP Assurance Team

- Dedicated team checked every robot for compatibility with our ramp
- Roving pit team made mods to robots if necessary (and agreed to)
- Had teams meet us at the practice field before matches to test run climbs



Practice Makes Perfect

- Run drills. Also practice full matches.
- Time different plays (how long to fill a rocket, how long to run a gear cycle etc). Write times down and keep track of progress
- Practice against strong defense (Newman 2019)
- Practice “decision points” - 2018 mental math flashcard game
- Train a backup team too - people can get sick
- Put together a practice bot if you can, even if it’s made from old parts. Give drive team as much time as humanly possible.
- Come to the Robodrome! “FIRST Aid” event in late February

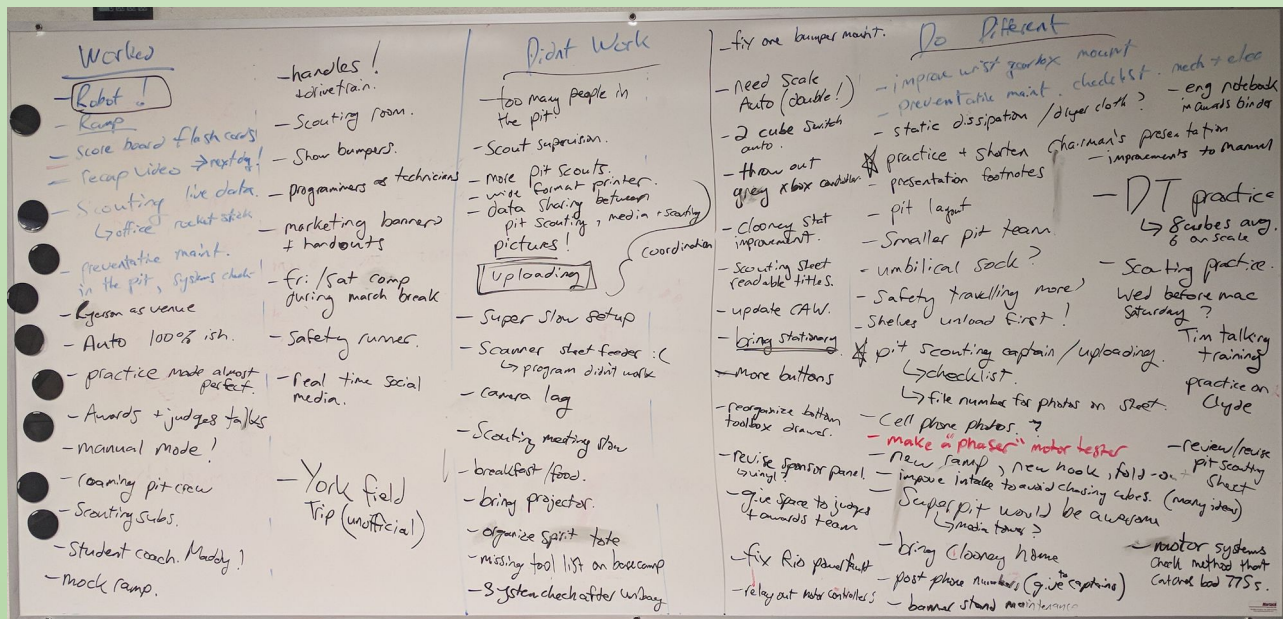


4. Improve

“Progress cannot be generated when we are satisfied with existing situations.” - **Taiichi Ohno (Developer Toyota Production System)**

Debrief

- We go over what “Works”, “Didn’t Work”, and what we could “Do Differently” after every competition
- Never assume an observed failure was a fluke - always make changes to resolve it. Blaming the user is the laziest resolution!



Instant Replay

- Record each match, using a tablet, focusing on recording our robot.
- Stole the idea from team 2337 Engineerds at IRI
- hand tablet off to drive team after a match. Answers the question “what went wrong there” - memory fades quickly



Steal Ideas from Other Teams!

Watch Chief Delphi, Ri3D, Twitch. Be aware of how the game evolves. 3000 teams are smarter than one!

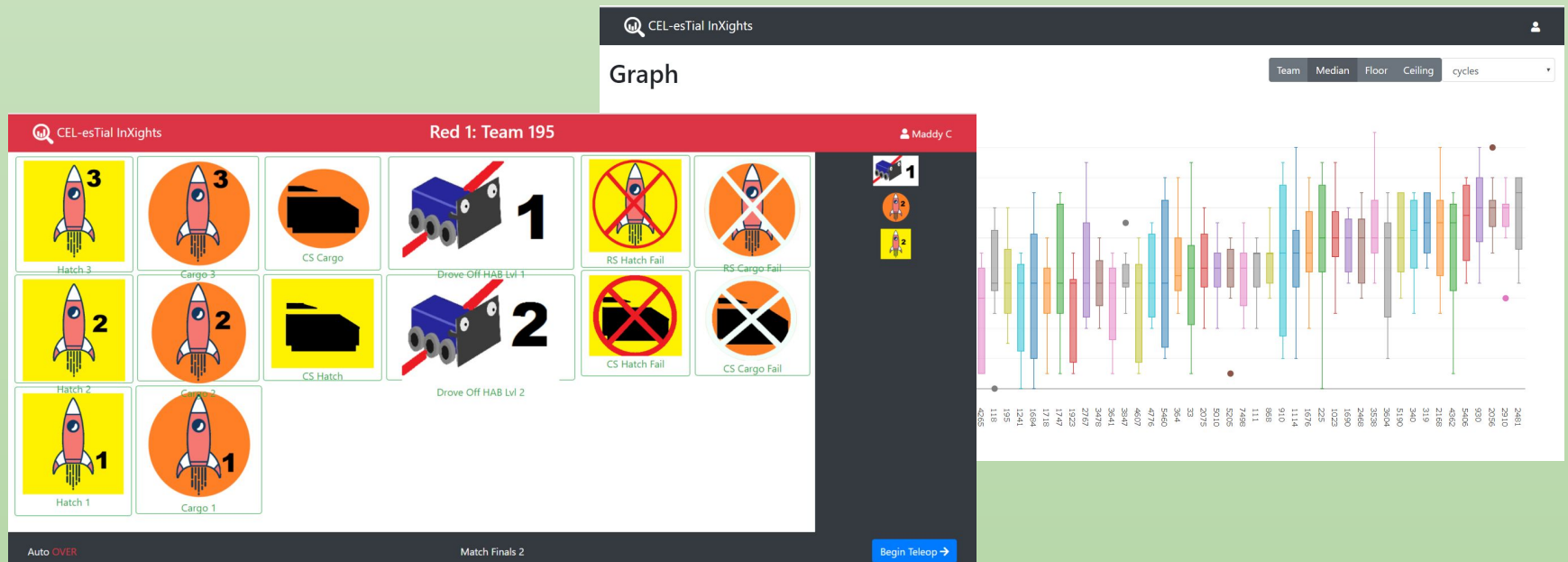
Examples:

- 2014 human-pass plays
- 2015 human player tote table
- 2016 camera poles (thanks 1126!)
- 2017 gear hiding and gear counting signs.
- 2017 velcro ropes with stretchiness
- 2018 two team auto dances
- 2019 ball flooding



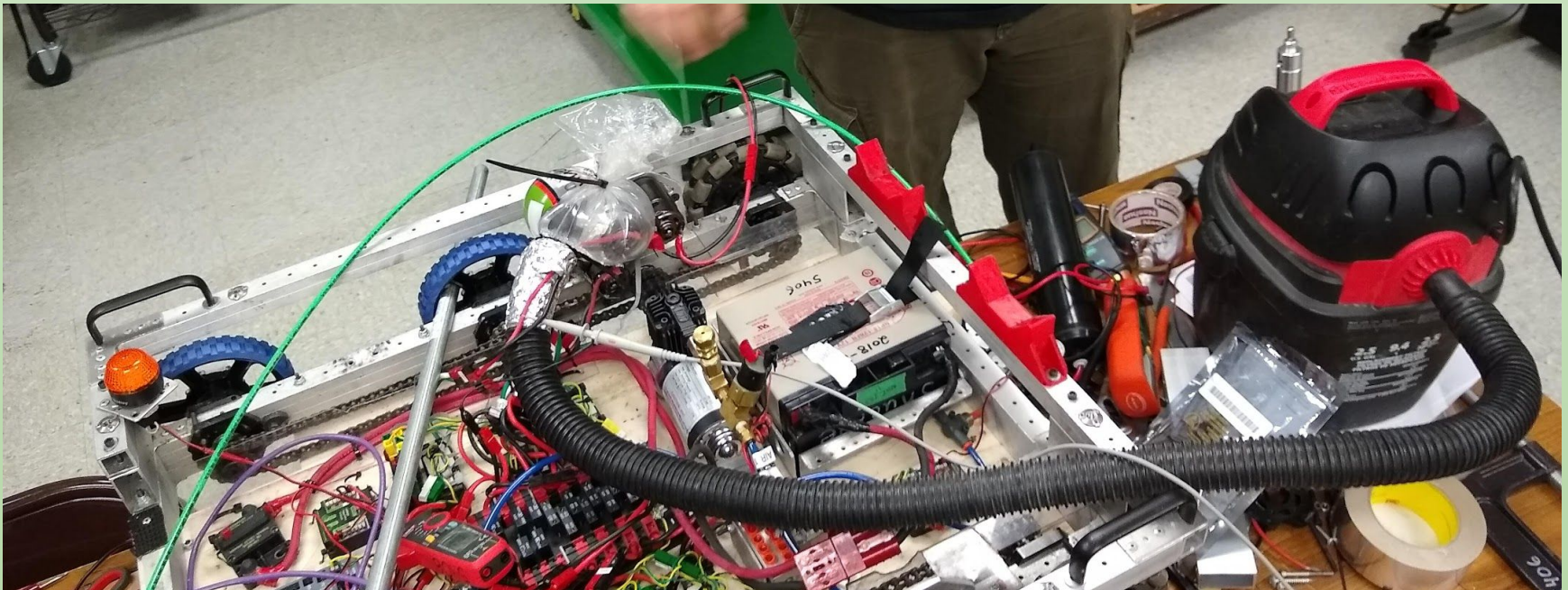
Example: Scouting wasn't valued

- Wrote a scouting tablet App - many ideas from 2056's presentation here
- Use live scouting data for more than just a picklist (inform match strategy)
- Have student leaders and mentors do some scouting as well



Example: 775s Burned Out

- Characterize the motor on an in-house test bed - did the same with the NEOs
- Determined the safe stall current limit (wasn't a published spec at the time)



More Examples of Things We've Learned

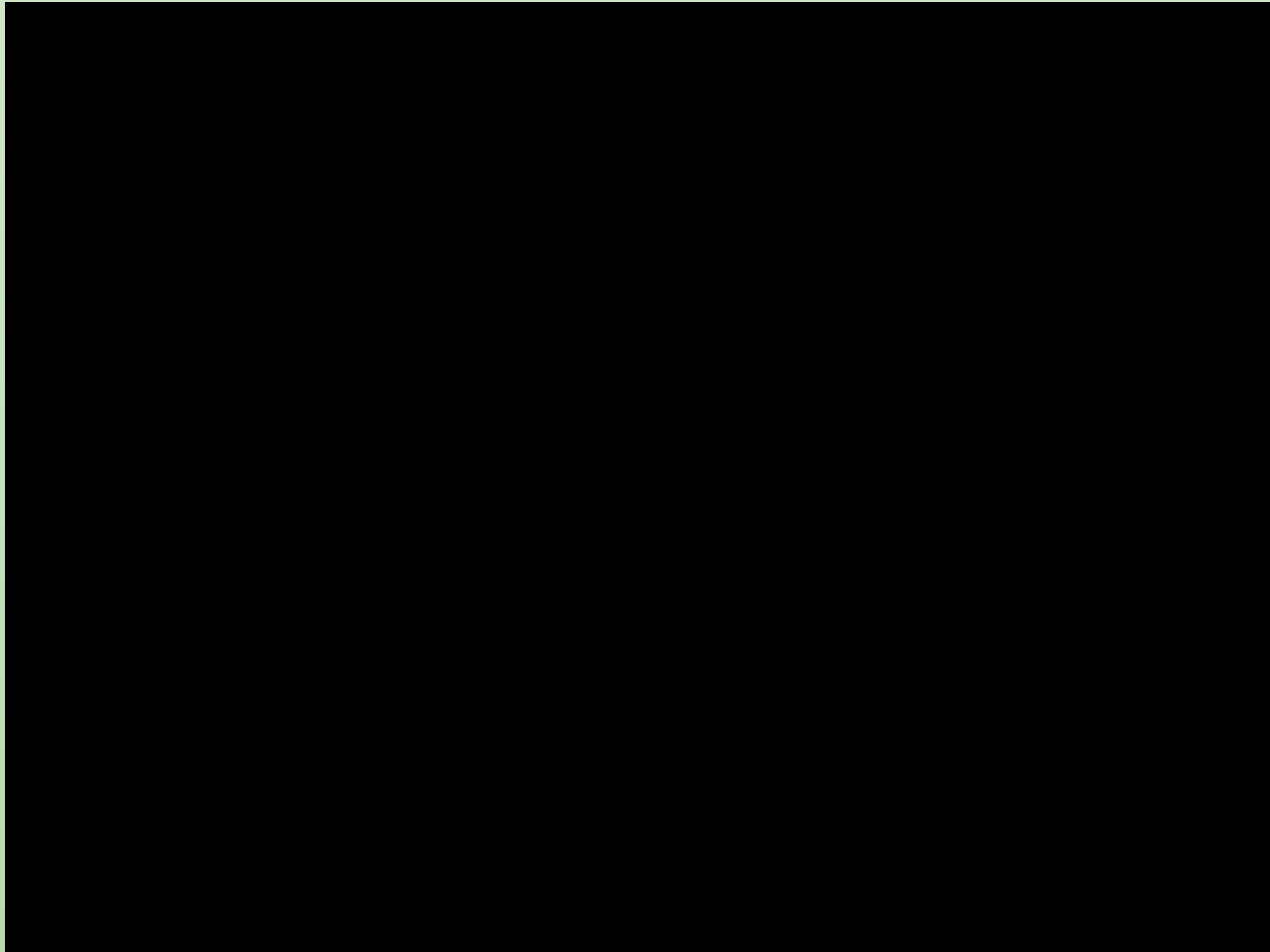
“Diligence is the mother of good luck.” – **Benjamin Franklin (US Founding Father)**

Example: Versaplanetary Gearboxes Stripped

- We now use Andymark 57 Sports exclusively.
- Bonus: 57 Sports come pre-assembled, so less risk they'll be put together wrong



McMaster Semi Finals 2018

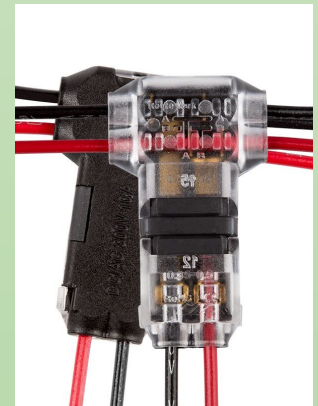
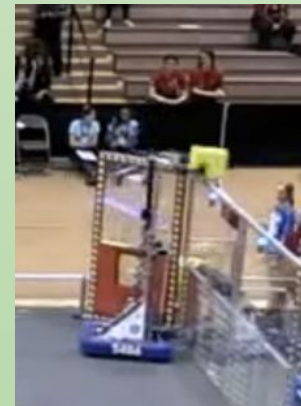
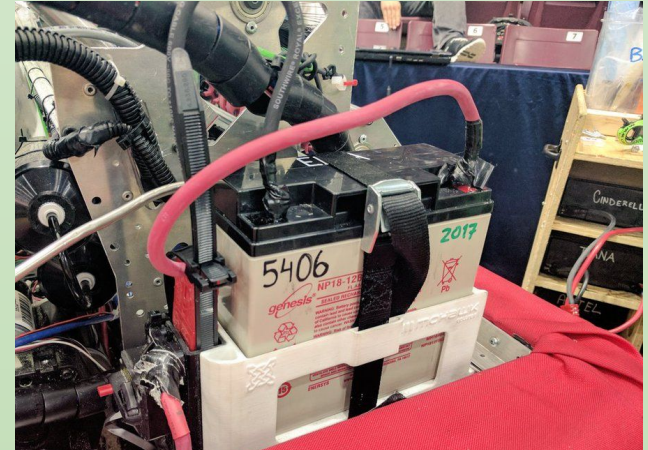


Example: Connectors Coming Unplugged

- SB50 cable on Batteries lost us Mac Finals 1 in 2017
- CAN disconnections gave us trouble throughout 2018.

Solutions:

- IDC connectors on CAN bus (CAN is particularly hard to diagnose)
- Add ferrules to weidmullers on PDB, etc.
- Use POE with Radio
- Use USB ethernet or a “port protector” on driver station laptop



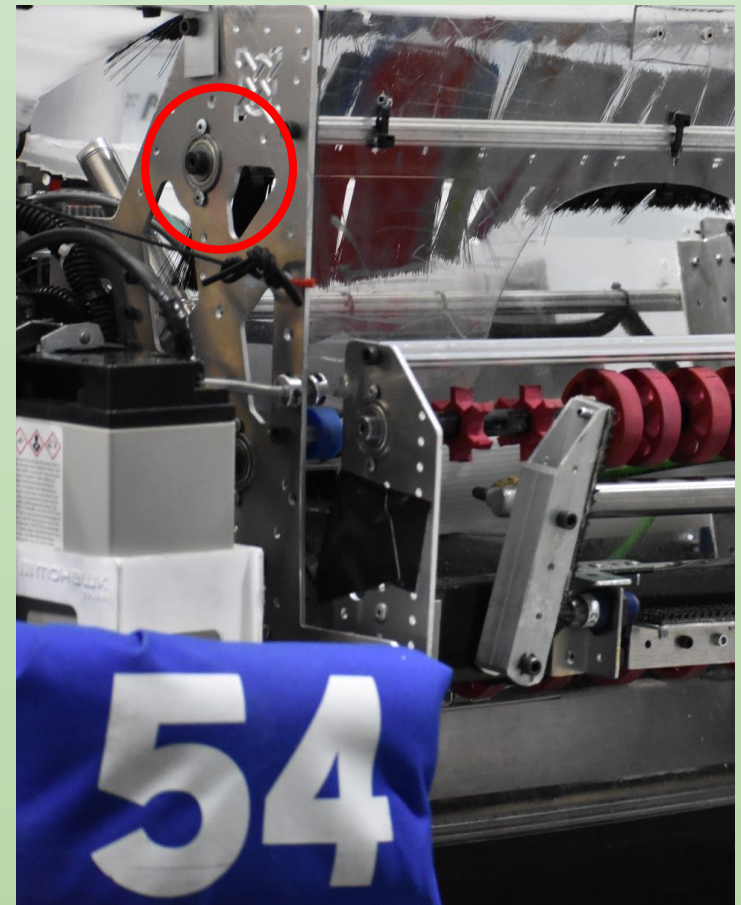
Example: Bolts Loosening

Frequent problem with rotating parts that rub or vibrate

- 2016 Shoulder sprocket bolts
- 2017 Intake live axle shoulder bolts
- Wheel holding bolts every year

Solutions:

- Use threadlocker and Nylock nuts
- Check critical bolts frequently



Example: Metal Shavings in Rio

Solutions:

- Tape over exposed ports
- 3D printed enclosure?
- Cover Rio and use vacuum when drilling
- Return Rios to NI (they'll replace them!)



Example:

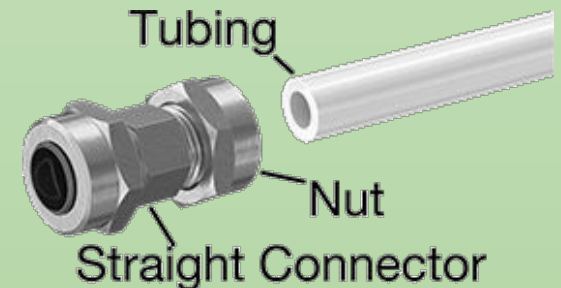
Air hoses coming undone

Problem: Our robot lost all ability to pickup or deploy hatches or cargo (2019 ON District Champs)

- Loss of air pressure.
- Connection at the compressor came undone - could not be reconnected!
- The hot air discharge from the compressor deformed the air line!
- Resolution: replace the short length of air line near the compressor with a higher temperature tolerant material

We've also switched to compression fittings

- tubes kept coming out of push-to-connect fittings in 2016
- Compression fittings more tolerant of bad tube?



Example: Students Miss Shifts at Comp.

These techniques apply not just to technical problems!

Solution: print and post work schedules

Celt-X McMaster 2019 work schedule

Match	Scout Red 1	Scout Red 2	Scout Red 3	Scout Blue 1	Scout Blue 2	Scout Blue 3	Scouting Lead	Scouting Spares
Mentor:	Michelle C, Rethum	Michelle C	Michelle C	Michelle C, Rethum	Michelle C	Michelle C	Mr. Pinto	Michelle C
Saturday AM	Team A	<-	<-	Team B	<-	<-	Alex W	D3
Saturday PM (start before end of lunch)	Team C	<-	<-	Team D	<-	<-	Alex W	C4
Sunday AM	Team A	<-	<-	Team B	<-	<-	Alex W	D2
Playoffs	-		-	-	-	-	-	
Match	Drive Team	Technician	Roving Repair Team	Pit Captain / Battery Wrangler/Safety Captain	Pit Team	Media, Match Video	Pit Scouting / Team Experts/ Qualitative Scouting	Instant Replay
Mentor:	Brendan S	Brendan S	Brendan S	Danny	Danny	Paul C	Andrea V.	Paul C
Saturday AM	Drive Team	Victoria	Nathan C, Dylan	Faith	Team C	Liv, D2	Team G	D1
Saturday PM (start before end of lunch)	Drive Team	Victoria	Nathan C, Dylan	Faith	Team A	Liv, B2, B3	Team G	B1
Sunday AM	Drive Team	Dylan	Nathan C, Victoria	Faith	Team C	Liv, D3	Team G	C1
Playoffs	Drive Team	Dylan	Nathan C, Victoria	Faith	Team B, Alex W	Liv, C2, C3	Team G	D1, A1, C1
Rotating Teams	Team A	Team B	Team C	Team D	Team E	Team F	Team G	Drive Team
1	Francisco C	Ben L	Mike M	Nathan H			Luca R	Maddy C
2	Piercen D	Carla A	Francis D	Andy D			Melina	Lukas M
3	Noah L	Danial	Ethan N	Emmet D			Adiba	Emma M
4			Asher					Andrew C

The Future

Lots more to improve:

- Reduce single points of failure in design (e.g. pneumatic system in 2019 was needed for driving and scoring both game pieces)
- Programming - unit testing
- Motor tester?
- Scouting collaborative? - redundant data
- Keep looking out for better mechanical designs (eg #25 chain broke in 2017, 2019)
- Keep developing new skills in the off season - watch for our new student-designed robot at Ruckus!

Questions and Suggestions?

