

DESIGNING FOR RELIABILITY

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Robust

Replaceable

Robust

- ▣ A robust robot part is one that can handle the abuse of multiple competitions and still work near-perfectly.

Replaceable

- ▣ A replaceable part is a part that- were it to break- could be replaced very quickly.
- ▣ Both robustness and replaceability are desirable qualities in any robot part. For a part to be up to Team 20's reliability standards, it needs to be at least one of these.

Case Study: Cathy

- ▣ Each robot part on Cathy's initial design was built to be either *Robust* or *Replaceable*.



Collector

- ▣ The collector was built to be *replaceable*. The Banebots motors and gearboxes on the collector were known to often break, and needed to be easily replaced. The wheels on the collector wore down quickly as well, so the collector needed to be replaced every so often as well.
- ▣ The result was a collector that- with consistent maintenance and replacement- worked for us all season.

The Shooter

- ▣ The shooter was built *robustly*. The wheel was one that wouldn't wear down easily, and the motor was a reliable CIM motor.
- ▣ The result was a shooter that needed little maintenance all season, and still works today.

The Drivetrain

- ▣ Our original drivetrain was built to be both *robust* and *replaceable*. The reason it is so reliable is because of the West Coast Drive system, where the wheels are cantilevered outside the frame to be easily replaced, the center wheel is driven straight from the gearbox, so that even if a chain breaks, the robot can still drive.
- ▣ The directly driven center wheels demonstrate a concept called a *failsafe*.

The Tray, Climbers, and Other Features

- ▣ The shooter tray was easily removable to do maintenance by removing three pins and detaching some wiring.
- ▣ The climber cylinders were easily *replaceable* by removing a pin and cutting three zipties.
- ▣ The tray's lifting cylinder was easily *replaceable* by removing two pins. This had to be done when the cylinder was bent by another robot ramming it at championships.
- ▣ The sidebelt was built to be robust, but the electrical tape on the belt was easily *replacable*.

Quality

- ▣ Our robot's reliability won us two Quality awards, as well as the Connecticut Regional.
- ▣ After World Championships, where we performed quite well, we set our eyes on the greatest off-season event in the world: IRI.

IRI “Improvements”

- ▣ In order to compete well at the premier offseason event of the world, we decided we needed to improve.
- ▣ While some of these improvements were given the same consideration for reliability that the rest of the robot was, some were not.
- ▣ Items added include:
 - Two-speed gearboxes
 - A pneumatically activated back-of-the-pyramid shooting position
 - A full-court shooter blocker

The Two-Speed Gearboxes

- ▣ The Two-Speed gearboxes should have put up some red flags before we even arrived at IRI. The pinions needed to assemble the gearboxes came too late, and our manufacturing/assembly time cut into practice time. We also had no spares.
- ▣ On the bright side, the gear ratios were made to be traction-limited. This demonstrates a practice known as *designing for failure*. The robot, if it were to get into a pushing match with another robot, was designed to break traction with the ground before any part of the robot breaks.

Point of Failure

- ▣ The addition of the two-speed gearboxes made our robot less reliable by generating a conditional failure point.
- ▣ The wheels on the robot had broken previously, but in the case of the single-speed gearboxes, a broken wheel could not create a catastrophic failure, since the single-speed gearboxes were built with only robust parts.
- ▣ The two-speed gearboxes relied on one small, less robust part called a “Dog Gear”.

The Shattered Dogs

- ▣ The dog gear could handle any load normally applied during driving, but when one of the wheels broke, the wheel was no longer breaking traction with the ground, and was instead breaking the next weakest thing- the dog gears. The gear shattered.
- ▣ In an ideal situation, we would have spares, and the gearbox would have been designed to be replaced. But in our time crunch to finish the new addition, we forgot to design to replace, and as such, we lost 7/9 of our qualification matches at IRI. Our final two matches went well only because we spent time replacing the 2-speeds with the old single-speed gearboxes.

Lessons

- ▣ Design to be *robust* and/or *replaceable*.
- ▣ Design in *fail-safes* in case something goes wrong.
- ▣ Design for *failure* to prevent an important part from breaking.
- ▣ Don't introduce a system unless you are certain of it's reliability.