Final Report

Sportsman Subteam
Florence

Spring 2023
Cornell University

Contents

1 Introduction

1.1 Subteam Purpose

This semester, the Sportsman Subteam will take our design for Florence and bring it into reality. We will machine and assemble Florence into a competition-ready robot. Then, we will take Florence to the Norwalk Havoc Robot League's March 17th competition and tactically dominate all of our opponents!

1.2 Subteam Members

Marcus Esposito	Mechanical Engineering '24	Subteam Lead
Molly Drumm	Mechanical Engineering '23	Vice Subteam Lead
Alex Jenkins	Mechanical Engineering '26	
Caleb Schlissel	Mechanical Engineering '25	
Charles Liu	Mechanical Engineering '24	
Narayan Rueppel	Mechanical Engineering '26	
Sana Gaya	Computer Science '24	
Zarif Pathan	Mechanical Engineering '24	

2 Fall 2022 Process and Florence Overview

During our Fall 2022 semester, we designed Florence, a 12 lb. triangular robot with three flippers (one on each side). It has a two-wheel indirect tank drive, and its chassis is composed of aluminum. We started our design process using the Crazy Eight's brainstorming method and used a Pugh Matrix to rank our ideas. We completed the CAD of our chassis and finalized our drivetrain and electronics using sketches and a circuit diagram. ground.

The ability to right oneself and attack when flipped was a significant focus of Florence's design. Florence was designed to be both invertible and to utilize three 180^o flippers as a self-righting mechanism to remain functional when overturned.

3 Spring 2023 Timeline

Week 1 Meeting 2	Evaluating Jan-Fab progress and moving forward
Week 1 Meeting 3	Begin Assembly of Florence
Week 2 Meeting 1	Assembly and modifications to motor holder
Week 2 Meeting 2	Assembly and modifications to controller
Week 2 Meeting 3	Assembly continues
Week 3 Meeting 1	Assembly and solve belt tensioning issue
Week 3 Meeting 2	Assembly and filing crossbars
Week 3 Meeting 3	Assembly and fitting crossbars in
Week 4 Meeting 1	Discussion of future plans with Lance revamp
Week 4 Meeting 2	Tuning the tension
Week 5 Meeting 1	Prototyping the drive motor wall
Week 5 Meeting 2	Finish prototyping the drive motor wall
Week 6 Meeting 1	Assembly adjustments and electronics wall
Week 6 Meeting 2	Drive motor wall testing
Week 7 Meeting 1	Continue drive motor wall testing
Week 7 Meeting 2	Transmitter joystick addition
Week 7 Meeting 3	Fitting the circuit
Week 7 Meeting 3	Brazing and first test drive
Week 8 Meeting 2	Final competition preparations
Week 8 Meeting 3	COMPETITION
Week 9 Meeting 1	Competition debrief
Week 9 Meeting 2	Subteam report
Week 9 Meeting 3	Planning for the rest of the semester
Week 10 Meeting 1	Subteam report
Week 10 Meeting 2	Subteam report
Week 12 Meeting 1	Starting simulations and calculations
Week 12 Meeting 3	Continuing simulations and calculations
Week 13 Meeting 2	Pulley CAD modifications, part 1
Week 13 Meeting 2	Pulley CAD modifications, part 2
Week 14 Meeting 1	Setting up the 3D printer
Week 14 Meeting 2	Updated drive motor wall prototyping
Week 14 Meeting 3	New pulley prototyping
Week 15 Meeting 1	Drive motor wall prototyping and testing
Week 15 Meeting 2	Subteam report
Week 15 Meeting 3	Finalizing subteam report

4 Overview

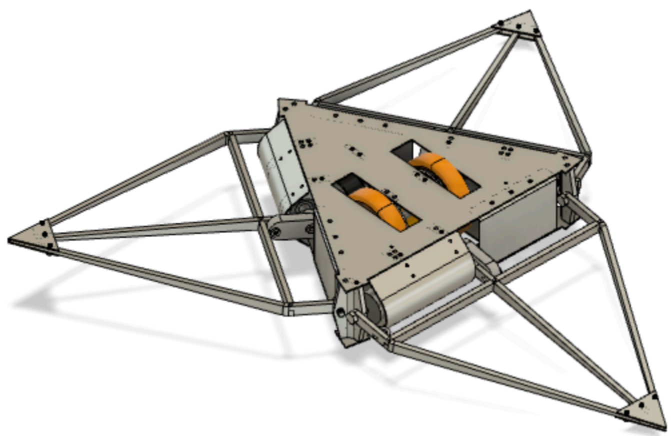

Figure 1: Florence

4.1 Chassis

Florence's chassis is composed of aluminum components fastened with machine screws to symmetrical aluminum sheet metal plates on the top and bottom. Angular edge plates attach to it at the corners to protect it from enemy attacks. The sides are protected with aluminum-sheet-metal-shielded weapon motors and sheet-metal walls attached in a similar fashion to the other chassis components.

4.2 Weapons

Each flipper on Florence is individually actuated by a motor on each side. The flippers are composed of three bars, two of which attach to the sides and the third of which is connected to and actuated by the motor. The bars are welded together at their intersecting ends by a metal triangle that goes under enemy robots. The bars are also connected by a crossbar that is screwed into each of them. The motors are covered in sheet metal to protect them from damage.

Each drive motor is held in place with two walls that slip over the OD of the motor and gearbox. These walls are attached to the motors with the motor gearbox screws.

4.3 Drivetrain

Florence has two-wheel, indirect drive. Each wheel is connected via pulleys to the drive motors. The drive motors are both mounted on a singular wall forward of the wheels. The wheels stick through both the top and bottom plates of the robot, allowing Florence to drive when inverted.

5 Assembly Process

5.1 Chassis

5.1.1 Aligning the Top Plate

During Florence's assembly, we encountered issues assembling its top plate. Although the bottom plate holes aligned with the chassis components, most of the chassis components needed to be pushed into place with quite a bit of force to align the top plate holes. Furthermore, depending on which screws were inserted first, other screws would end up being too tight or completely uninstallable. As a result, we left some screw holes empty in each assembly.

5.1.2 Chassis Walls

Florence utilizes bent sheet metal walls as its top and bottom plates as well as for side protection. However, we encountered some issues with attaching the top and bottom plates. Once the top plate was on, it was impossible to attach the securing nuts on the inside of the chassis. To resolve this, we affixed 3D-printed fixtures with nut-shaped inserts to the inside of these walls for easy assembly.

5.2 Weapon/Arms

5.2.1 Crossbar and Attachment Points

Florence's original design had a crossbar attaching the three flipper arms. The crossbars slotted into the flipper arms with puzzle-fit slots cut to their width. Bolts passed through these slots and held the crossbars in place with a tightened nut.

5.2.2 Brazing

We originally looked at welding the three flipper bars together but found that aluminum welding was extremely difficult and not readily available at the Bovay lab (our contact there is Jim Strait). We then looked into brazing (essentially soldering with a blow torch). It was difficult to control what we melted: we ended up melting the bars and the triangle tips while still failing to melt the brazing bars.

It was challenging to find how long we should expose the bar to the heat. With short exposure times, the brazing bars would melt but the area that the bars need to connect would not be hot enough to bond. However, with longer times, the flippers would get too hot and would melt. A way to avoid this is by applying the blow torch to the intended area for more frequent, shorter periods instead of trying to weld the part in one go. Also, make sure that the bottom joint of the part you are brazing is on a flat surface. Otherwise, the aluminum base will melt out under you.

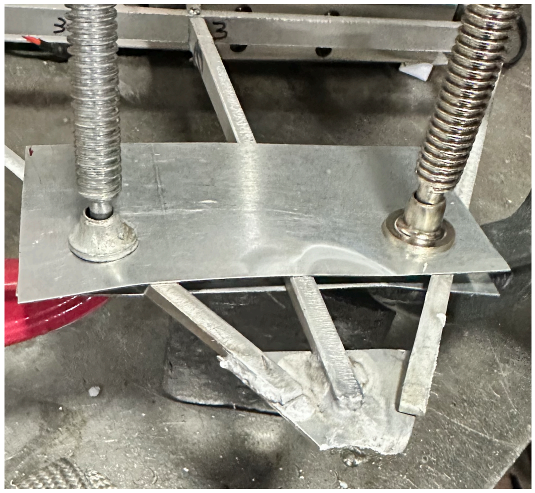

Figure 2: Melted Braze

While researching, we learned that we should not put the brazing rods directly in the flame from the blow torch. For the brazing to succeed, the triangular piece and sidebar had to be connected at an angle so the molten brazing rod could flow into the connection with gravity. A large amount of solder flux was necessary for this to happen.

Figure 3: Single Braze

Despite days of effort, the brazing was not able to form a connection that could withstand any impact at all. Luckily, we received help from a Baja Racing Project Team member who had access to an aluminum welder and was able to help. With his help, we attached the bottom triangle to the rods. From there, we connected the top triangle with brazing. While we were lucky in finding someone to aluminum weld for us, a more permanent solution is needed for attaching the tips to the flippers.

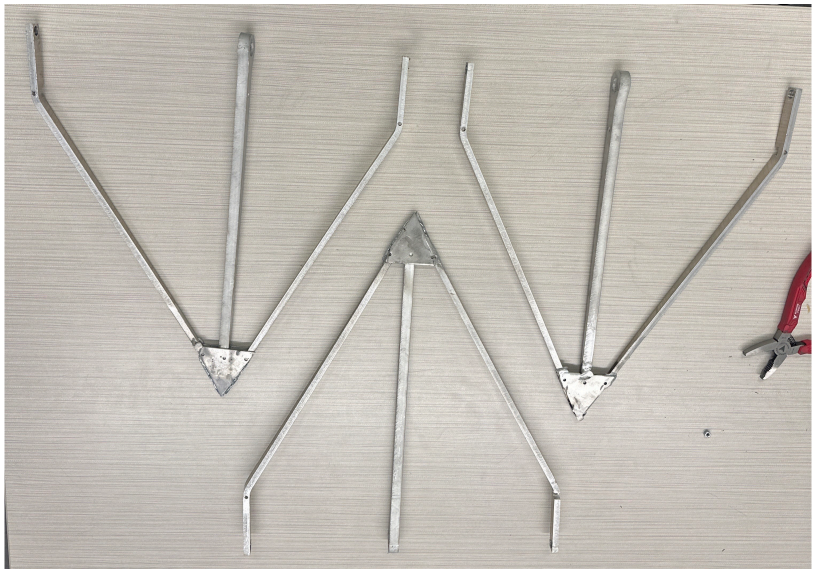

Figure 4: Fully Brazed Flippers

In testing, the top triangle of the green flipper broke off. Besides this, the welds and brazes held up quite well. Figure 4 depicts all the filler material we piled on underneath the top triangle plate.

Figure 5: Fully Brazed Flippers

5.2.3 Brazing Research

We used four different types of brazing rods: ”Alumiweld Rods”, ”Bernzomatic AL3 Aluminum Brazing/Welding Rods”, Amazon’s ”Aluminum Brazing Rod”, and ”Aluminum Solder”.

The best rods were ”Alumiweld Rods”, bought at Harbor Freight. They had a good melting point, adhesive capacity, and flow. The downsides were that they were rather long and thick, so it was hard to be precise with them.

The next best was the ”Bernzomatic AL3 Aluminum Brazing/Welding Rods”, bought at Home Depot, can also be found on Amazon). They were pretty decent at melting at a sustainable temperature and worked better in smaller spaces. The downside was that they came in packs of two which made them a more limited resource considering that you go through a lot of brazing material per braze.

The third brazing rod was the ”25 Rods Aluminum brazing Rod NEW”, bought from Amazon. This was the first one we tried to use. They were a decent thickness but were very unreliable, and their range of melting points varied immensely. They would either melt too quickly or not at all, and we would be left with melted aluminum bars and triangle connectors.

The final type of brazing material we tried was ”Aluminum Solder”. It had too low of a melting point and would just melt out into a pool making it hard to use. In addition to this, it formed brittle connections.

5.2.4 Blow Torches

The best blowtorch for brazing is a yellow canister Butane torch. This torch was borrow from the Baja Racing Project Team, who also lent us the space to braze in their workshop (Auto Lab). The blow torch reached a good temperature and was easy to use.

In the future, use the blow torch inside and do not braze in the cold or wet weather. Brazing rods do not flow well in uneven temperature outdoors and cold, wet, and windy weather makes it nearly impossible to reach the desired flow temperature

Do not use blue canister, Propane torches for brazing. They do not get hot enough to melt the braze and material into a nice even flow.

Figure 6: Blue and Yellow Blow Torches

5.3 Drive Train

5.3.1 Wheel Spacers

After fully assembling Florence, we noticed that there was a large amount of wobble in the wheels due to a sizable gap between the wheel and the wheel walls. To fix this problem, we introduced wheel spacers (washers). While these helped the issue of the wheels wobbling, they caused some other issues with the drivetrain: now that the wheels were shifted, the pulleys on the wheels were slightly misaligned with the pulleys on the motors, which may have played a role in some of our belt tensioning issues.

6 Electronics

6.1 Circuitry Overview

Given the unorthodox nature of Florence's design, our circuitry is also fairly complex. With five different motors and ESCs (three separately actuated weapon motors, and two drive motors), we needed to overcome some particular design challenges in developing the layout of our circuit.

We decided to split the current into two branches: one for the drivetrain, and one for the weapons. Each branch contains its own receiver, which is connected to the corresponding ESCs in each branch. With three weapon motors, we had to split the current in the weapon branch three ways, and we analogously split it two ways in the drive motor branch.

At the head of the circuit is the connection port for the battery, separated from the rest of the circuit by our power switch. Upon connecting the battery and closing the switch, current is delivered to the rest of the circuit.

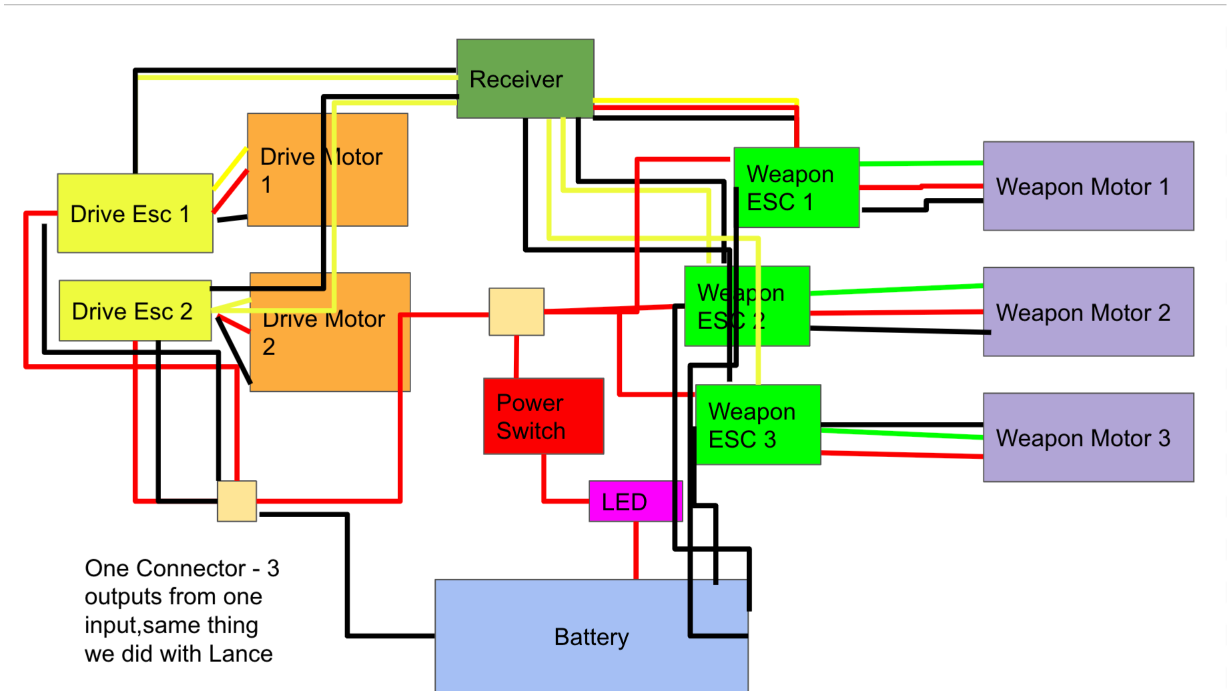

Figure 7: Final Circuit Diagram

6.2 RC Overview

Florence's unique design also necessitated the use of two different transmitters and receivers. Since we wanted Florence to have five separately-actuated motors, we needed access to 5 separate primary channels (to be controlled by the transmitter). Since the receivers we were using only supported 4 primary channels and 2 auxiliary channels, this gave us the opportunity to use two different transmitters: one for weapon control, and the other for drive control.

As mentioned previously, we placed one receiver in each main branch of the circuit. For each receiver, the corresponding transmitter sends the user's signals to the receiver to power the motors at different speeds. The receiver dispenses the transmitter's signals to each of the ESCs. The ESCs control the voltage sent to the motors and consequently determine their speed.

6.3 Transmitter Modifications

While using two different transmitters allowed us access to five different primary channels, we needed to make some modifications to allow for intuitive user control. Specifically, we wanted to support isolated joystick actuation for each weapon and single-joystick tank drive for the drivetrain. It is important to note that holding down the "cancel" button on Flysky transmitters saves the current settings.

6.3.1 Weapon Transmitter

The most intuitive control mechanism for the weapons is the vertical movement of a joystick, with an "upward" movement moving a flipper up, and vice versa. Since Florence was designed to be invertible, this meant that we needed joysticks that could "auto-center" (i.e. non-throttle gimbals). Each transmitter includes two joystick, only one of which is spring-loaded ("auto-center").

To fix this, we spring-loaded the existing "throttle" joystick and incorporated a third joystick to be mounted on the side of the transmitter. The first step was rather straightforward but incredibly tedious. Using a gimbal upgrade kit, we added a spring to the existing throttle to enable "auto-centering."

The second step was more complex. We ordered an additional joystick, but connecting it to the transmitter was a challenging ordeal. Upon analyzing the transmitter's circuitry, we learned that it was possible to connect the third joystick to a port that previously accepted input from two switches. After soldering to re-purpose existing wires, we successfully connected the third joystick to the transmitter and sent a signal to the receiver.

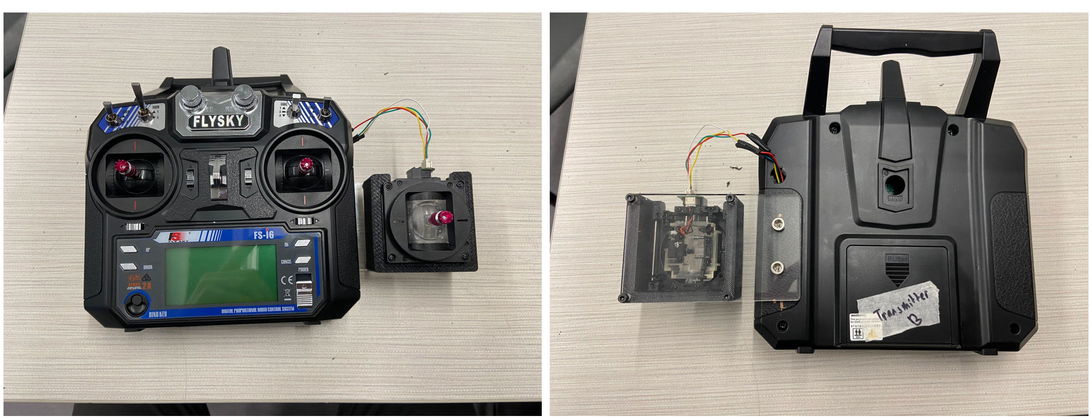

Figure 8: Finished Joystick Attachment

However, one complication we failed to account for was the existence of the transmitter's default safety warning upon startup. This message prevents the use of the transmitter unless all switches are in their upright position and the "throttle" is in its downward position. Since we had replaced the switches with a joystick, the solution to bypassing this warning was less intuitive and took some trial and error. After some investigation, we realized that moving the third joystick to its leftward position (which we proceeded to orient as its relative upward position) served the same functionality as putting a switch in its upright position. This allowed us to get past the safety warning and use the transmitter without issue.

Another complication was the translation of analog joystick input to a port (originally used for a switch) that solely recognized binary modes. There was nothing we could do to circumvent this issue: it just meant that the weapon controlled by the third flipper could only be actuated if the joystick was pushed to its fullest extent (either up or down). This then activated the flipper at maximum speed. While this is inconvenient for the driver, it was easier to use after limiting the max power sent to the motor with the transmitters built in programming.

After 3D-printing and laser-cutting parts for a simple mount, as well as drilling a few holes in the transmitter's casing, we affixed the additional joystick to the side of the transmitter, making our weapon transmitter fully ready for use.

After competition, we continued to experiment with the weapon transmitter and successfully assigned the third joystick to the knobs instead of the switch control, allowing for analog control rather than binary control from before. We also adjusted the power output from the flipper motors by using the "Throttle Curve" feature in the systems menu and adjusted the curve to have a maximum of 80 percent and a minimum of 20 percent. The knob was centered slightly off-center, and we fixed this by using the "Trim" menu and adjusting the base position.

6.3.2 Drive Transmitter

With the weapon transmitter figured out, we proceeded to modify the drive transmitter to suit our needs. This process was much more simple and only required some foundational knowledge of channel mixing.

In order to accomplish a single-joystick "tank" drive, we had to establish two channel-mixing lanes. We configured the transmitter so that the one spring-loaded gimbal was bound to Channels 1 and 2. From here, we implemented two mixes (one with Channel 1 as the master and Channel 2 as the slave, and the other with the opposite relationship). To ensure the tank drive would function as intended, the former lane was set to possess relative scaling of 100 percent, with the latter at -100 percent (for purposes of symmetry).

After implementing these standard methods, our drive transmitter was fully configured and ready to be used to control Florence's drivetrain in battle.

7 Recurring and Unresolved Issues

7.1 Belt Tensioning

7.1.1 Initial Design of Drive Motor Holder

The drive motor holder is 1.5 inches by 0.25 inches by 3.0 inches, with screw holes on the top and bottom to attach it to the top and bottom plate of Florence. There are a top and bottom set of holes that are used to attach the motors. The left motor is attached to the bottom set of holes, while the right motor is attached to the top set. In the initial design, the top and bottom sets of holes were offset from the side by the same distance, as we initially assumed that both motors would need to be the same distance from the wheels.

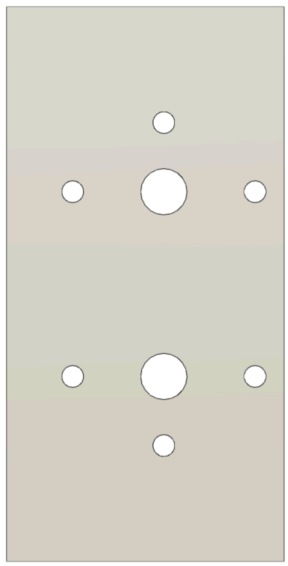

Figure 9: Initial Drive Motor Holder

However, when we first fully assembled Florence, we noticed that while the tensioning on the right belt was acceptable, the left belt was much too loose.

7.1.2 Prototyping Sprint

To fix this problem, we designed several iterations of the drive motor holder with the bottom holes shifted towards and away from the wheels, changing the tension on the belt. Additionally, we shifted the screw holes on top to help them better line up with the chassis plate holes. Our twelfth iteration worked the best, and the tensioning on the left belt seemed very good. However, the tensioning on the right belt was suddenly very tight, despite us not moving those holes at all. To fix this, we made another four iterations with the right motor holes shifted in relation left motors to the and the width increased slightly. The first of these worked the best, and we decided to use this as our final design.

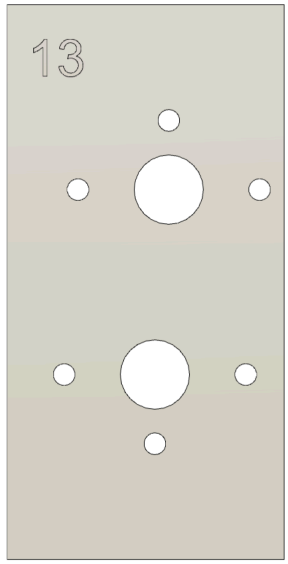

Figure 10: Final Drive Motor Holder

7.1.3 Final Design Flaws

Having decided on the 13th iteration of the drive motor holder, we had the final version printed again in PLA and inserted it into the fully-assembled Florence. While the tension seemed good initially, the belts lost tension after a few minutes of driving. This increased belt slippage and led to the pulleys being stripped. One issue that may have caused this is the fact that the constant tension may have caused the bending of the wall, thus loosening the belt tension. As well, the motors were unable to provide sufficient torque to drive Florence, instead stripping the pulleys, loosening the belts.

7.2 Belt Tensioning v2

7.2.1 Thicker Pulleys

After watching the pulleys get stripped at competition, we redesigned our pulleys to be stronger. We used thicker belts and adjusted the width of our pulleys accordingly (from 4mm to 6mm). We also decreased the pitch so that our teeth were larger and less easy to strip/break.

7.2.2 Pulley Prototyping Plate

Given how much of an issue the poor belt tensioning proved to be at competition, we decided we needed a more robust method for testing the belt tensioning. To do this, we designed a plate that we could attach the pulleys to while changing the distance between the center holes of the pulleys. The initial plate hole was spaced based on the calculated distance between the pulleys (2.858 inches). The distance to the other holes was then increased or decreased by 1mm so that we could test different spacings.

Figure 11: Drive Motor Plate: Iteration 1

This worked fairly well. Since the larger pulley rested so far above the plate, it caused the axle to bend. This affected the belt's tension, making it appear looser than actuality. To fix this, we sank the motor into the plate so that the large pulley would be just above the plate itself.

Figure 12: Drive Motor Plate: Iteration 2

This improvement worked quite well and aided us in finding a pulley separation that got us an agreeable tension (3mm longer than the calculated Center-to-Center Distance).

7.2.3 New Tensioning Implementation

Now that we had a new value for the center-to-center distance between our pulleys, we reprinted our drive motor holders and put them into the robot. Unfortunately, this did not seem to fix the tensioning on the belts. Just as before, the belts were incredibly tight. Before we could run the motors, we discovered that several new issues had arisen from our use of wider pulleys. The wider pulleys now collided with our electronics wall, meaning we had to widen the electronics wall to accommodate the pulleys. However, this was difficult since we had limited room in the chassis and our print kept failing. Additionally, both the wheels and the new pulleys attached to them were now running into the sides of wheel holes in the top and bottom plates. To fix this, we attempted to file down the inside of the wheel holes so that the wheels would not run into them. This worked for the wheels, and they no longer ran into the plates. However, we could only file so much before we ran into the screw holes, which prevented us from filing away as much as we needed. This meant that despite any changes we made to tensioning, the wheels still would not turn properly since the pulleys were grinding against the top and bottom plates. In trying to run them, we again stripped the smaller pulleys.

7.3 Chassis Sparking

If the power switch on Florence touches any of the metal walls while the circuit is on, then it will immediately begin sparking. This is because there is at least one other metal part of the circuit that is touching Florence, so as soon as the power switch touches the side, the circuit shorts. This caused some major issues for us at the competition, as we were unable to insulate the chassis enough, and the circuit would be rendered useless. To fix this in the future, we need to work on better insulating the chassis from the power switch as well as making sure that the circuit itself is completely insulated. For instance, there were many components such as the receivers (with their exposed metal leads from unused channels) that were simply left uncovered without any insulating material. In the future, any unused metal leads or unconnected wires will be wrapped in electrical tape or 3D printed covers to prevent any shorting of the circuit.

7.4 Overtorquing Weapon Motor

During testing and at competition, we bent four separate weapon motor axles. This is most likely attributed to the fact that we applied too much power to the motors through the transmitter. Since the weapon motors' range of motion was only physically constrained by the chassis, if the motors were pushed too far, they would bend themselves against the chassis.

We attempted to repair these motors by bending the motor axles into place with a hammer. While we could not bend these back into place, our attempted repair did not damage the motors and we did still use them.

7.5 Electronics Wall

The electronics wall is designed to keep the electronics contained within Florence. It prevents the wires from getting entangled with the wheels in the robot. However, the tolerancing in the design was too close. We did not account for the correct width and length of the electronics wall.

Originally, we planned to make the electronics wall with holes so that it could be screwed onto the bottom plate. However, because of its complications, we decided on placing the electronics wall inside the chassis, constrained by compression between two edges of the wall. We also placed a skid as a spacer to keep it in place. In the future, we should design the electronics wall with a length such that it fits perfectly inside the chassis without moving.

7.6 Transmitters

While we found a temporary solution to the transmitter challenge, it feels like there should be a better way to go about controlling Florence. For starters, separate joysticks for each flipper can be a bit annoying, especially in cases where it could be useful to activate all flippers at the same time. With only two hands, it can be a bit difficult to flip all three joysticks simultaneously. Perhaps introducing some channel mixing might be worthwhile. In the case that we are able to consolidate all flippers under one joystick, we could use the secondary joystick for tank drive, meaning that we would only need one transmitter to fully control Florence.

7.7 Chassis Wall Nut Fixtures

Since there is not a lot of room to reach inside Florence, we did not have much flexibility to secure nuts in place while screwing in the chassis walls. As such, we had to devise a solution to hold the nuts in place for us. This came in the form of a small rectangle, with three inlays for nuts. Gluing these to the chassis wall allowed screws to be screwed through the holes directly into the nuts. Unfortunately, the glue wore off after a while, making this solution unsustainable. We need to find a better way to secure the nuts or design different ways to attach things with only one side free.

8 Design Critique

8.1 Weak Flippers

The original design of the flippers included one powered central flipper and two angled flippers on each side. The flippers were to be attached together near the chassis with a crossbar and brazed at their ends to a shared triangular tip plate.

The main flaw with this design was the puzzle-fit crossbar and the screws that were meant to secure it. The puzzle fits removed half of the width of the flippers, significantly reducing their stiffness and ability to reduce bending. Since the puzzle fits were only on half of the flippers, the flippers would experience tension or compression under bending. The screw hole was also drilled directly in the middle of these puzzle fits, reducing the cross-sectional area of the flipper and concentrating the bending stress. In the end, the smallest cross-sectional area of the 13 in flipper was 0.03125 in^2, much too small to actually support flipping 12 lb. robots.

8.1.1 Crossbar

The purpose of the crossbars was to hold the three flippers in place so that the weapon motor moved each side as a single assembly. The crossbar fit snugly into the center of the side flippers using puzzle fits and was secured to each flipper with a 5-40 screw and nut. However, the high torque motors combined with weakened puzzle-fit joints and screw holes, made the crossbar snap in the middle. The crossbars can be approximated as a beam fixed at both ends with a force applied at the center (the center flipper powered by the weapon motor).

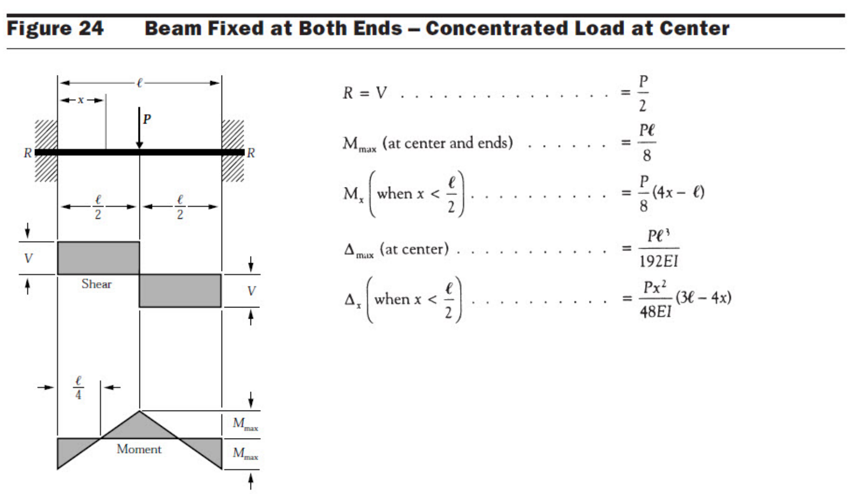

Figure 13: Crossbar Bending Moment Diagram

While this approximation is not exact, Figure 13 illustrates how the maximum bending moment endured by the crossbar is in the middle, directly where the crossbar experiences the most stress and where the crossbars broke.

8.2 Florence Cannot Flip

Once we fully assembled Florence and were testing out its flippers on heavier objects, we noticed that instead of flipping them, the opposite end of its chassis would lift up. This was not a one-time issue and comes from a critical design flaw. When Florence lifts an object, it applies a torque to its flipper, whose axis is at the motor on Florence's side. This torque is counteracted by Florence's weight which acts in the opposite direction. However, since Florence is in the 12-pound weight category, all of its opponents are almost exactly 12 pounds. There are less than 12 pounds of Florence on the other side of the axis when it attempts to flip an opponent, which is why Florence lifts into the air. As Florence is currently designed, it would need to be around 40 pounds to be able to successfully flip a 12-pound opponent.

We designed Florence and our previous robot, Lance, to both be invertible and reversible. In the future, we should not do this again because it is redundant (if a robot can reverse itself, it does not need to have the ability to drive when inverted) and basic statics. Having a symmetrical design for the robot to enable reversibility would constrain the locations of the flippers and lower the maximum amount of torque it they deliver.

8.3 Difficult Assembly

There are too many screws on the top plate. It took a long time to remove the top plate and replace components on the inside in the event of a failure. In the future, we should reduce the number of screws needed assembly. Moreover, the holes on the top plate did not fit perfectly with the components inside the main body. We should use slots instead of individual holes on the top plate for an increased tolerance of screw hole alignment. Longer slots would allow the screws to have more flexibility in their position and allow us to screw parts and avoid "holding things in place" while doing so.

In addition, we could not access the holes on the top of the side walls. We tried to remedy this problem by gluing down 3D-printed plastic nut fixtures on the side walls but they often fell off. In the future, we should instead design screw holes and screw the 3D-printed part onto the side wall.

The crossbars were very difficult to attach to the center flippers. The center flippers would not attach to the crossbar because the tolerances were off, and the screws did not fit well. In the future, we should not use crossbars and increase the tolerance of puzzle-fits.

9 Competition Analysis

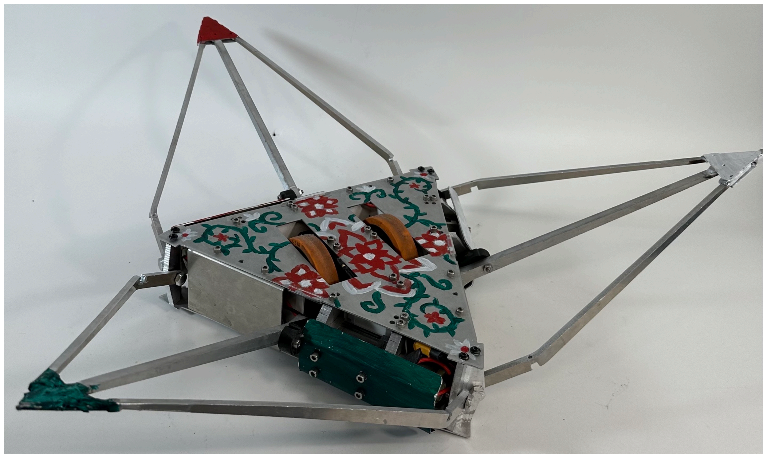

Figure 14: Florence Ready for Battle

9.1 Matches and Results

Note: Florence's finalized weapon lock was Marcus's belt.

Match 1: With little hope for success, we could only hope to make a spectacle with our robot. While Florence did lose, she gave a spectacular match that included tabling (activating all flippers at once to rest on them) and full-body spinning. However, she was mostly unable to move throughout the match, and the flippers deactivated for unknown reasons. During the match, three flippers and one of the wheels were disabled. In addition, since Florence was only fully assembled the night before competition, our drivers (Zarif Pathan driving and Alex Jenkins controlling the weapon) had little practice and could not reliably control Florence.

Match 2: In this match, we conservatively controlled Florence to reduce the damages taken. Florence won this match but still sustained a lot of damage. We had better control in this match and performed a phenomenal dodge into tabletop mode. The drivers (Alex Jenkins and Zarif Pathan) worked better as a team. We may have won this match by shocking and disabling the opponent with our faulty power switch. After this match, we completely replaced all the chassis walls and reinserted all of the internal components. We also used lots of electrical tape in the area around the power switch after we found out the power switch was short-circuiting when its metal screw touched the aluminum chassis walls. Because of the circuit and external damage, we took much longer than the officials gave us to prepare for the next match.

Match 3: We forfeited this match due to the aforementioned short-circuiting power switch. Florence short-circuited shortly before the beginning of the match.

9.2 Spares Preparation

Florence did have enough spare chassis wall parts. However, we only had one set of spare flippers per side. There were no spares for the side flippers because they were custom welded. Since the center flippers were a rush job finished the week of competition, they did not feature side flippers.

Florence consisted of several custom (and difficult to manufacture) parts that made making spares nearly impossible. Similar to the welded flippers, the angled edge plates were incredibly difficult to machine (the angles required custom fixtures, many of which did not work). Furthermore, we do not own much tooling so we had to borrow all tooling from other teams and the Emerson Machine shop.

9.3 Preparation Outline

To effectively organize our competition preparation workflow, we should begin by creating a detailed timeline of tasks and goals leading up to the competition. This timeline should include tasks such as robot design, prototyping, testing, and refining. We should also schedule regular testing sessions to ensure that the robot is fully functional and operating at its best capacity. We should assign specific tasks to each team member, based on their skill set and expertise, and establish regular check-ins to ensure that everyone is on track. To streamline our preparation efforts, we should also prioritize tasks and allocate resources based on the importance of each aspect of the competition. By carefully organizing our competition preparation schedule, we can ensure that future robots are well-prepared to compete and have the best chance of success at NHRL.

10 Reflection of Work Flow

10.1 Task Assignment

Throughout the entire assembly process, Sportsman struggled with keeping everyone busy with meaningful work. There are a lot of Sportsman members for a relatively small bot. In Fall '22, the last ten minutes of each meeting were dedicated to assigning tasks for the next meeting. However, the subteam lost this part of the organization when the team expanded with the new members. Losing this organizational time was even worse because of the expanded team size. With so many more members and no time for assigning and organizing tasks, the team's meetings were somewhat chaotic. We would crowd around the robot, observing the few members working on Florence. Only a few other members would be working on external components because as we got closer to competition, Florence became more assembled and it was harder to distribute tasks. Toward the end, we identified members to work on the drivetrain and prototype pulleys, and we assigned others to work on the physical assembly of Florence.

10.2 Lance Revamped

An idea was proposed to revamp Lance, purposed with keeping members occupied and engaged. However, due to a lack of clarity as to the guidelines and end goal of the project, members quickly became frustrated with the task. A lack of communication on all sides of the project led to growing frustration. After having a meaningful conversation with all members regarding their desires and interests, the issue was rectified, and Sportsman got back on track.

11 Brands and Product Analysis

The process of procuring the necessary materials and components for our project was an essential aspect of our work throughout the semester. We conducted extensive research and evaluated various brands to determine which would best suit our needs.

As we reflect on our experience and plan for future projects, it is clear that obtaining our own 3D printer could prove to be a valuable investment. The Bambu printer, in particular, has been identified as an efficient and effective option that could significantly minimize delays and expedite our assembly process. By having greater control over the manufacturing of essential components, we would be able to progress more efficiently and effectively toward our project goals. Overall, our experience with procuring materials and components throughout the semester has taught us valuable lessons about the importance of reliable suppliers and having access to necessary resources.

11.1 Midwest Steel

Most of the brands we ordered from worked well for us this semester. The one issue we had was with Midwest Steel, the company that we ordered stock from, which took up to a month to deliver each time. Later, we switched to Online Metals, shipping in about a week compared to Midwest Steel's two months.

11.2 Rapid Prototyping Lab

The other place we ordered from was Cornell's own Rapid Prototyping Lab (RPL). Relying on another source for 3D-printed prototypes was incredibly detrimental to the pace of our assembly. As we were trying to prototype the drive train tensioning and make pulleys, we had to wait weeks to get our pieces from the RPL. In the future, we will be able to prototype on a more accelerated timeline with our recently acquired Bambu printer.

12 Conclusion

12.1 References / Citations

A large amount of research and information used in this report is credited to the popular Combat Robotics forum, Ask Aaron.

12.2 Contributors

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