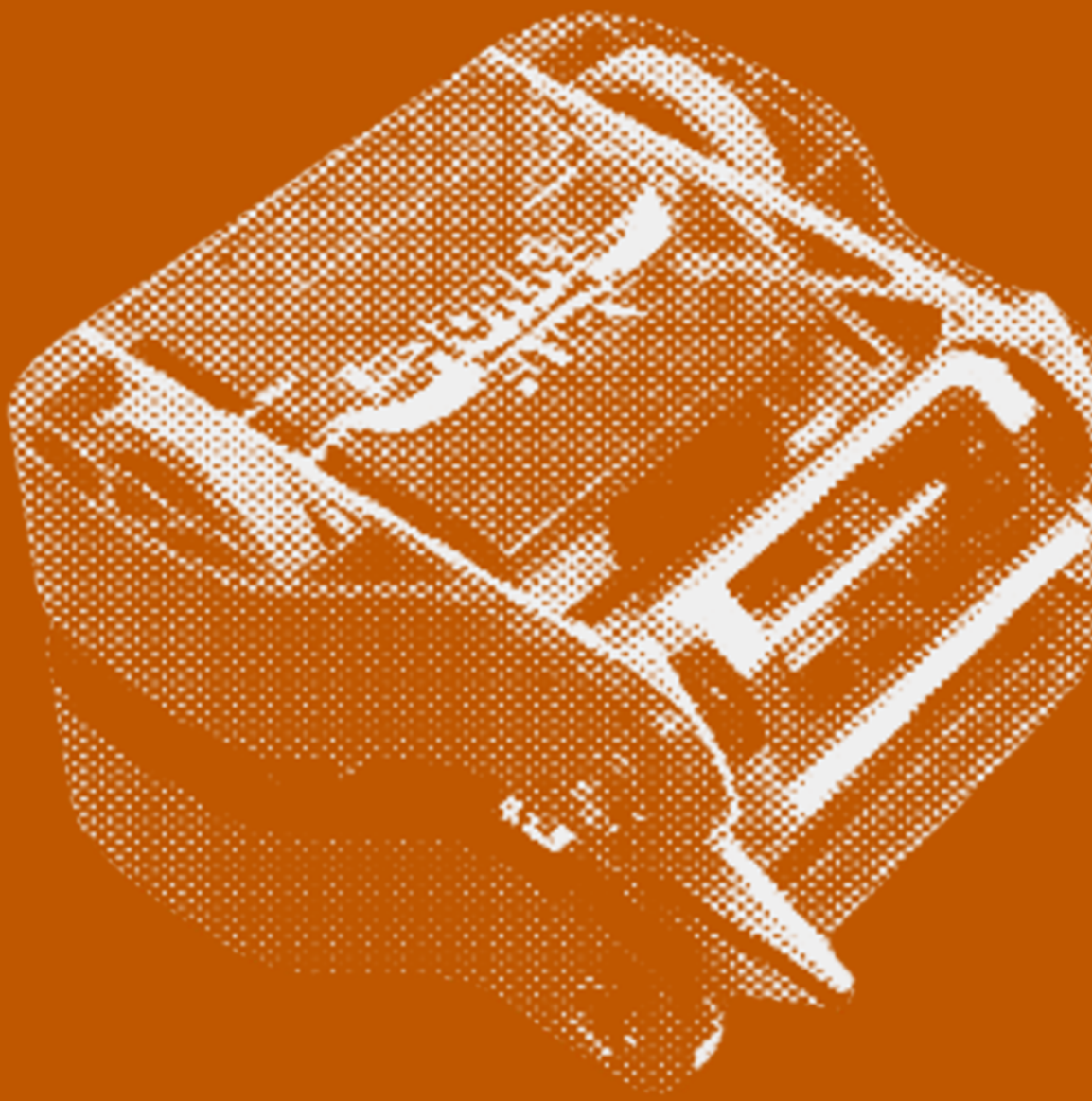
Spring 2024

TEXAS COMBAT ROBOTICS

HORNS OF FURY



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TEXA
MECHANICAL
FAMILY SIZE
CHEEZ-IT
CHEEZ-IT

TEAM INTRO

Texas Combat Robotics was born from a collaboration between Texas Inventionworks, the University of Texas' President's Office, and the Robotics Department. The team, inspired by the University of Texas' "Year of AI", is a combination of engineering disciplines from all around the engineering school, from Aerospace to Electrical Engineering. The goal: to design, fabricate, and build a 15-pound Battlebot in 5 short weeks.

The team would not have made it off the ground if not for the generous support of the President's office and the Robotics Department, coordinated by Daniel Liu and Dr. Sridevi Rao. The bot is a collection of efforts from incredible mentors, especially the contributions of Jordan Neal, who has acted as a sounding board and library of experience for the team.

TEAM INTRO

ABHI VEDIRE

JOHN LYLE

JAMES ZHANG

ALEX CARLSON

ANOUSHKA SINGHANIA

ADITYA RAO

JAVIER RAMIREZ

ALEXANDER KELLEY

CHARLES BELL

SIDDHARTH THAKUR

BOT STRATEGY

The cornerstone of our battlebot's strategy lies in its **adaptability**, enabled through the use of **interchangeable front forks or wedges** tailored to counter specific types of opponents paired with our powerful vertical spinner. This adaptability allows us to optimize our bot to ensure we're always equipped to exploit the weaknesses of our adversaries, regardless of their design or fighting style.

Interchangeable Forks System:
- Design Philosophy: The bot is engineered with a modular fork system, allowing for quick changes between matches after a thourough analysis of our next opponenets weapon type, to equip the most effective tools against the upcoming opponent.

Weapon Specific Applications:
- Against Vertical Spinners: We might opt for a wedge that is designed to get underneath and lift or destabilize these opponents, preventing them from bringing their weapons to bear on level plane.
- Against Horizontal Spinners: Longer wedges reduce the ability for horizontal spinners to execute swing manuevers, preventing heavy damage.
- Against Full Body Spinners: Low-profile, angled forks can be used to deflect spinning attacks and push opponents towards arena hazards.
- Push Bots and Passive Wedges: Low-profile, hooked forks that allow us to pull and restrain pushbots within range of our main weapon to deal heavy damage.

By prioritizing adaptability through our interchangeable forks system, we position ourselves to respond dynamically to the wide array of threats present in the competition, making our bot a challenger capable of facing down a wide variety of opponents.

OFFENSIVE + DEFENSIVE STRATEGY

Offense:

Kinetic Energy Utilization: Our bot's primary offensive strategy revolves around maximizing the kinetic energy of our drum spinner. When facing horizontal spinners and full-body spinners, this involves building up energy at a distance before closing in for a strike. For vertical spinners and undercutters, we aim for the sides or rear of the opponent to exploit vulnerabilities. We will be using a strategy coined “strafing”, where we will spin up to high speed, and charge directly, and repeatedly, until we land a hit. This manuever both looks menacing, and reduces the likelyhood we expose the rear section of our bot to our opponent.

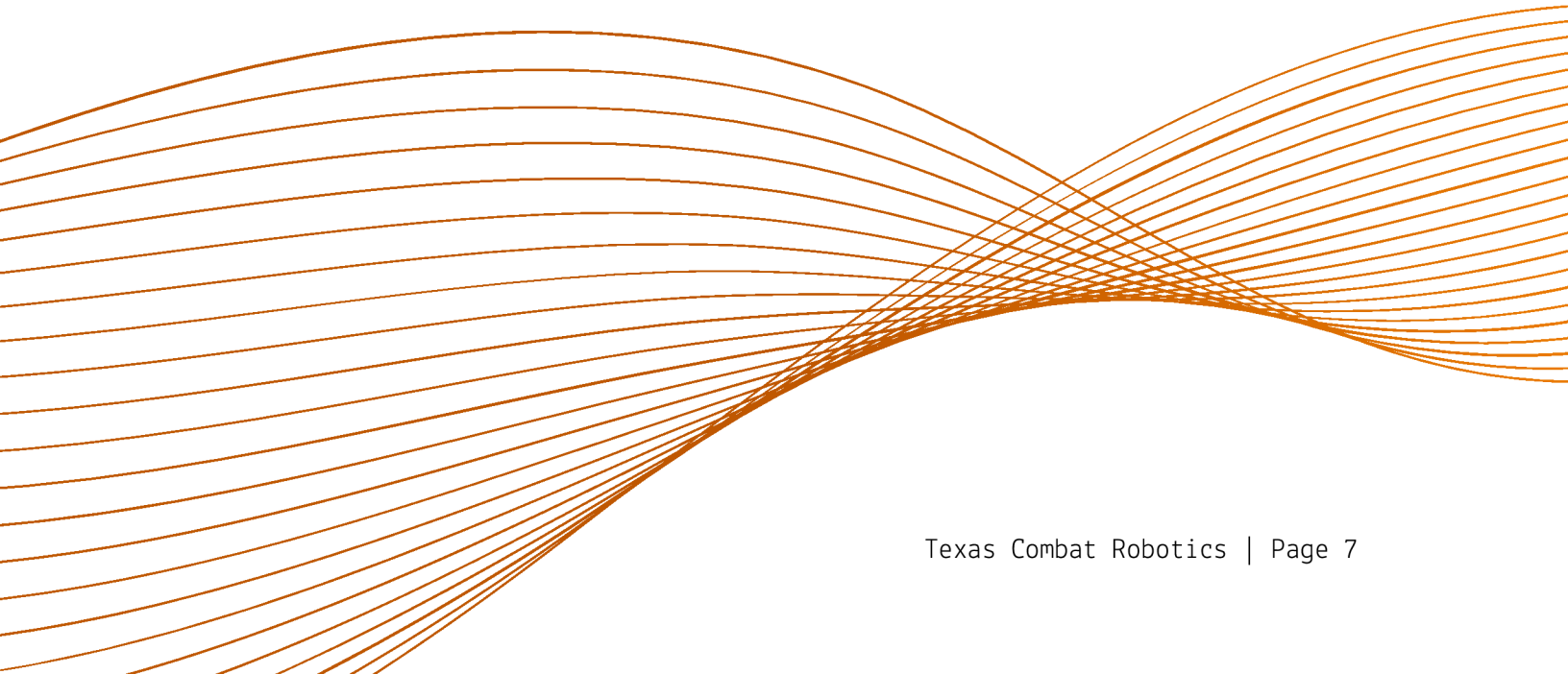
Defense:

Mobility and Evasion: We aim to have quick, agile movements to avoid opponent attacks, especially during periods of weapon spin-up when we are incapable of dealing significant damage. Once spun up, we intend to use direct strafing runs and rapid retreats to keep control of the field.

Winning Strategy:

Adaptability: Adjust tactics on the fly based on opponent behavior and arena conditions. If an opponent's weapon becomes disabled, switch to a more aggressive approach.

Maximum Damage: Attempt to inflict massive damage in quick runs at the opponent, while reducing the availible window for them to strike back.



BOT DESIGN

The design choices made on this robot were made to purposefully and pragmatically fully engineer, fabricate, and build a robot in 5 weeks. Multiple factors went into the different decisions made on this robot, including practicality, ease of fabrication, and efficiency.

STRUCTURE

Side Panels

Designing the body of the robot was a critical component of our success. A common piece of advice we received from multiple of our advisors was to keep the bot compact. To meet this requirement and increase the durability of our overall bot we made our side panels out of AR-500. This material allows our bot to take more impact and keeps the overall structure intact. These panels were also designed for mounting the drive motors, and are pocketed for weight management.

Bottom Panel

The bottom panel of our bot is made of 1/4" aluminum sheet metal. This design choice was made to decrease weight and increase the speed of machining time. The metal sheet was then flanged to allow for mounting holes and ease of assembly with the other pieces. The selection of a thicker aluminum baseplate was in direct response to potential attacks from another vertical spinner tilting our robot upwards and hitting us from below.

Back Panel

Similarly, the back panel is aluminum. This piece was CNC'd due to the complex geometries needed to allow the assembly to fit together seamlessly. Originally starting with a simple flat panel with holing on the sides, we pivoted to our current design with flanged ends as well as ledges on the top and bottom to allow the fasteners to have more interaction and secure our robot.

Wheel Guard

Another key component of our main frame is our wheel guards. These parts went through multiple iterations and changes to make them fully functional and efficient for our purposes. The geometry is designed to fully encompass the side panel and the wheel and protect the rest of the bot. The material, UHMW, and the pocketing are done to help drastically decrease weight.

WEAPON

When designing the weapon of our robot, we considered several designs. These included both active and passive weapons, consisting of vertical and horizontal spinners, full-body spinners, flippers, lifters, and passive wedges. We decided to design around a vertical egg-beater drum design because we found a vertical spinner to pose a much more interesting engineering challenge while not being overly complex, given our compressed design timeline. Additionally, we saw from background research that vertical spinners typically dominated the 12lb weight class, and hoped that this design would yield promising results at competition.

The egg-beater drum is milled out of 4340 steel and then hardened. The impact is dealt by a single “tooth” running along the entire width of the drum. The drum itself is an asymmetric weapon, allowing the effective diameter of the weapon tooth to be enlarged, significantly increasing the moment of inertia of the weapon for harder impacts, and transferring more energy with each hit.

We chose to mount this weapon off of a dead axle rather than a live axle and transferred power from the weapon motor to the weapon through a V-belt pulley system with a 3:1 reduction. The dead axle was chosen to optimize weapon moment of inertia and weapon motor efficiency. The weapon itself rides on a set of aluminum hex hubs, which each contain two to three needle-roller bearings to mate with the dead axle. As the name suggests, these hex hubs have an outer male hex profile that mates with a matching female hex profile on the weapon, significantly reducing the shear stress that is translated to the screws holding the weapon assembly together axially. This hex profile is a critical part of our design that will allow the weapon to withstand large impacts.

On either side of the egg-beater drum, we included a thrust-bearing stack to support the weapon axially. We designed a small gap between the egg-beater drum and the side plates, allowing the weapon additional room to spin even after taking a big hit which could deflect the side plates. These thrust bearings ensure the weapon does not translate axially into either side plate during operation, keeping the weapon constrained.

ELECTRONICS

The electronics component selection were done primarily based on commonly used commercially available solutions. Due to the limited time frame and component availability we ordered the best components in stock in order to mitigate the risk of failure due to electronics

Drive Motor Selection

The drive motor we originally selected was out of stock however there are many similar products on the market. We ultimately selected the Badass 870 KV motors with a 16:1 gearbox to produce desired torque levels. This was available as a kit with the gearboxes and a dual-motor ESC.

Weapon Motor Selection

In order to select the weapon we worked backwards from the ESC. We wanted to go with a Mamba X weapon ESC because, in previous smaller combat robots, we had run into issues with burning out ESCs. We then looked at the suite of motors Castle had to offer. Ultimately we decided on the Castle 1412 as it met our torque and speed requirements.

Battery Selection

To meet competition regulations our options were rather limited. We decided we wanted to run a 4S Li-Ion system as a 14.8 Voltage level met all of our motor requirements. The cells we have are each 4200 mAh so we wired two in parallel to get longer battery life and higher peak discharge levels.

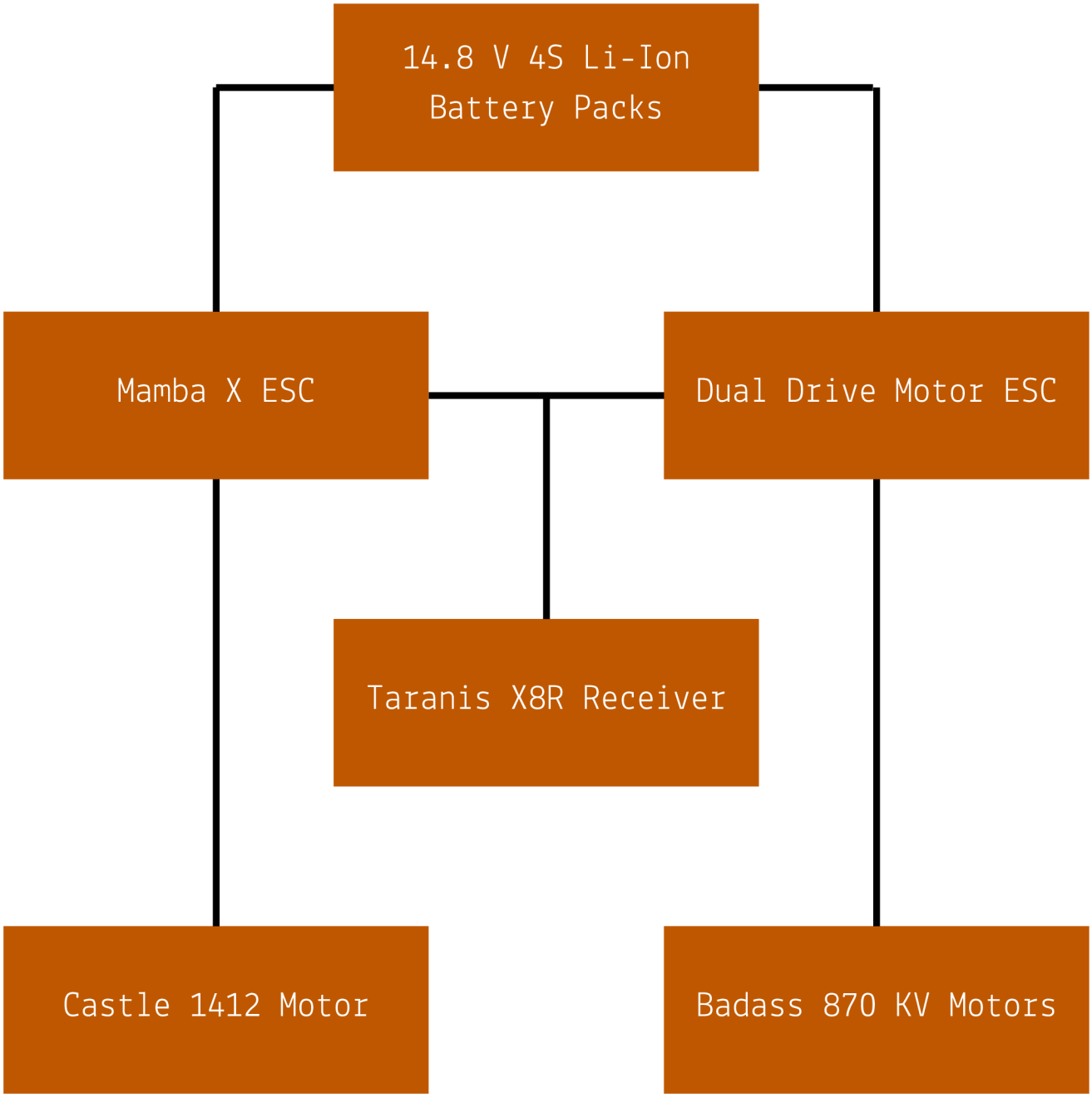
Wiring

We wanted to modularize our connections as much as possible to prevent solder in place components. We chose XT-60 connectors which have proved to work great. They are however a little large and working with them in small spaces was pretty difficult.

Transmitter/Receiver

We decided to use a Taranis QX7 transmitter and a X8R receiver. These appeared to be a pretty high end system used commonly in battlebots. We chose these specific systems as they allowed us more detailed control of the weapons and drive motors, including directionality and variable power. In addition, they adhered closely to the safety guidelines we needed to follow.

ELECTRONICS



DESIGN FOR MANUFACTURING

STRUCTURE

The materials and manufacturing methods we used for each structural component are listed below in the table.

	Material	Manufacturing Method
Side Plates	AR500 Steel	Laser Cut
Back Plate	6061-T6 Aluminum	CNC Milled
Base Plate	5052 H32 Aluminum	Laser Cut + Bent
Wheel Covers	HDPE	CNC Milled
Top/Front Cover	Polycarbonate	CNC Milled + Bent
Top/Front Cover Edges	PETG	3D Printed
Forks / Wedges	AR500 Steel	Laser Cut
Weapon Motor Bracket	6061-T6 Aluminum	CNC Milled
Drive Motor Cover	PETG	3D Printed
LED Bracket	PETG	3D Printed

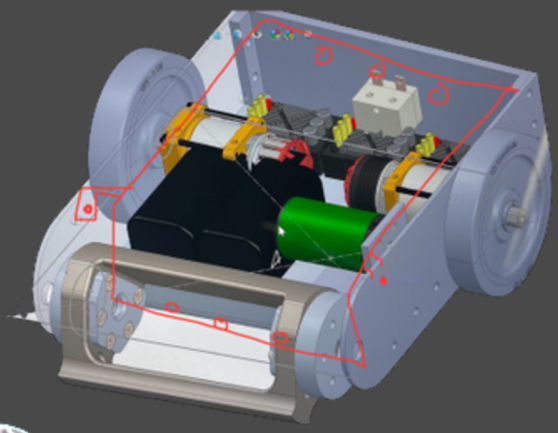
DESIGN FOR MANUFACTURING

WEAPON

The materials and manufacturing methods we used for each weapon component are listed below in the table.

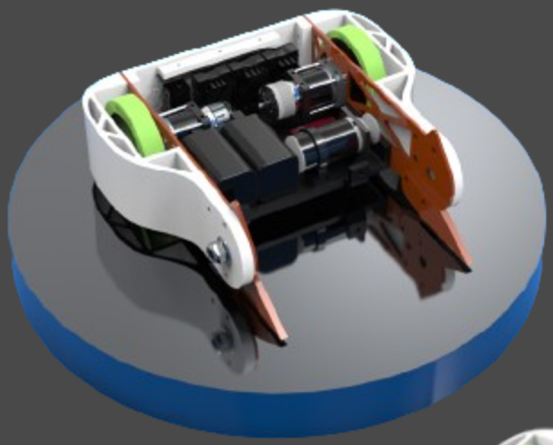
	Material	Manufacturing Method
Egg Beater	4340 Steel	CNC Milled + Heat Treated
Hex Hub 1	6061-T6 Aluminum	CNC Milled
Hex Hub 2	6061-T6 Aluminum	CNC Milled
Tapped Disc	6061-T6 Aluminum	CNC Milled
Large Pulley	6061-T6 Aluminum	CNC Milled
Small Pulley	6061-T6 Aluminum	CNC Milled
Axle	4340 Steel	Turned + Heat Treated

TIMELINE AND MANUFACTURING



Week 1

- Set guidelines and parameters
- Start design on CAD
- Find electronic and mechanical parts needed



Week 2

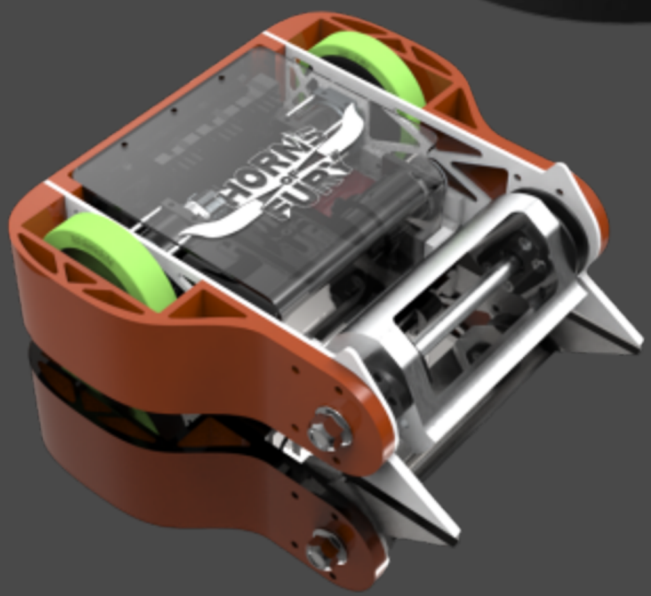
- Critical Design Review
- Work on assemblies on CAD
- Make BOM and order parts

Week 3

- Send custom parts to get fabricated
- Order all COTS parts
- Start testing electronics

Week 4

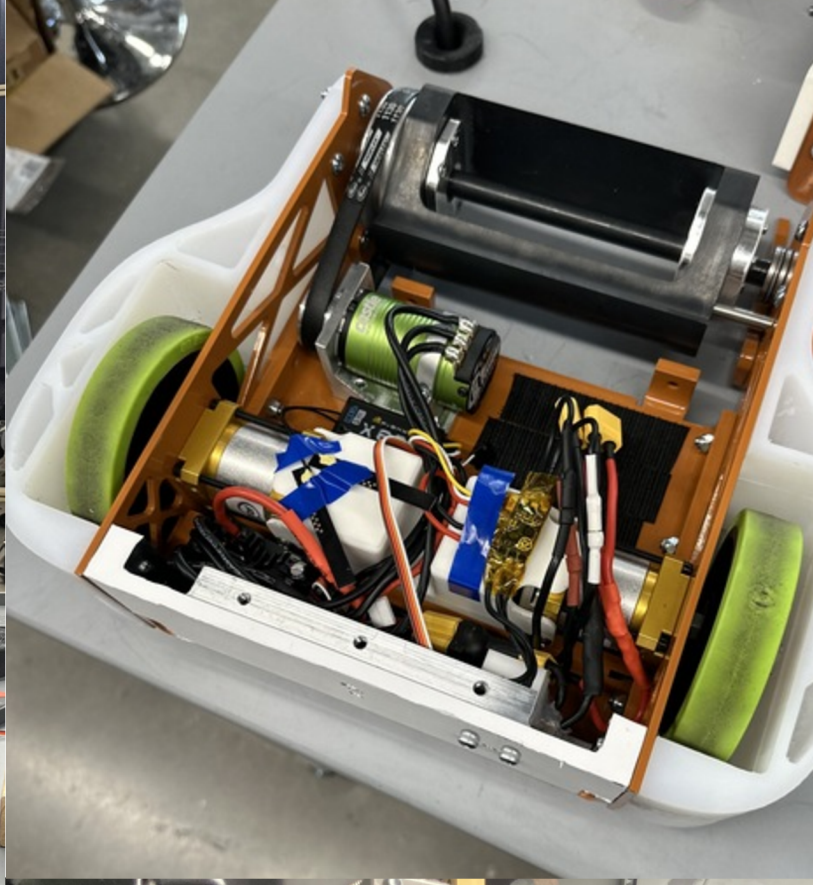
- Use test fits/prototypes for custom parts
- Work on iteration of robot and start driving



Week 5

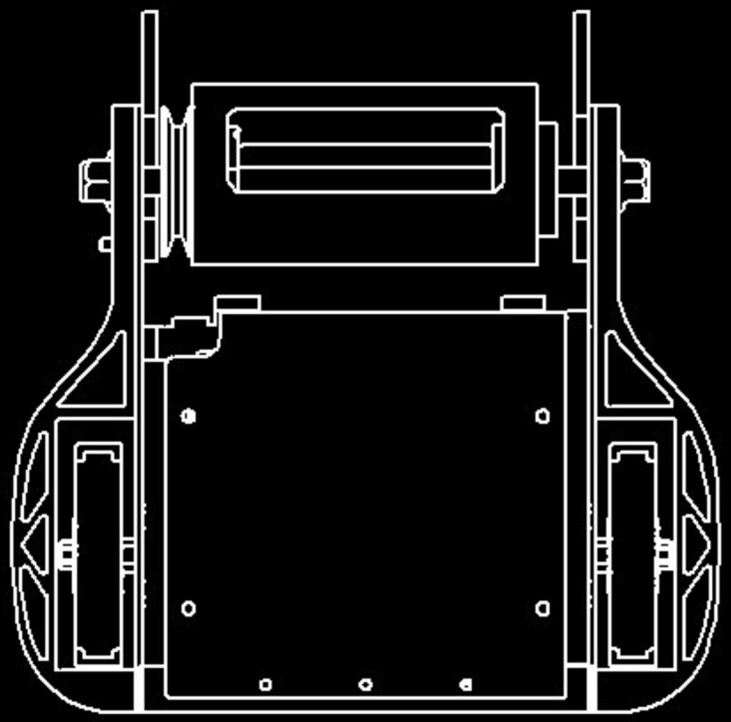
- Put together final bot with all parts and fasteners
- Ensure all parts fit
- Practice driving and pack up for competition

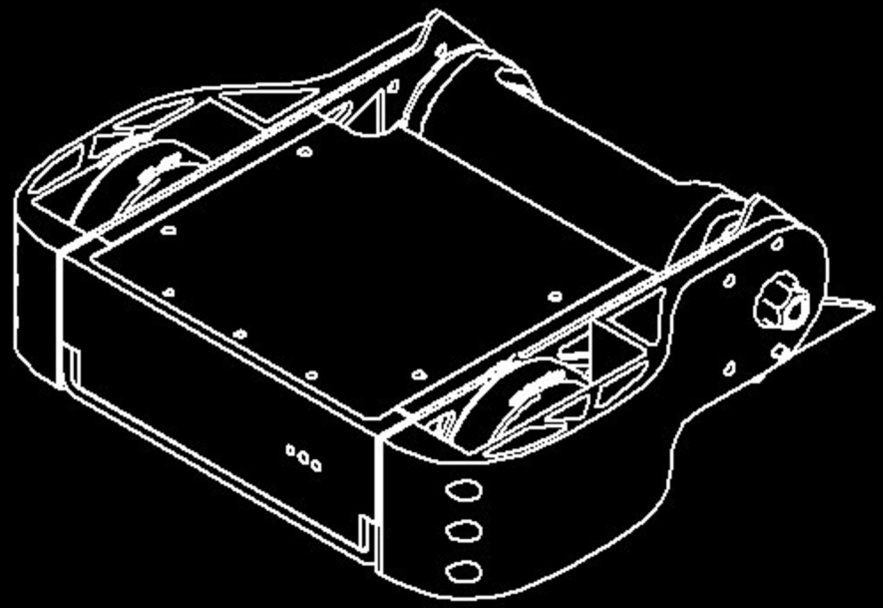

TEXAS




KURT

CAD DRAWINGS

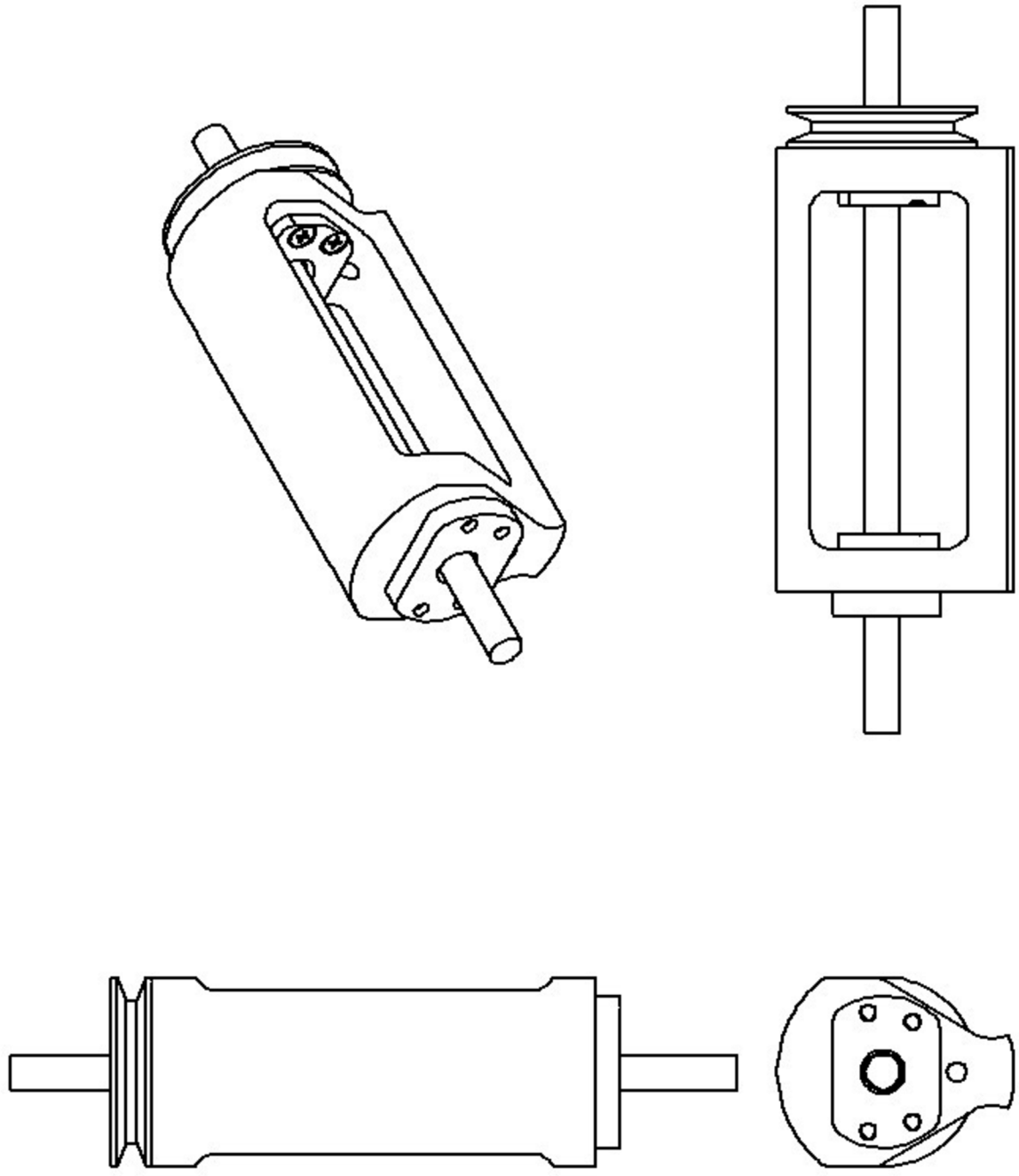




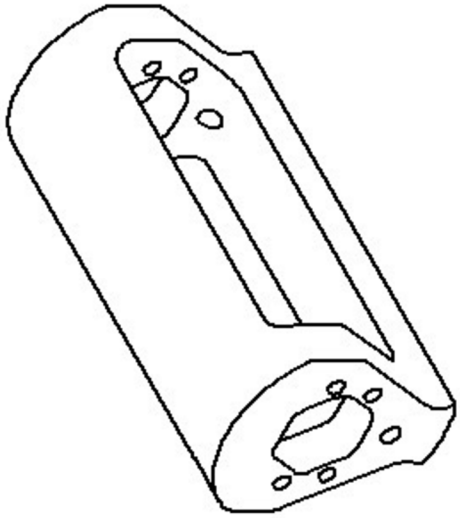
FINAL ASSEMBLY

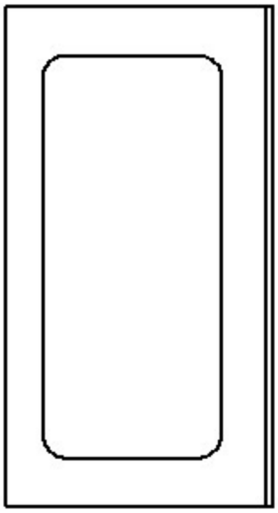
SCALE 1:3

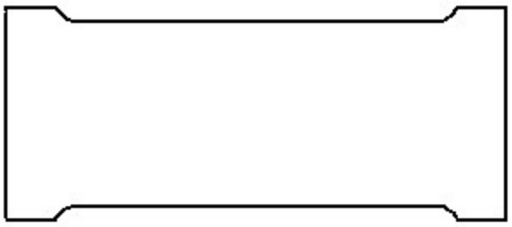
Weapon Assembly V3
SCALE 1:2

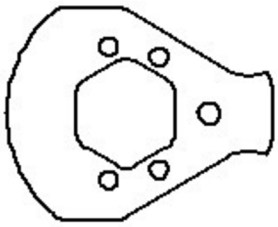


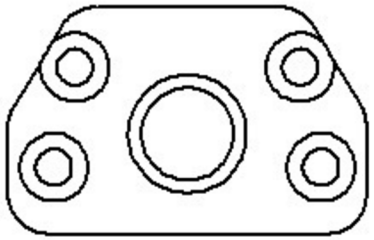
Egg Beater V2
SCALE 1:2

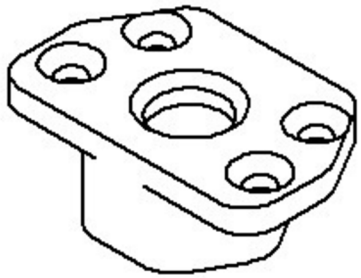


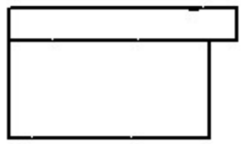




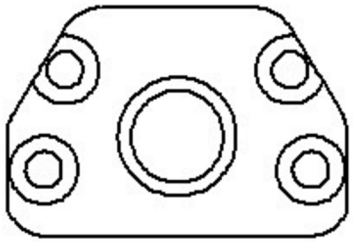


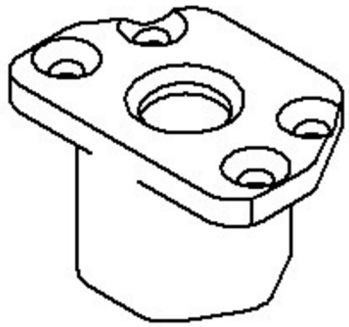


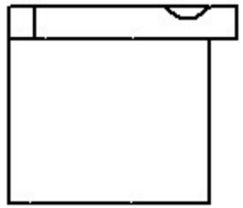




HEX HUB 1
SCALE 1:1

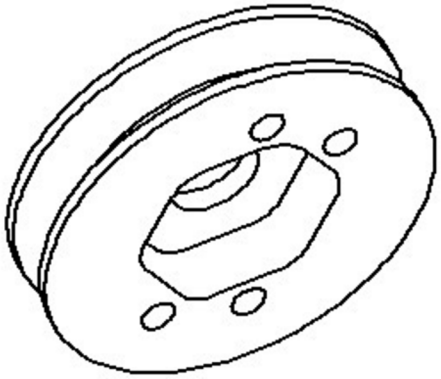


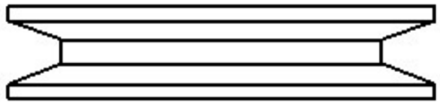


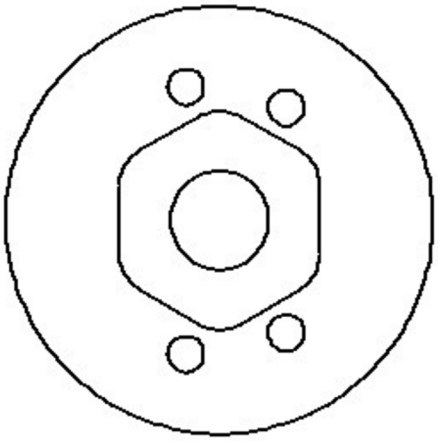


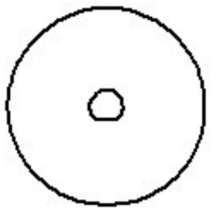
HEX HUB 2
SCALE 1:1

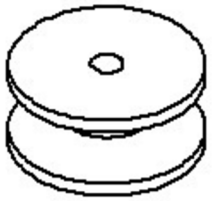
72T PULLEY
SCALE 1:1

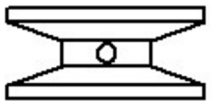


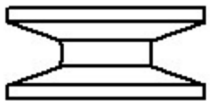




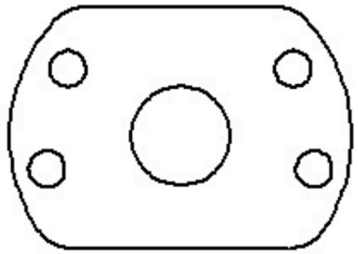


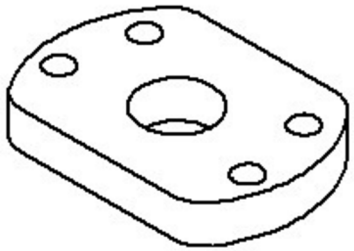


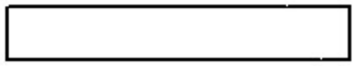


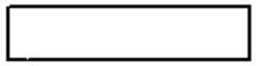


SMALL PULLEY
SCALE 1:1

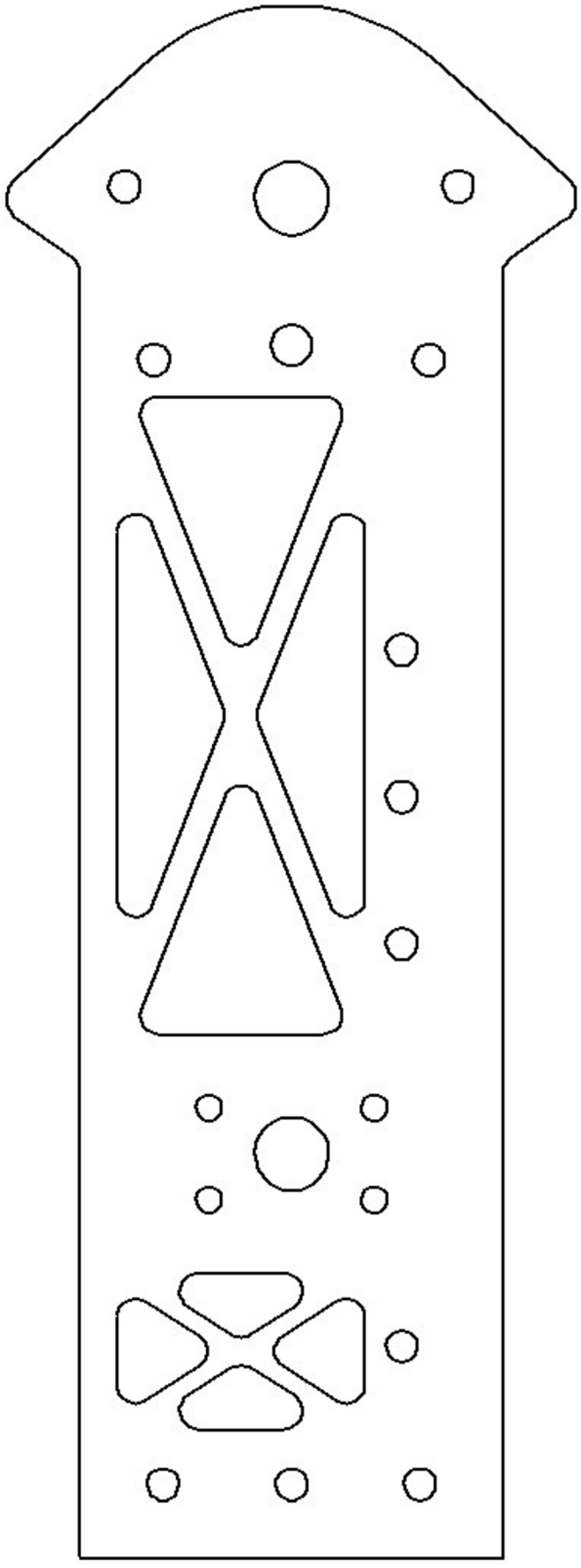






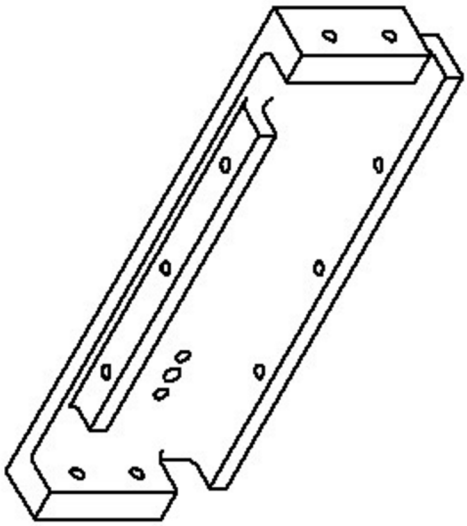


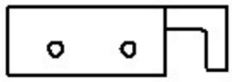
TAPPED DISC
SCALE 1:1

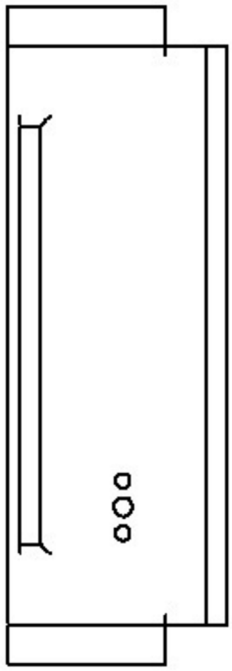


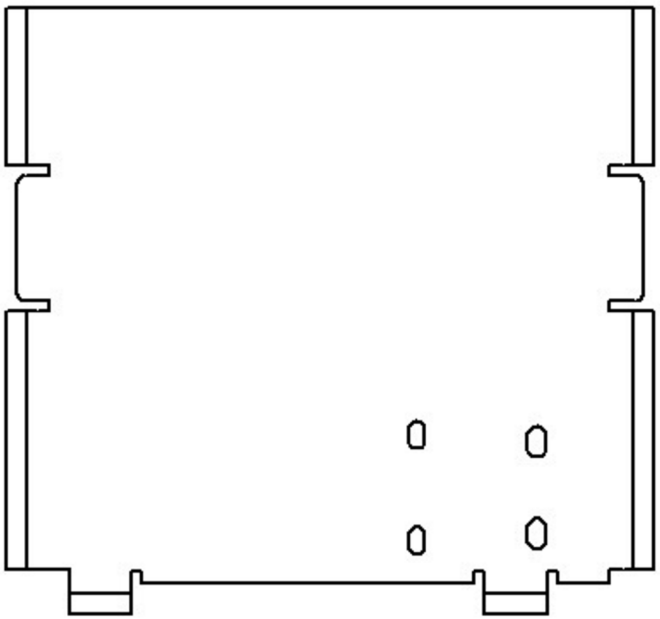
SIDE PANEL V2
SCALE 1:1

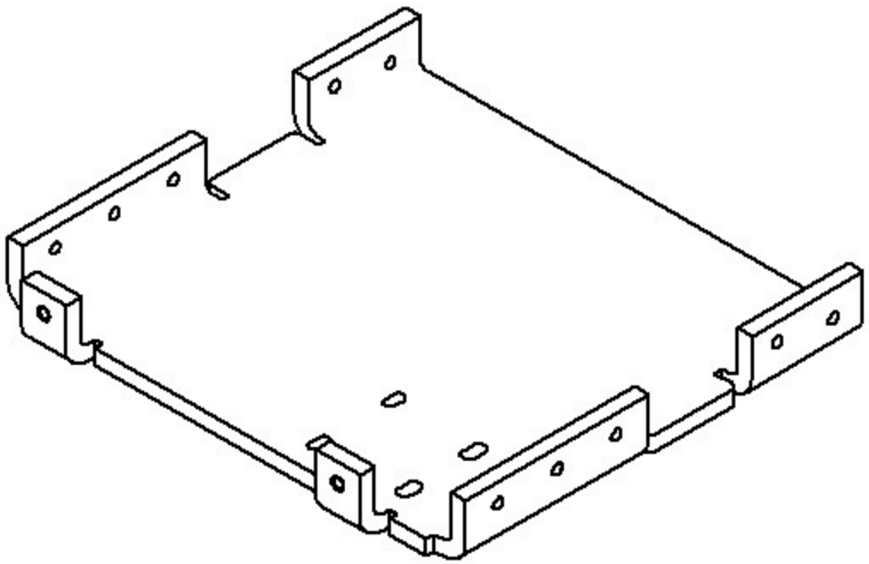
BACK PANEL
SCALE 1:2

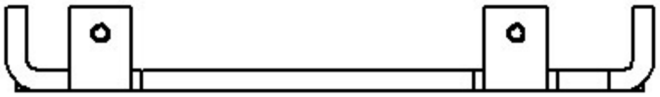


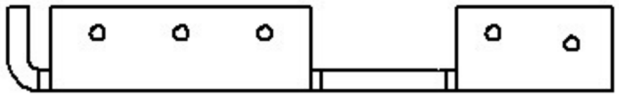






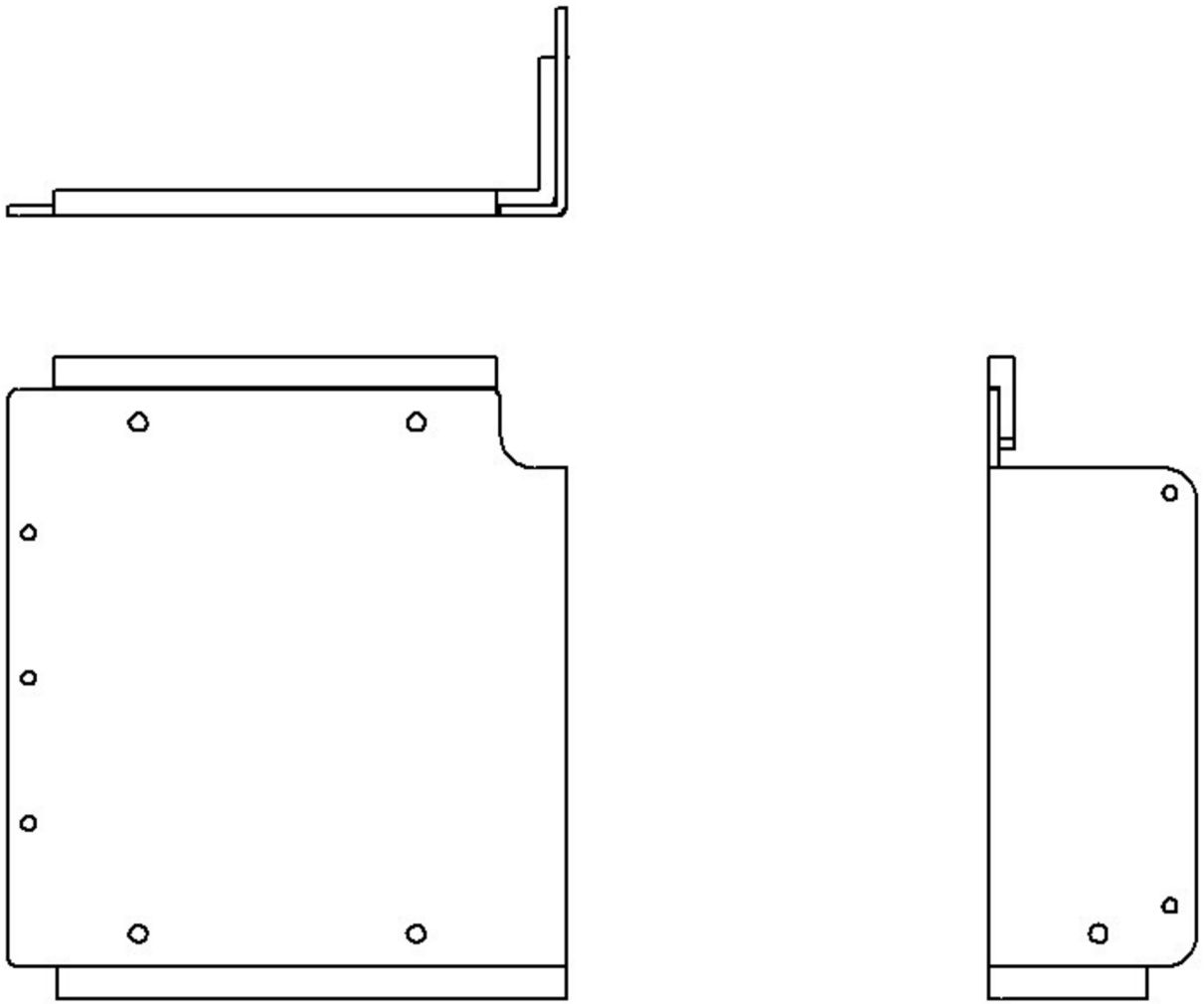






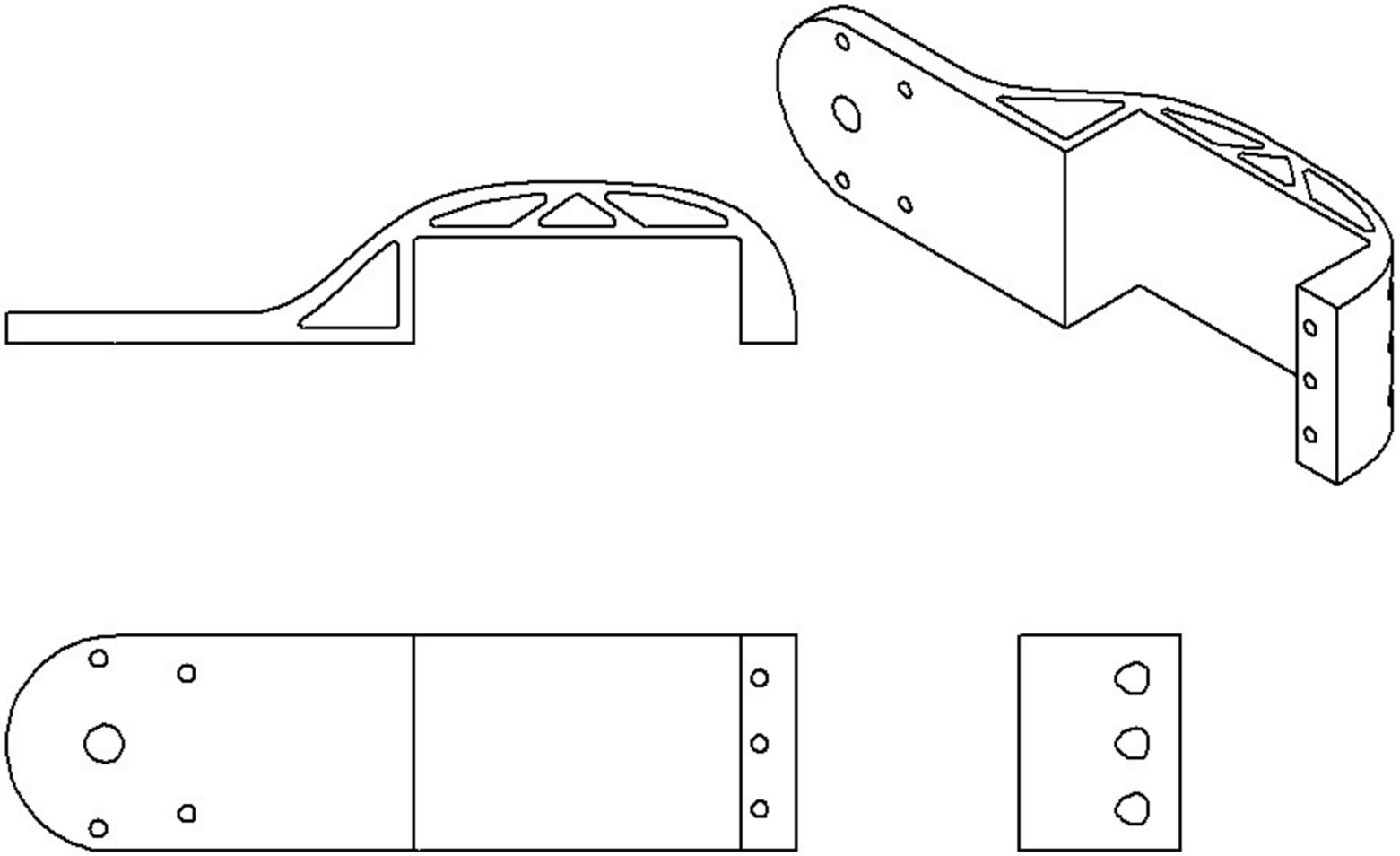
BOTTOM PANEL

SCALE 1:2



TOP AND FRONT COVER WITH SIDE COVERS

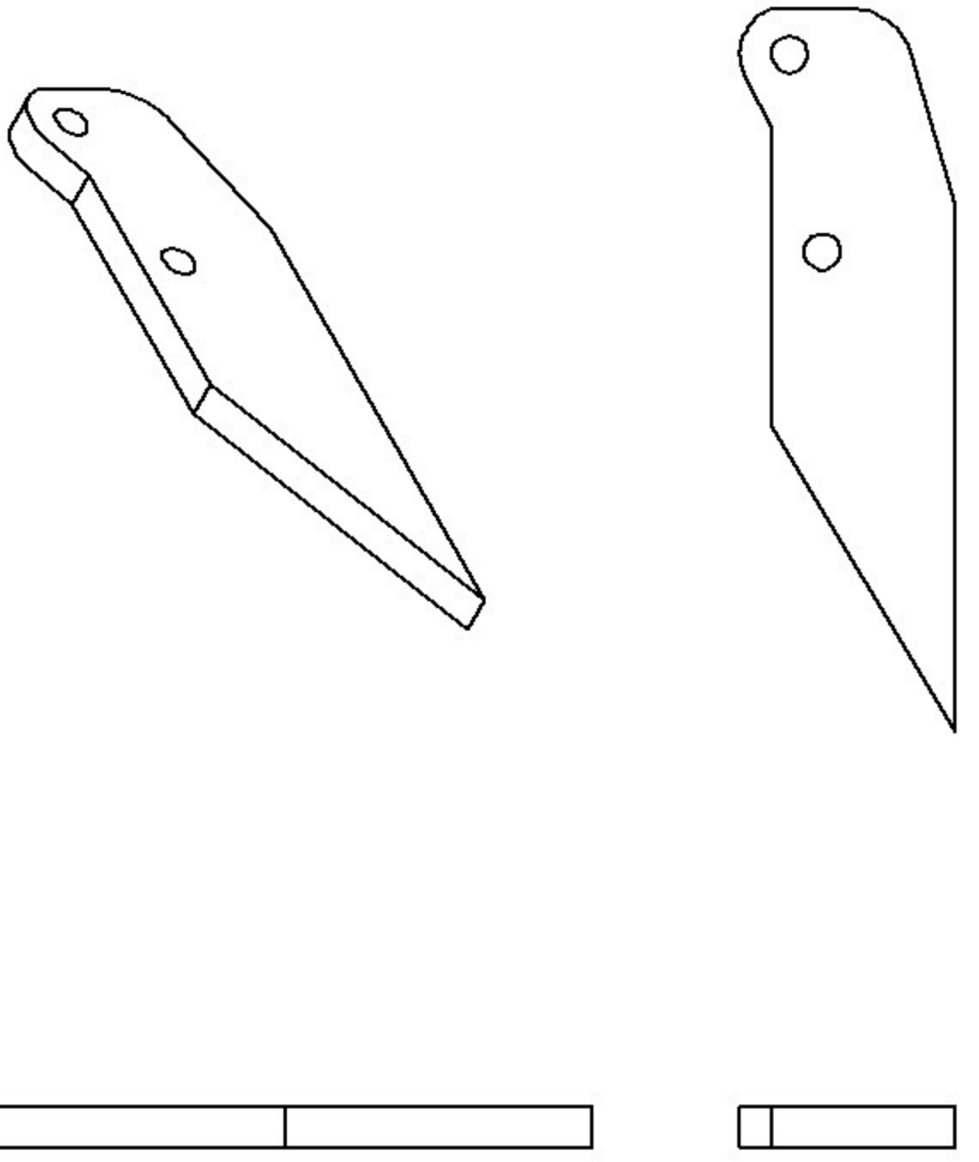
SCALE 1:2

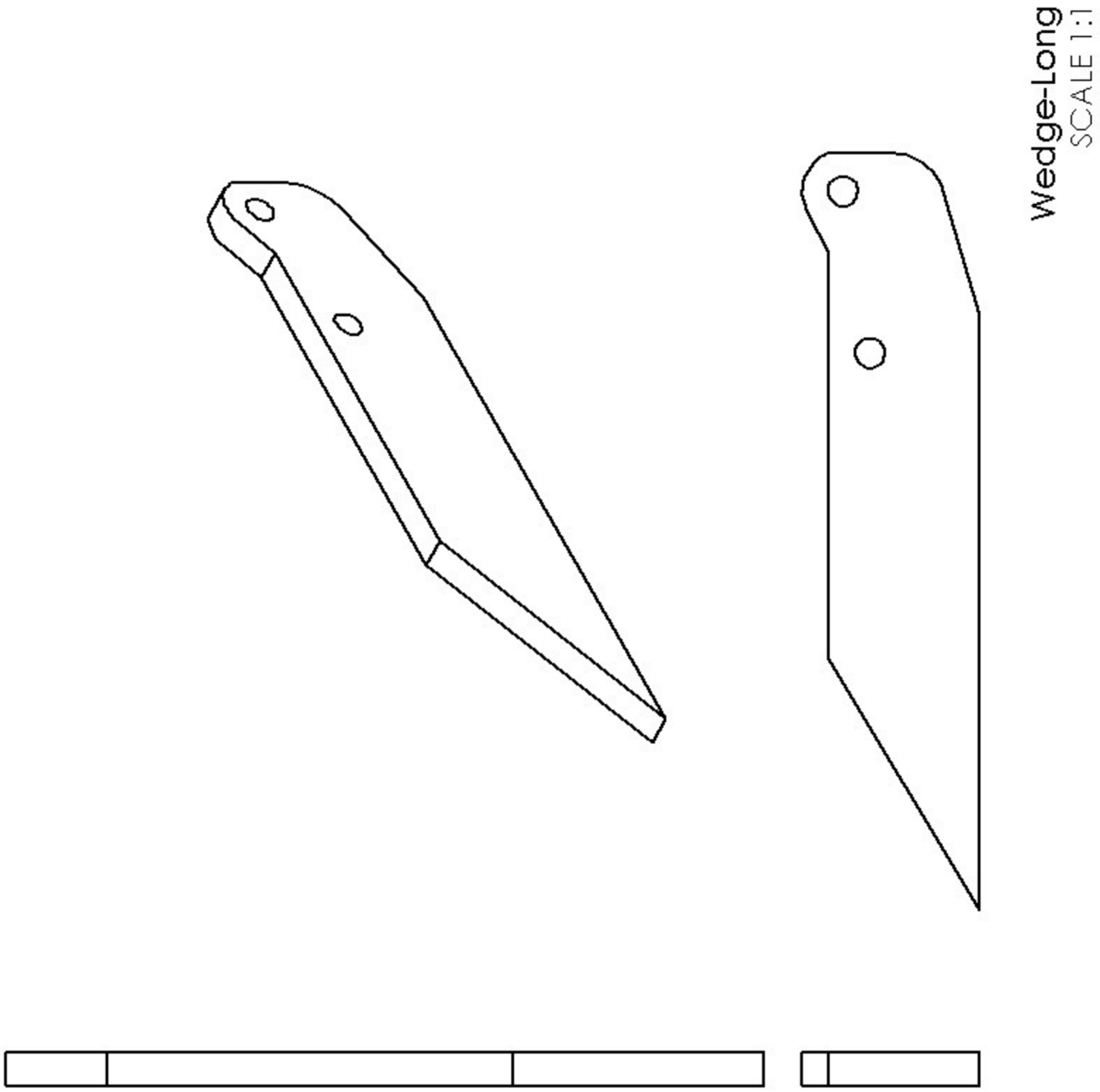


WHEEL GUARD V3

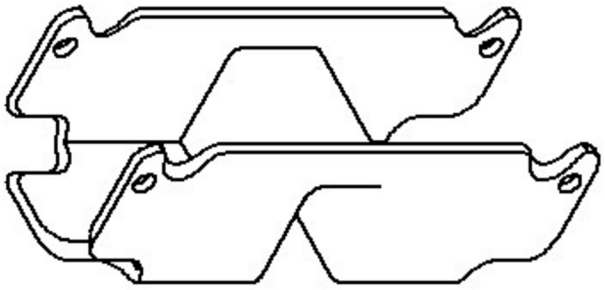
SCALE 1:2

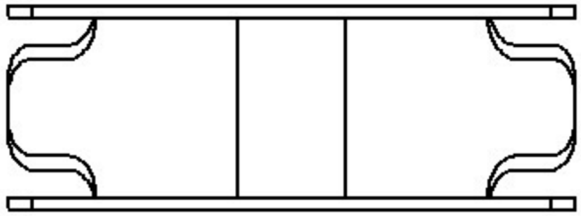
WEDGE
SCALE 1:1

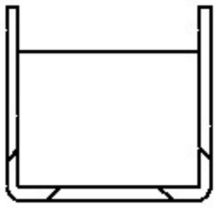


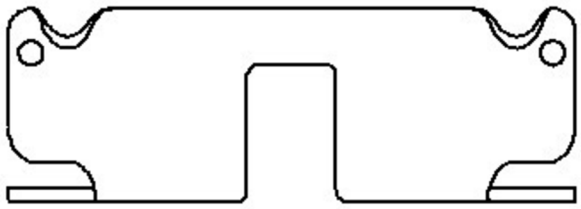

Wedge-Long
SCALE 1:1

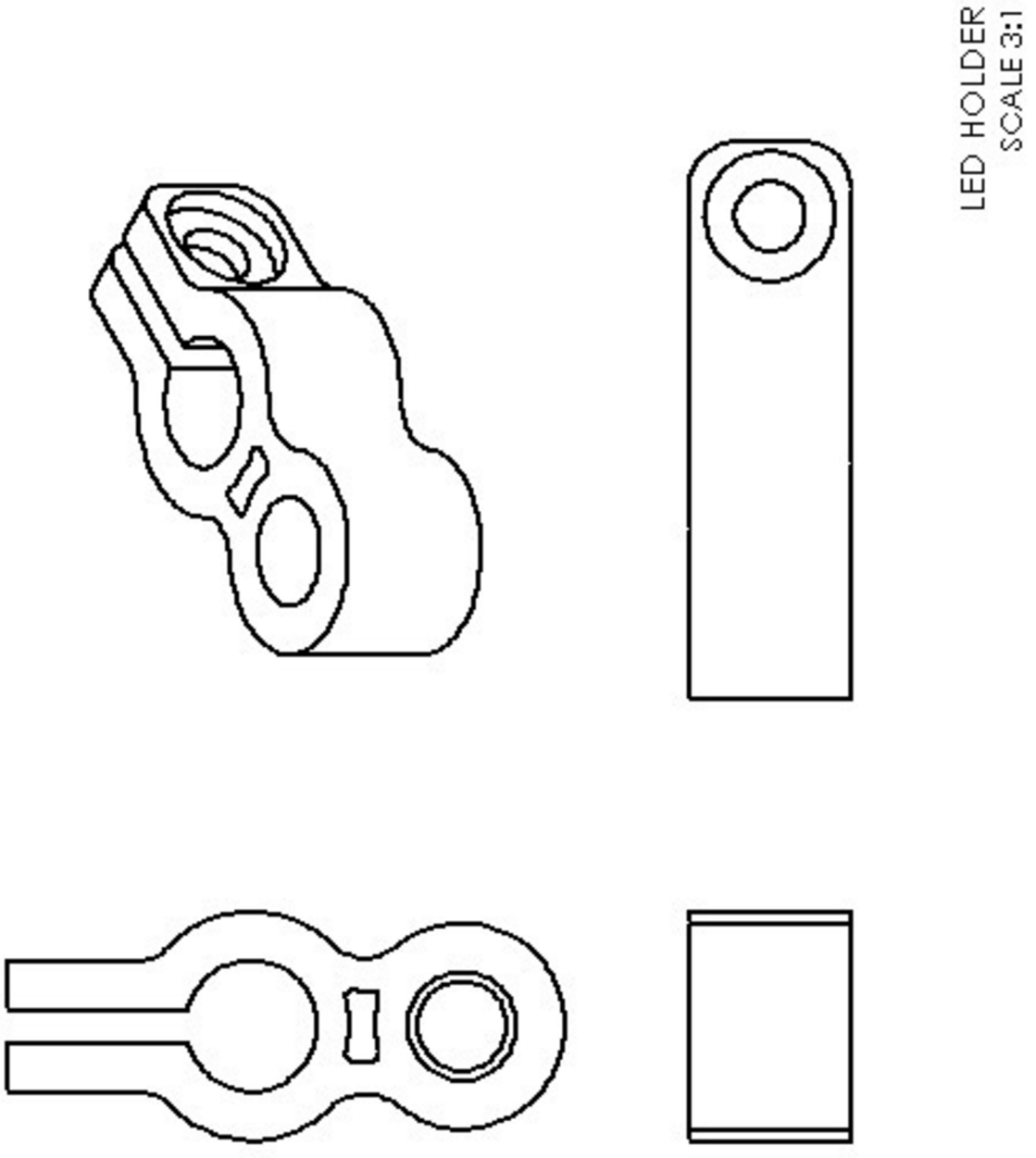
Drive Motor Cover
SCALE 1:1.4










LED HOLDER
SCALE 3:1

TAKE AWAYS & RECOMMENDATIONS

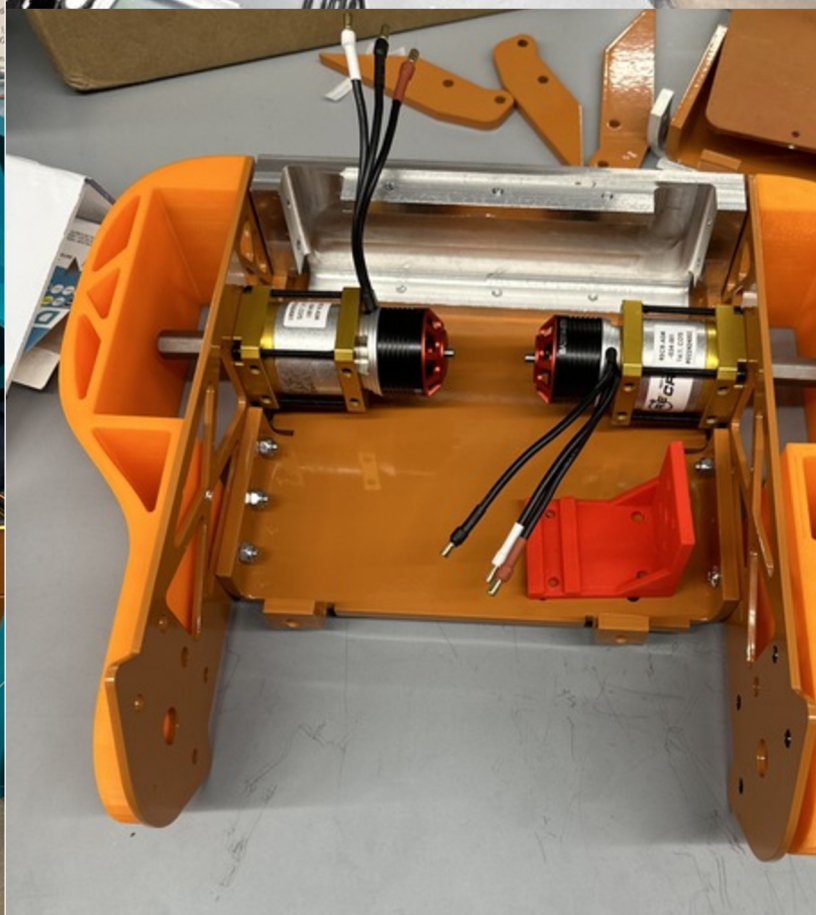
Throughout the course of designing, manufacturing, and programming our battlebot, we had some successes, made some mistakes, and learned a great deal about the engineering process.

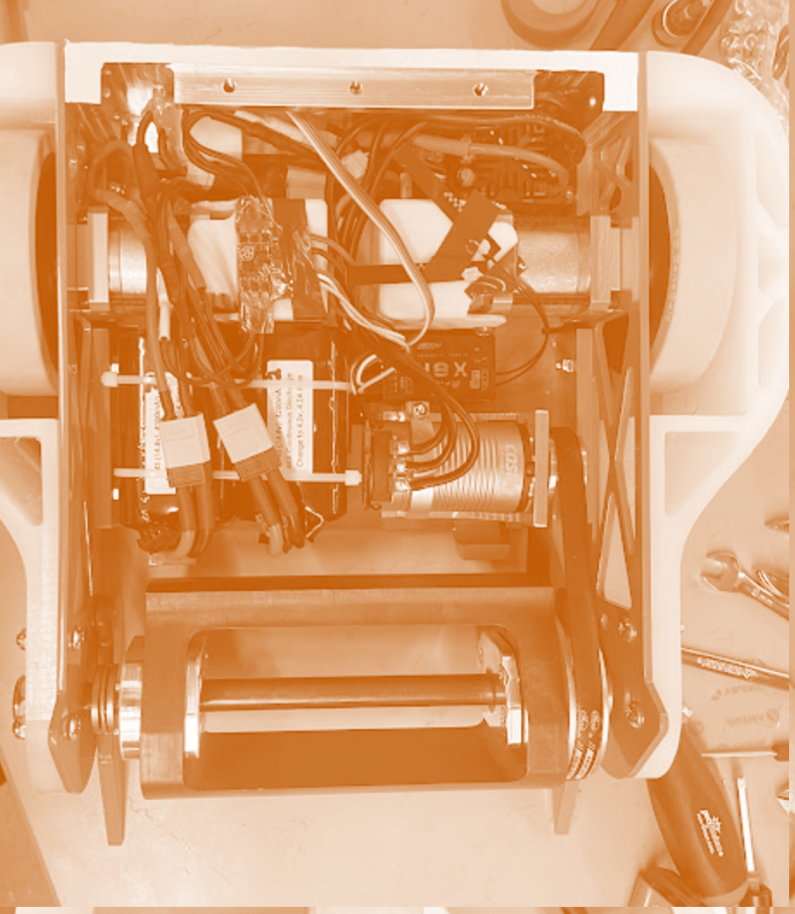
In the design stage, a critical mistake we made was not accounting for the assembly process from the beginning. After a significant portion of our CAD assembly was complete and we had integrated multiple subsystems, we realized the process of assembly was unclear and in some cases difficult, forcing us to redesign some pieces with this in mind. Learning to keep in mind how we were to fasten our screws, or tension our belts was important to ease building our robot.

Another oversight on our end was a consequence of our post processing. Our side panels and bottom plate were powder coated to produce a more aesthetic appeal. However, this increased thickness ever so slightly and not allowing our assembly to fit. We were able to fix this problem by manually milling down our backplate to allow for a smoother fit.

One of the parts that we had to alter after fabrication was our wheel guards. The wheel guards were manufactured through UHMW CNC machining, but we did spend some time manually machining new holes for the mechanical hard stop as well as to accommodate some new hubs for our wheels. This problem mainly arose due to the timeline, and us not being able to iterate more design changes.


JET
KURT
MACHINE SHOP





TEXAS COMBAT ROBOTICS

inventionworks.engr.utexas.edu
tiw-support@utexas.edu
+1 210-850-2800