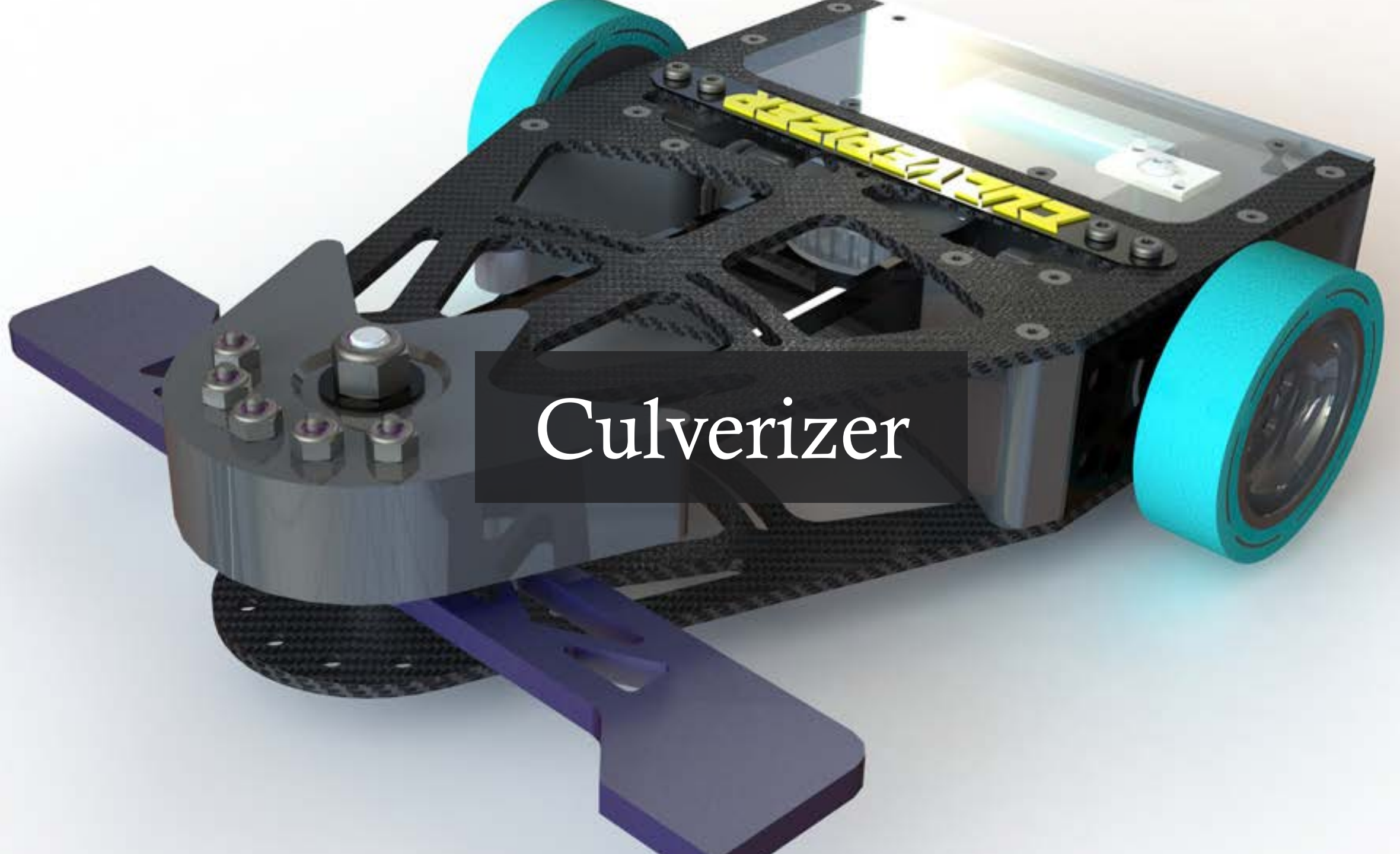


Manan Singh

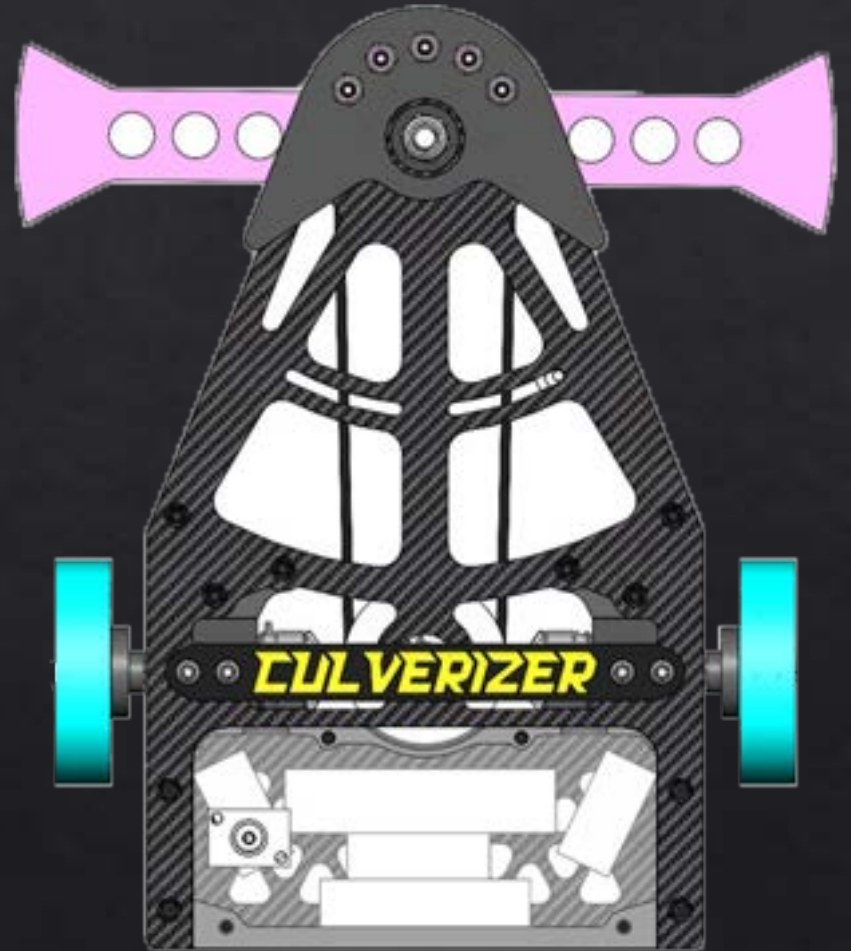
Engineering Project Portfolio



Culverizer

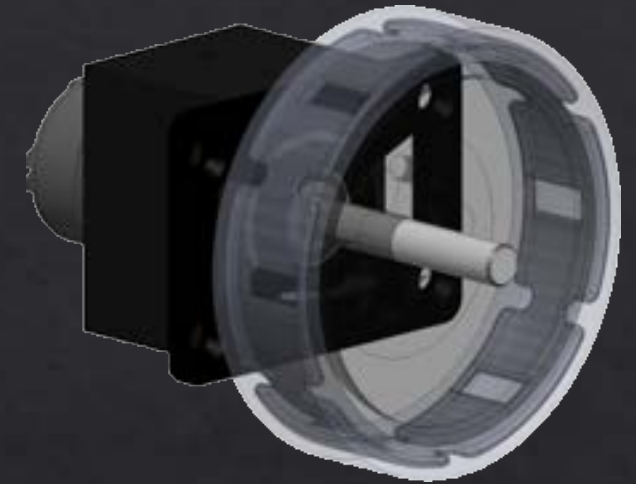
Culverizer – 31lb Combat Robot

- ◆ I designed and built Culverizer, which utilizes a heavy horizontal blade to batter and disable its opponents
- ◆ Carbon fiber plates give the chassis rigidity and hold weapon assembly
- ◆ 3D printed 95A TPU body flexes to absorb and disperse impact energy
- ◆ The TPU acts as ablative armor, designed to take damage and protect inner electronics



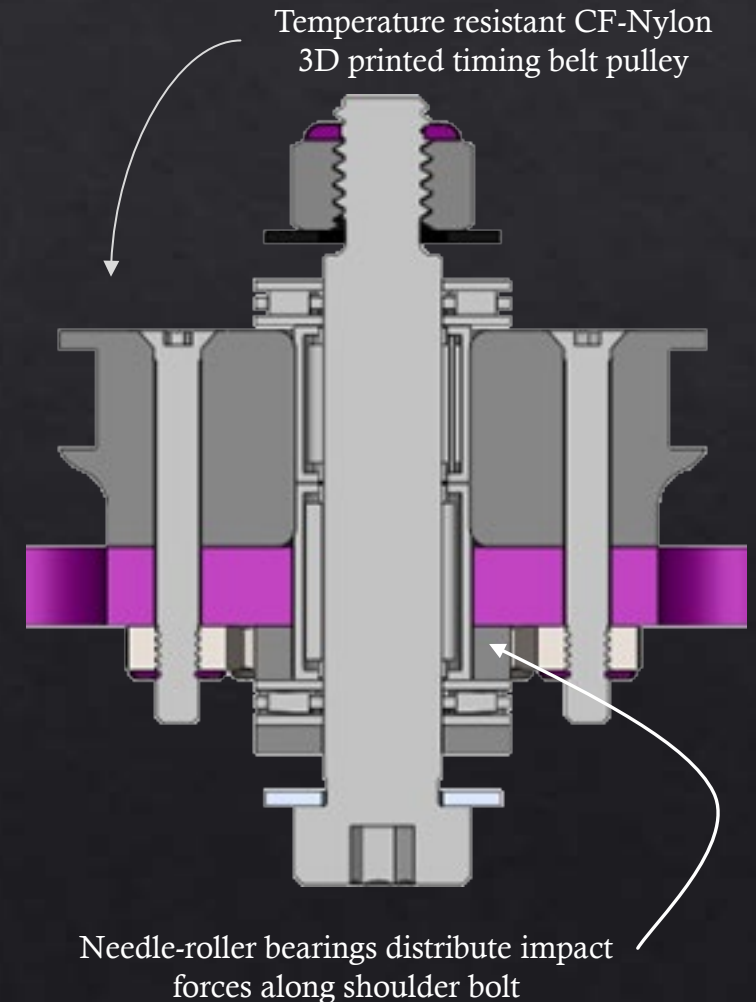
Culverizer – Drivetrain

- ◆ I used 2 brushless gearmotors to direct-drive the robot at 10.5 ft/s, enabling the bot to box-rush and engage opponents immediately
- ◆ The drive motors are shock-mounted with TPU, allowing drive motors to deflect and redirect energy away from the gearbox, preserving its lifespan
- ◆ Created custom molds to cast 2.5” OD TPU-core wheels with 40A Urethane treads
 - ◆ Urethane provides high traction and acceleration, while adhering to the TPU well
 - ◆ The TPU core absorbs impact energy and increases wheel and gearmotor durability



Culverizer – Weapon System

- ◆ 1400 kv motor @ 14.8V with a 6:5 belt reduction spins weapon blade at 340 mph
- ◆ Weapon blade stores a max of 1300J of energy
- ◆ While this iteration of the weapon system has been the most effective, I'm currently working on improvements to increase its reliability and energy transfer
 - ◆ Next iteration will replace 3D printed pulley with aluminum V-belt pulley, allowing the weapon system to slip on high impacts and reduce angular impulse delivered to the weapon motor
 - ◆ Aluminum pulley will transfer torque through a spline to avoid putting screws under shear forces



Culverizer - Competition

- ◆ Built 2 copies to be prepared for tight turnaround times between matches
- ◆ Competed at 3 tournaments with an all-time match record of 15-8
- ◆ Watch it in action! -> [Culverizer vs Surgical Procedure](#)





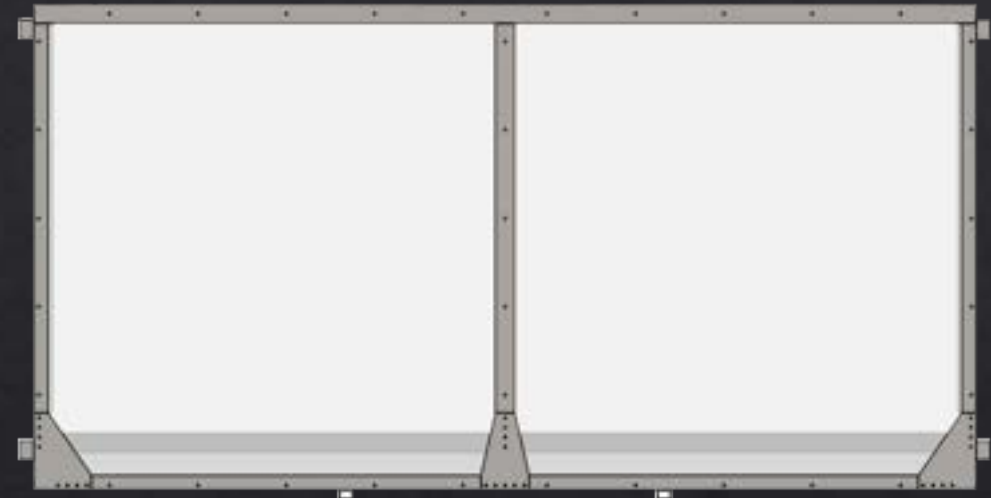
Beetleweight Arena

Beetleweight Combat Robotics Arena

- ◆ I was assigned to lead the development and construction of a new arena for 3-lb combat robots for the Purdue University combat robotics club
- ◆ Design requirements and constraints:
 - ◆ Large footprint for robot combat - 64 square foot minimum
 - ◆ Easy to assemble, transport and store as our competition venue and workspace are 4 miles apart
 - ◆ Quickly serviceable in case of damages throughout the tournament
 - ◆ High visibility from all angles
 - ◆ Double-walled polycarbonate panels with an air-gap to safely contain combat robots
 - ◆ Negative pressure ventilation system to extract fumes in case of battery fire
 - ◆ \$10,000 budget

Beetleweight Arena - Construction

- ◆ I came up with a design totaling \$7,000, saving \$3,000, that meets all the necessary requirements, while prioritizing serviceability and ease of assembly
- ◆ 8' long, 8' wide, 4' tall arena stands 3' above the ground providing ample space for combat at a comfortable viewing height
- ◆ The entire frame is assembled and disassembled without use of fasteners, enabling rapid setup
- ◆ Double-layered plywood floor provides a safe, durable, and smooth driving experience



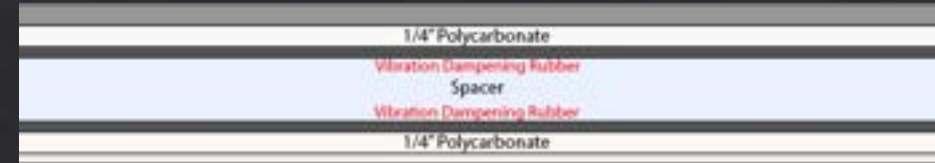
Each frame has a ~4'x8' footprint and can be transported flat-packed on a 4'x8' trailer



Frames assemble by being stacked at peg & tube joint at vertical bracket

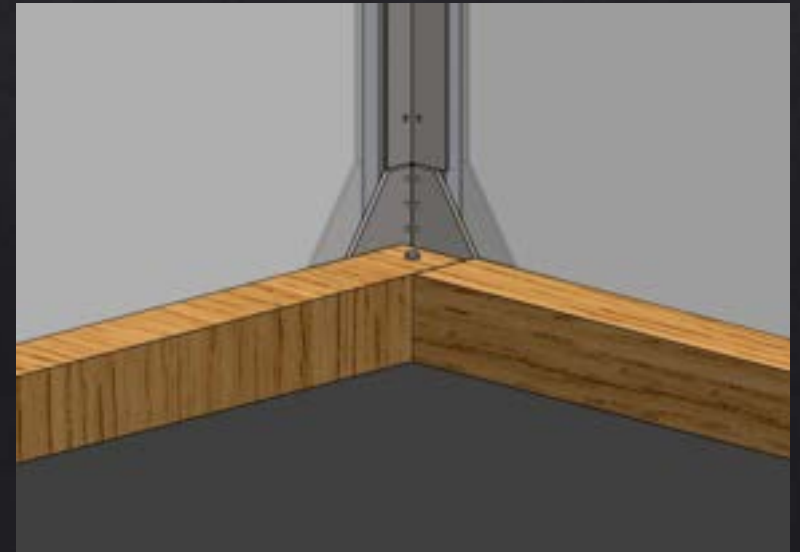
Beetleweight Arena - Safety

- ◇ Safety is the highest consideration in the design of this arena, guiding the decisions I made
- ◇ Double layered 1/4" polycarbonate panels have a 1" air-gap to minimize damage to the outer layer and reduce the chance of a breach
- ◇ An 800 cfm fan can pull out all air within the arena in ~20 seconds, extracting toxic LiPo battery fumes in the event of fire
- ◇ Sensored door lock changes the arena lights from white to red when the doors are unlocked



Beetleweight Arena - Serviceability

- ◆ Polycarbonate panels are inserted from the top and can be replaced in less than 10 minutes
- ◆ Polycarbonate panels bisected to save costs; replacing a 4x8 panel is much more expensive than a 4x4 panel
- ◆ Consumable wood kickplates limit gashes and scrapes from damaging polycarbonate
- ◆ Floor panels can be inserted through the door and replaced in 20 minutes



Arena - PDM

- ◆ We're using the Aras Innovator PDM system to collaborate with other club members on the design and share data for manufacturing
- ◆ I trained members on understanding and utilizing the PDM software
- ◆ Using PDM to link part drawings for manufacturing to their Part Documents

The screenshot displays the Aras Innovator PDM software interface. At the top, the part number 'P0004039' is visible, along with a star icon and a notification icon. Below this, there is a toolbar with icons for 'Edit', 'Refresh', 'Back', 'Home', 'Print', 'Share', and 'More'. The main content area is titled 'Part' and contains a form with the following fields:

- Part Number: P0004039
- Revision: A
- State: Preliminary
- Assigned Team: Railside Robotics
- Name: Beetleweight Arena TLA
- Designated User: Railside Robotics
- Type: Assembly
- Unit: IN
- Make / Buy: Make
- Cost: [Empty]
- Effective Date: [Empty]
- Long Description: [Empty]
- Changes Pending:
- Control Type: [Empty]

Below the form, there is a navigation bar with tabs for 'BOM', 'Part NC', 'BOM Structure', 'Alternates', 'AML', 'Documents', 'CAD Documents', 'Analysis Containers', 'Goals', 'Changes', and 'Part Submission Warrant'. The 'BOM Structure' tab is currently selected. Below the navigation bar, there is a toolbar with icons for 'Refresh', 'Expand/Collapse', 'Eye', 'Arrow', '3', 'Home', 'Print', and 'More'. The main content area is a table with the following columns: 'Part Number', 'Re...', 'State', 'Sequence', 'Quantity', 'Claimed By', 'Name', and 'Effectivity'. The table contains the following data:

Part Number	Re...	State	Sequence	Quantity	Claimed By	Name	Effectivity
P0003940-001	A	Preliminary	5	2		Beetleweight Arena Wall Frame	
P0004036	A	Preliminary	25	3		SWAR Rubber Strip	
P0004036-001	A	Preliminary	30	4		SWAR Rubber Strip	
P0004041	A	Preliminary	40	2		SWAR L-Channel	
P0003939-001	A	Preliminary	45	1		SWAR Door Panel VerticalTube	
P0004040-002	A	Preliminary	70	1		SWAR UHMW Retaining Plate	
P0004036-002	A	Preliminary	75	1		SWAR Rubber Strip	
P0004054	A	Preliminary	90	1		SWAR Tube Mirror	
P0003939-003	A	Preliminary	105	1		SWAR Door Panel VerticalTube	
P0004140	A	Preliminary	110	4		SWAR Wall Peg Holder	
P0004213	A	Preliminary	125	2		SWAR Tube Guide	
P0004212-001	A	Preliminary	130	2		SWAR Floor Brace Mount	

Beetleweight Arena - Manufacturing

- ◆ Considering the scale of this project, after completing the design, the next biggest challenge for me has been managing the arena's manufacturing
- ◆ Leading a team of 10 members in manufacturing over 40 unique parts
- ◆ Using part drawings to ensure consistent and accurate parts are made
- ◆ Utilizing CNC Mills, laser cutters, and welding to construct the steel frame

