Title
Rogue: UCI’s First All-Wheel-Drive Off-Road Vehicle

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Rogue: UCI's First All-Wheel-Drive Off-Road Vehicle

Advisors: John Michael McCarthy, Quoc "QV" Viet Dang, Robert "Smitty" Smith, Phil Chipman, Ron Kessler

Project Leads: Alan Diaz, Yavin Evenich, Natalie Luu, Wil Deomampo, Kamal Elamri, Bevan Chiu, Nathan Martinez, Cindy Tan, Blaise Baker

ANTEATER BAJA RACING

UCI Samueli School of Engineering

Department of Mechanical and Aerospace Engineering

Overview

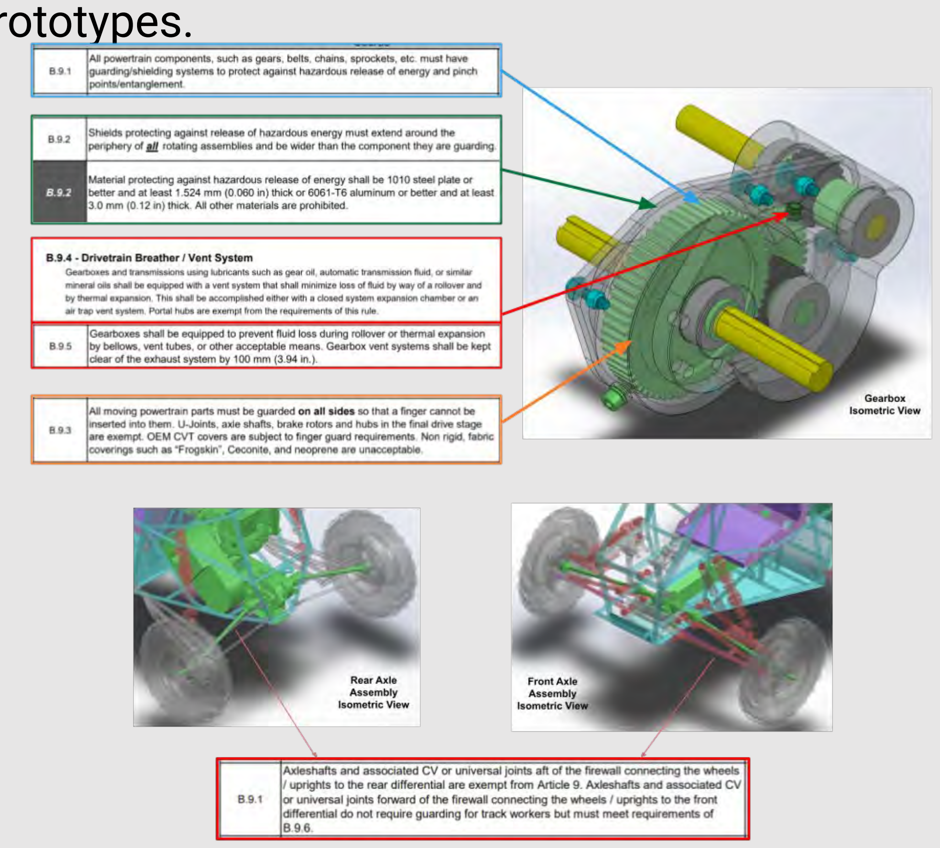
Rogue is Anteater Baja Racing's first All Wheel Drive (AWD) All-Terrain Vehicle (ATV). Our objective is to design, manufacture, and race a reliable vehicle to complete every event at the 2023 Baja SAE Oregon competition scheduled for May 31 - June 3rd, 2023.

The Baja SAE competition features student teams from over 100 universities directly competing in several performance event categories: Acceleration, Maneuverability, Hill Climb, Suspension, and Endurance.

BAJA SAE Rules Verification

Every year Baja SAE provides a set of rules and technical requirements teams must follow to standardize the pool of competitors and ensure the safety of all competing vehicles. A rigorous technical inspection is done during the first day of competition.

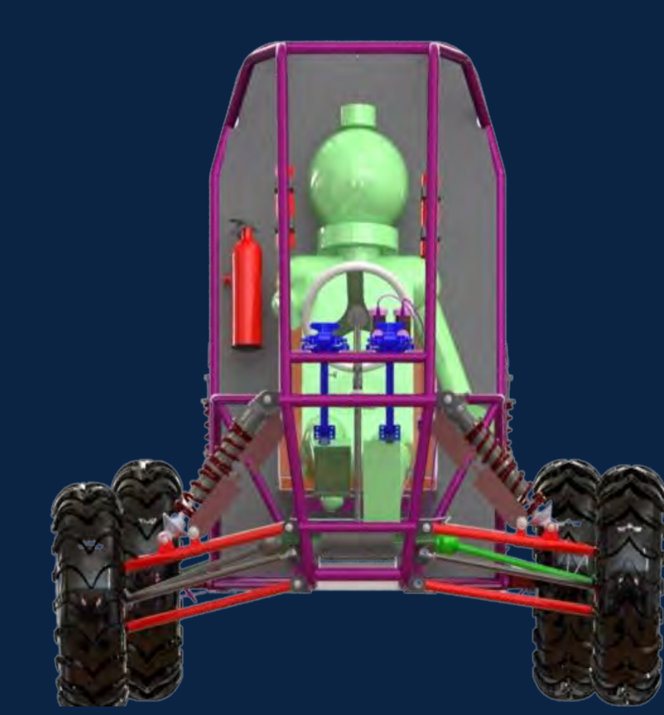
Anteater Baja Racing is continuously verifying all rules for each subsystem to meet SAE requirements through CAD models and physical prototypes.



System Requirements

Requirements	Design Target	Performance Estimates
Weight (w/ 155 lb driver)	412-721 lbs	640 lbs
Weight % Bias Front/Rear	40-50 / 60-50	45-55
Wheelbase	Max: 60 in	57 in
Overall Width (Outside Edge of Wheels)	Max: 60 in	59 in
Overall Height (Ground to Top of Roll Cage)	50-65 in	64 in
Ground Clearance	Min: 12 in	12 in
Tire Size	Min: 20in	22 in
Front Suspension Travel	9-10 in	10 in
Rear Suspension Travel	9-10 in	10 in
Steering Wheel Rotations Lock-to-Lock	216-290 deg	270 deg
Turning Radius	Max: 12 ft	7.9 ft
Steering Effort	8 - 10 ft*lbs	8.8 ft*lbs
Top Speed	25-35 mph	35 mph
Torque Output ea. Wheel	100 - 120 ft*lbs	107.9 ft*lbs
Acceleration Time (100ft, 150ft)	150ft: 5 to 6.6s	6.1 s (accel: 7.7 m/s^2)

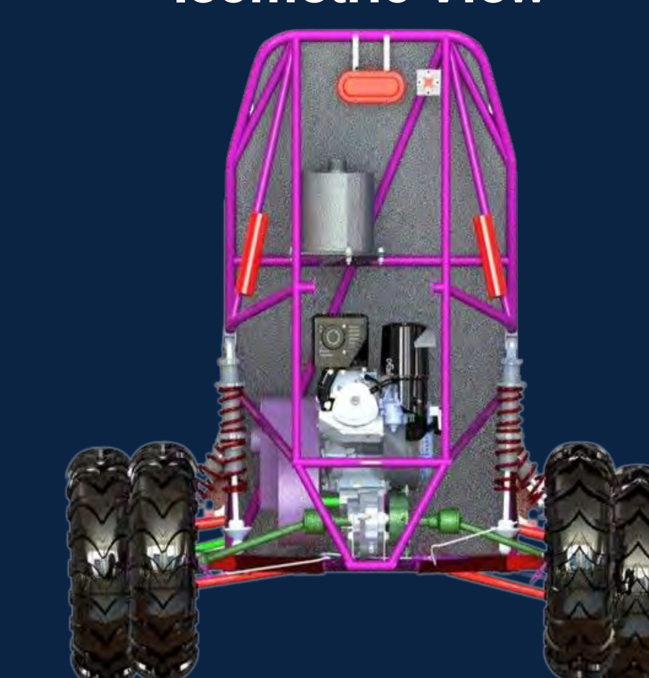
Rogue Winter 2023 CAD Model



Front View

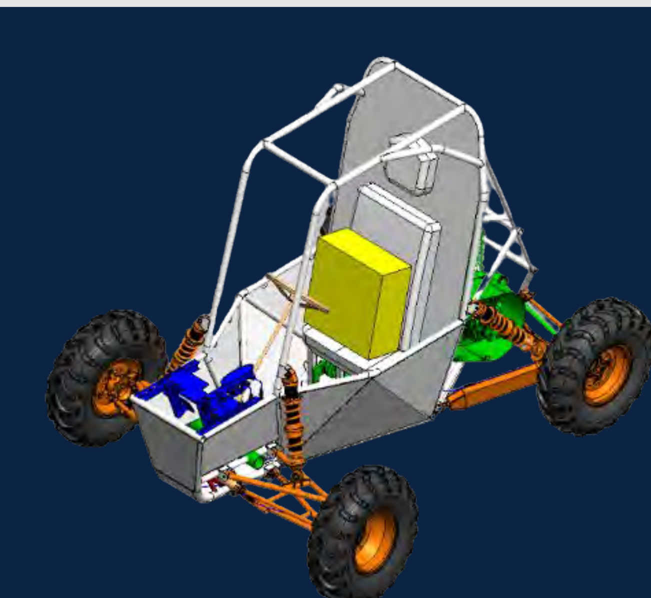
Isometric View

Side View



Rear View

Rev. A, Spring 2022



Rev. B, Summer 2022

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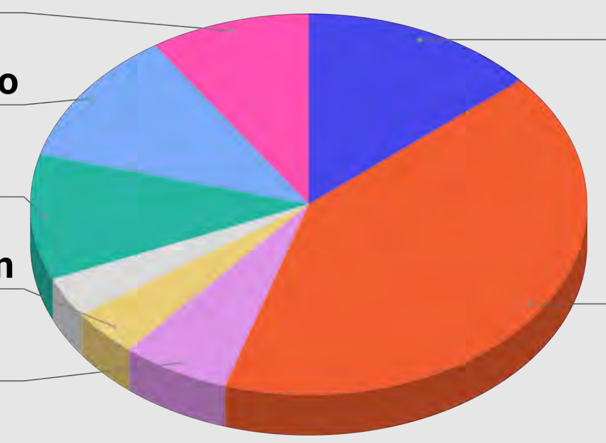
Cost Analysis

Cost Breakdown by Subsystem



Projected Total Cost: $15,000

Manufacturing Methods

Angle Grinding

Tube Bending

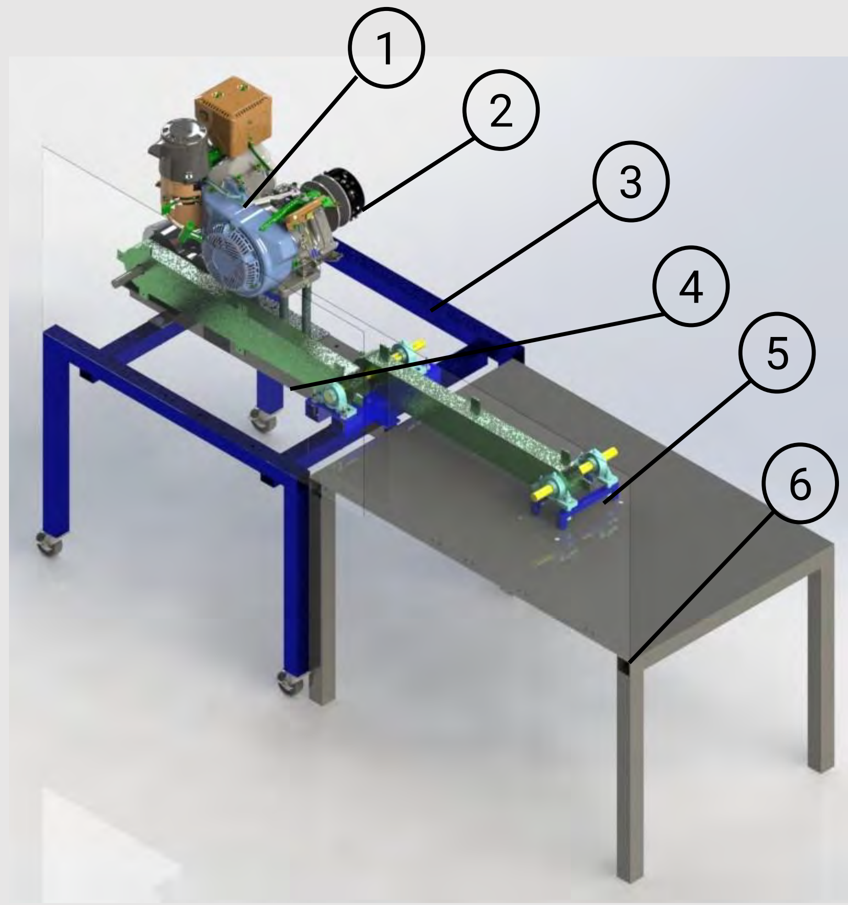
Machine Turning

Welding

Riveting

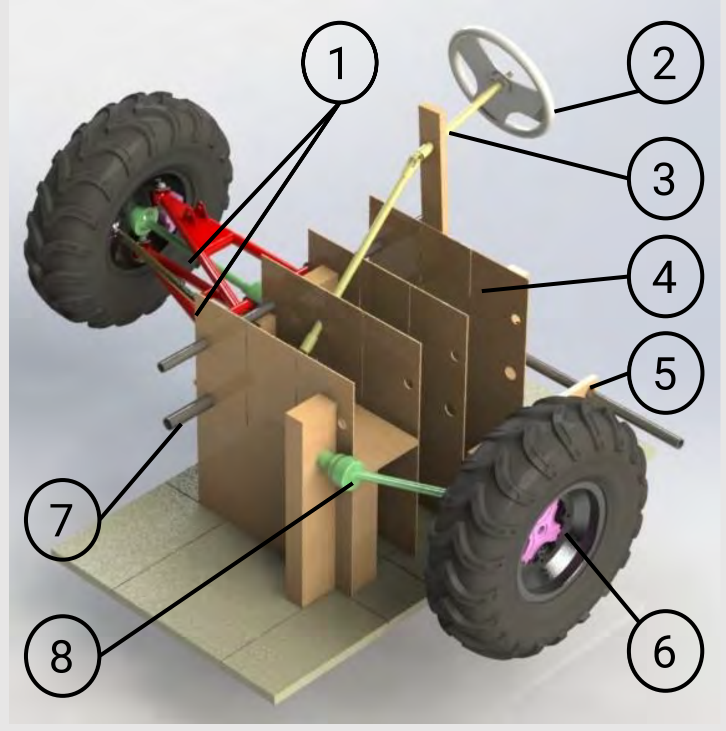
Website | **Zotfunder** | **Instagram**

Powertrain Subsystem Prototype



Component Breakdown	
1	Kohler CH440 Engine
2	GX9 CVT Transmission
3	Test Bench
4	6061 Powertrain Driveline Guards
5	Front Axle and Pillow Block Bearings
6	Safety Panel Guards

Suspension & Steering Subsystem Prototype



Component Breakdown	
1	4130 Upper/Lower Control Arm
2	13" Al Steering Wheel
3	Steering Shaft
4	Wooden Supporting Panels
5	Wooden Trailing Arm
6	Wheel Assembly
7	Relative Chassis Geometry
8	Front CV Axles

Prototype Goals

1. Verify no interference between any cross-subsystem components exists in the Powertrain and Suspension/ Steering Prototype.
2. Visually verify successful torque transfer from Kohler CH440 to front axle
3. Measure torque input/output at each Powertrain interface.
4. Visually verify suspension and steering travel throughout entire travel.
5. Measure suspension and steering travel at extremes.

Prototype Results

Powertrain Prototype

- ➢ Successful visual torque transfer test with live engine
  - ○ Utilized previously SAE mandated Briggs and Stratton Engine. Pending modifications to run with CH440

Suspension & Steering Prototype

- ➢ Found binding & interference while steering near max levels of droop and compression
- ➢ Pending rear suspension travel with trailing arm and rear CV axles.

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Powertrain Subteam

Advisors: John Michael McCarthy, Quoc "QV" Viet Dang, Robert "Smitty" Smith, Phil Chipman, Ron Kessler

Subteam Members: Wil Deomampo, Nathan Kim, Luis Perez, Abraham Robles, Jonny Holt, Adrian Prado Falcon, Blaise Baker

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Table 1: Engine Performance Curve

Engine Speed (RPM)	Engine Torque (ft-lb)	Gearbox Ratio	CVT Ratio	Vehicle Gear Ratio
2400	18.5	7.2	4.33	31.2
2600	18.1	7.2	3.89	28
2800	17.4	7.2	3.44	24.8
3000	16.6	7.2	3.00	21.6
3200	15.4	7.2	2.56	18.4
3400	14.5	7.2	2.00	14.4
3600	13.5	7.2	0.89	6.4

Table 2: Powertrain Requirements

Requirement	Design Target	Performance Estimates
Weight (w/ 155 lb driver)	412-721 lbs (186.88 - 327.04 kg)	640 lbs (274.4 kg)
Top Speed	23 mph (37.0 kph)	32 mph @ 3600 RPM (52.5 kph)
Acceleration Time (150ft)	150ft: 5 to 6.6s	6.1 s 25.3 ft/s^2 (7.7 m/s^2)
Torque on Shaft (Rear/Front)	400 ft-lb at peak (542 N-m)	577.2-86.4 ft-lb (783-117 N-m)
Hill Climb Performance (30 deg)	100 ft without stopping	Torque: 200 ft-lb (271 N-m)
4x4 Type (Chain, Shaft, etc.)	AWD Belt-Pulley System	

Driveline Breakdown

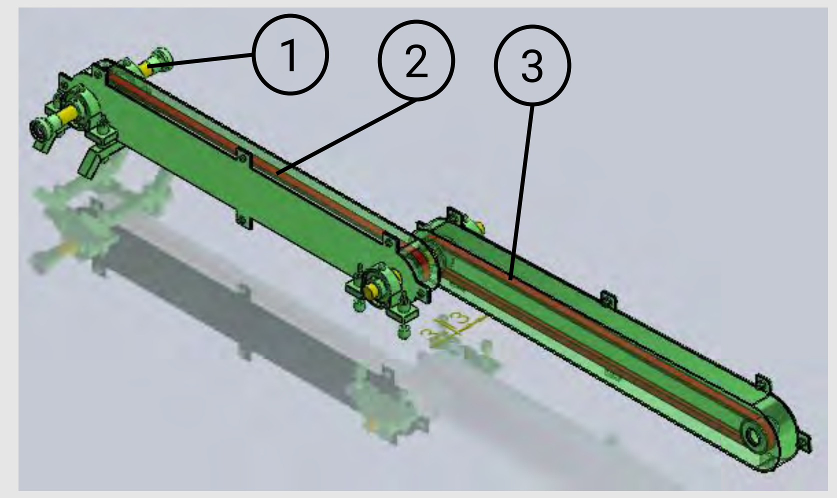

Figure 1. Driveline CAD

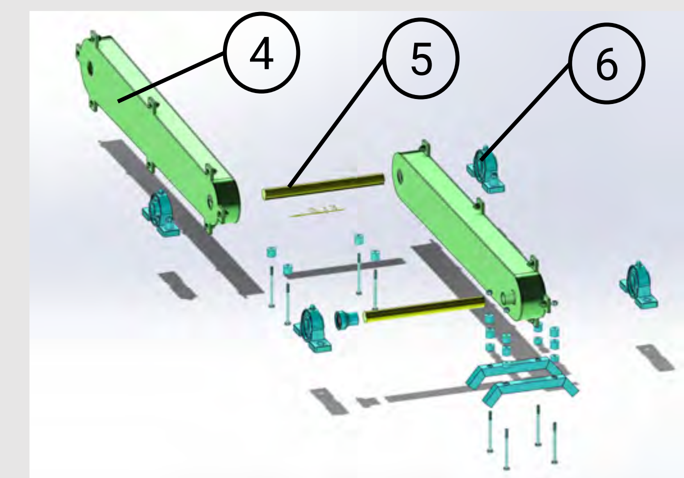

Figure 2. Driveline Component Breakdown

1	1" Front Shafts	3	65" Rear Cogged V-Belt	5	1" Intermediate shaft
2	63" Front Cogged V-Belt	4	2x Belt Guards	6	4x 1" Pillow Blocks

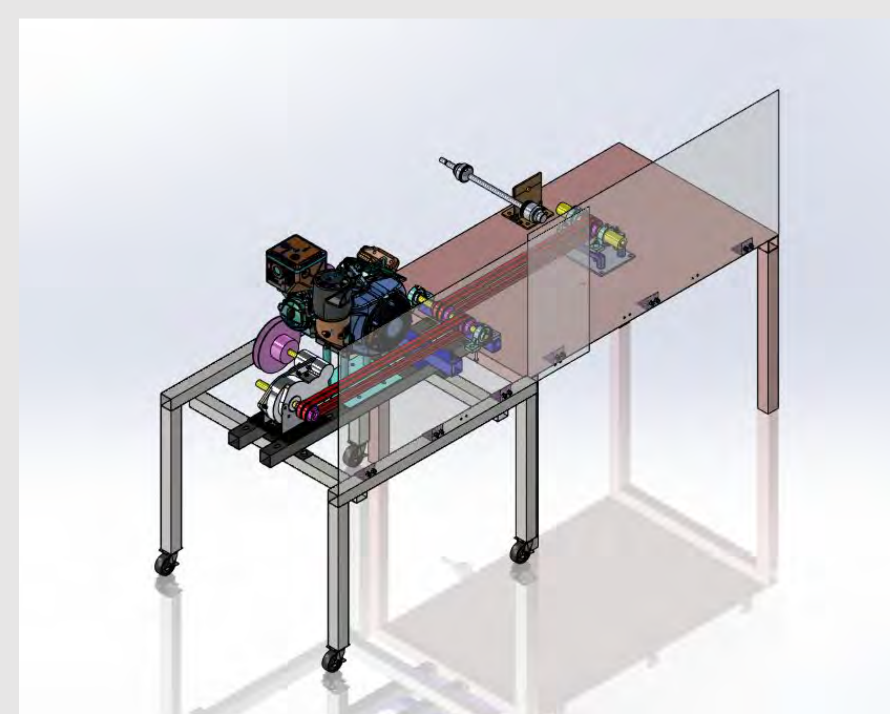

Figure 4. Powertrain Prototype Isometric View

Figure 5. Manufactured Powertrain Prototype

Table 3: Collected Data on Grommets

With Rubber Grommet	Front CV Run 1	Front CV Run 2	Front CV Run 3
Idle	108 RPM	113 RPM	113 RPM
Full Throttle	416 RPM	434 RPM	435 RPM
w/o Rubber Grommet	**Front CV Run 1**	**Front CV Run 2**	**Front CV Run 3**
Idle	120 RPM	135 RPM	120 RPM
Full Throttle	440 RPM	437 RPM	431 RPM

Powertrain CAD Design

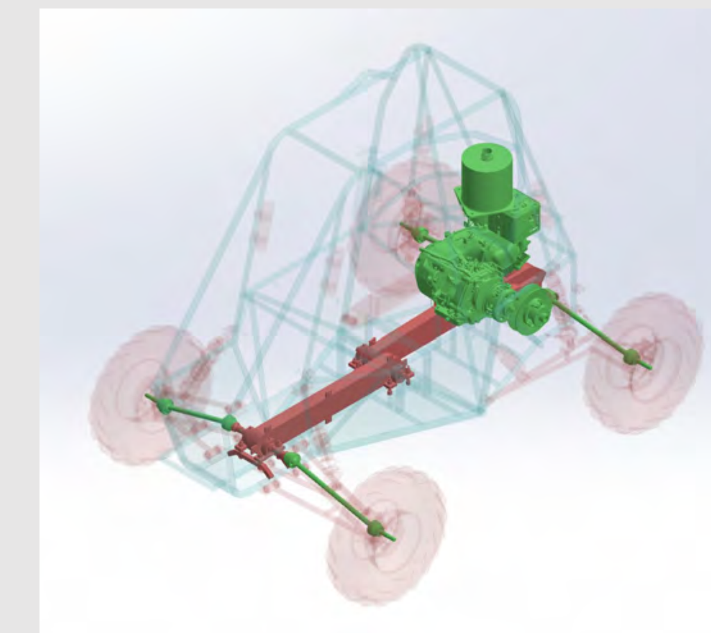

Figure 3. Isometric View of Powertrain Components Integrated into Rogue

Belt Analysis FBD

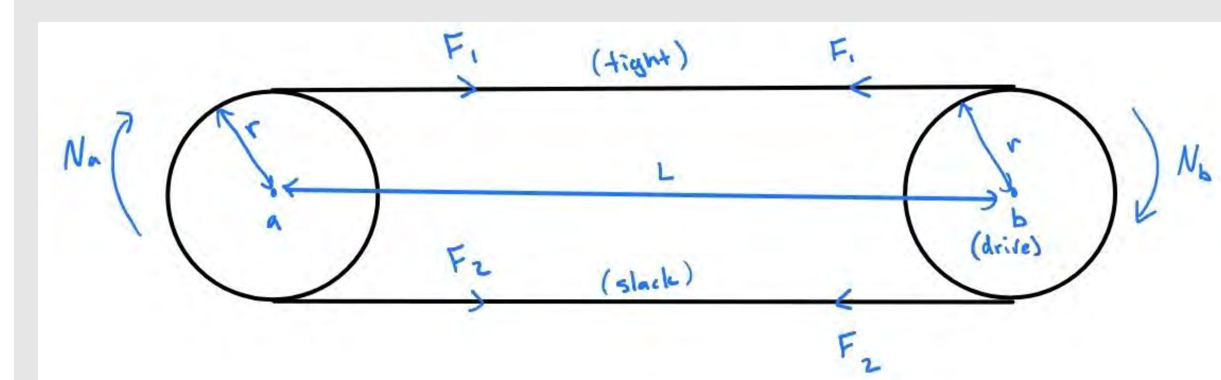

Figure 6. Driveline Belt FBD

Single Belt At Max Motor Torque 18.5 Hp

$$577.2 \text{ ft·lb} = 0.104 \text{ ft}\,(1465.57F_2 - F_2)$$

$$577.2 \text{ ft·lb} = 0.104 \text{ ft}\,(1464.57F_2)$$

$$577.2 \text{ ft·lb} = 152.56F_2$$

$$F_2 = 3.78 \text{ lb}$$

$$F_1 = 1465.57F_2$$

$$F_1 = 5544.88 \text{ lb}$$

Estimated Force Belt Can Sustain = 13,678 lbf (60,842 N)

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Suspension & Steering Subteam

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Subteam Members: Bevan Chiu, Kamal Elamri, Jamshid Atashbar, David Bazan, Yu-Lun Wang

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Estimated Performance Requirements

Table 1: Front Suspension

Description	Requirement	Reason
Chassis Ground Clearance	> 11 in	Tallest obstacles is about 10"
Suspension Travel	> 9 in	Common ATV Travel is > 9in
Outer to Outer Width	< 64"	SAE Rule B.1.6
Toe Angles	Inward throughout wheel travel and less than 2 degrees of change throughout wheel travel	Provides more stability when landing in the air.
Camber Angles	0 deg at full droop and a range of -2deg/2deg throughout wheel travel	Don't want to introduce more stress

Table 2: Rear Suspension

Description	Requirement	Reason
Chassis Ground Clearance	> 11 in	Tallest obstacles is about 10"
Suspension Travel	> 9 in	See table comparison
Toe Angles	-2/2 degrees of change throughout wheel travel	Provides more stability when landing in the air.
Camber Angles	0 deg at full droop and a range of -2deg/2deg throughout wheel travel	Don't want to introduce more stress

Table 3: Steering

Description	Requirement	Reason
Turning Radius	< 8 ft	SAE Event Turn 8 ft
Steering Effort	< 10 ft-lbs	Tested holding 10 lbs dumbbell
Steering Ratio	> 7:1	-
Max Wheel Turning Angle	27	Limited by the max angle of inclination of the CV axle

CAD Design

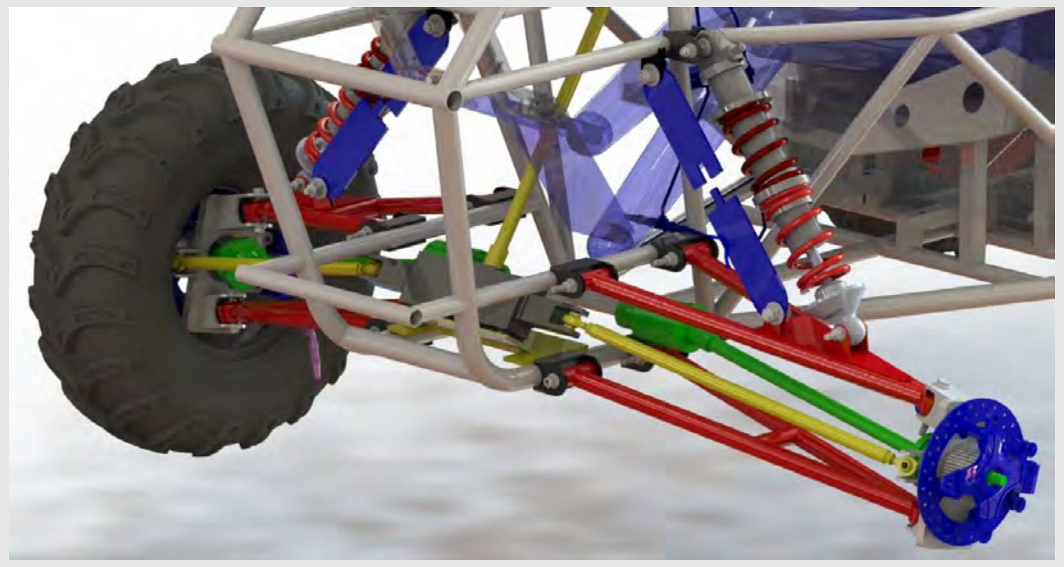

Figure 1: Isometric View Front Suspension and Steering

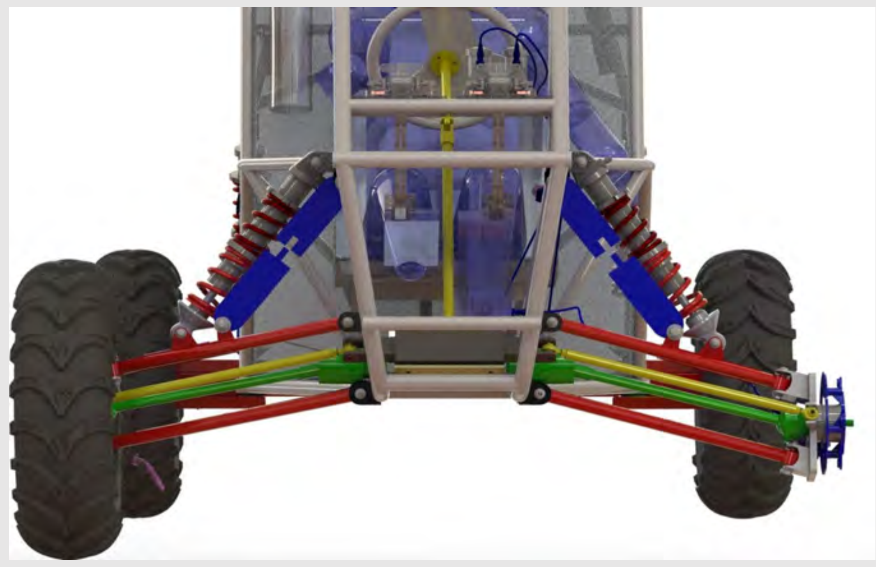

Figure 2: Front Suspension and Steering Front View

Figure 3: Rear Suspension

Rules Verification

SAE Rule B.1.6 - Width: 162 cm (64 in) at the widest point with the wheels pointing forward at static ride height.

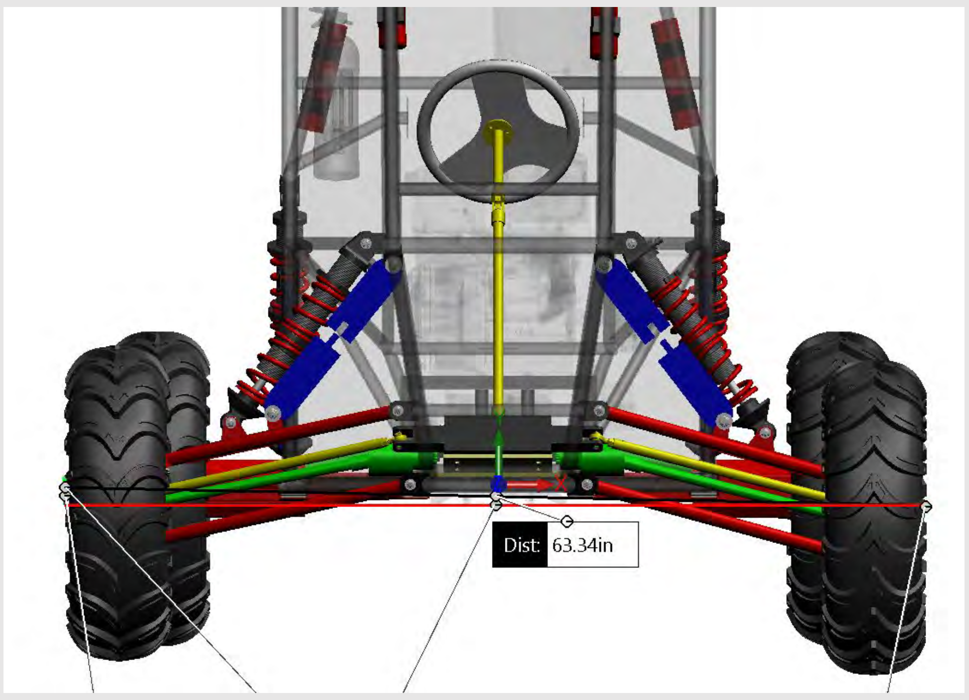

Figure 4: Outer to Outer Width Verification

Prototype

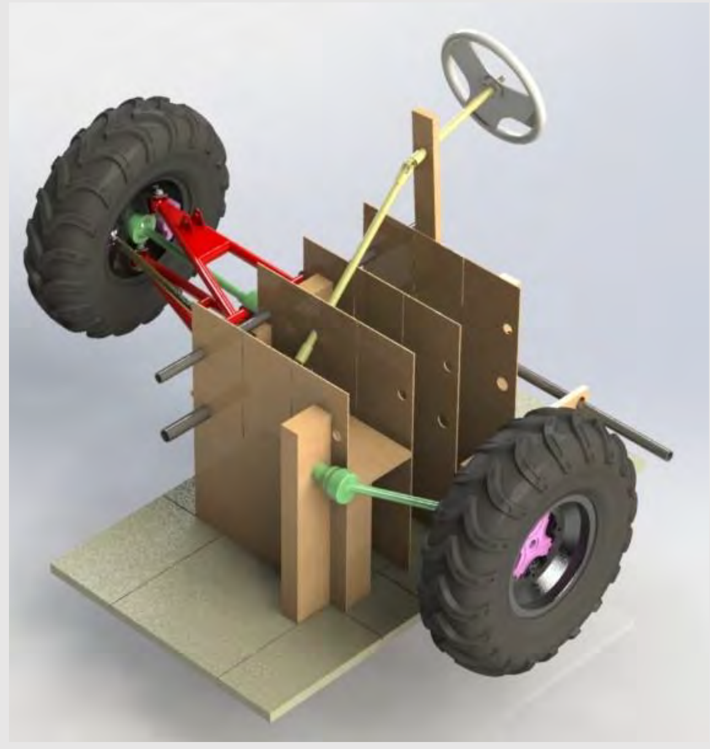

Figure 5: Front Suspension Prototype CAD

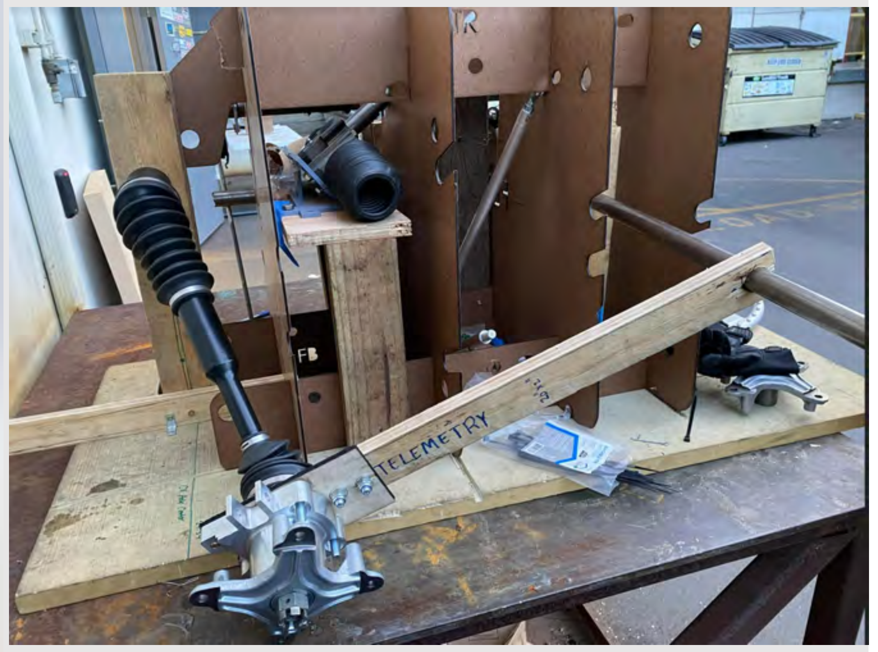

Figure 6: Rear Suspension Physical Prototype

Figure 7: Front Suspension Physical Prototype

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Brakes & Human Interface Subteam

Advisors: John Michael McCarthy, Quoc "QV" Viet Dang, Robert "Smitty" Smith, Phil Chipman, Ron Kessler
Subteam Members: Cindy Tan, Amber Ramirez, Lori Fung, Daniella Murillo, Kristen Chung

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Estimated Performance Requirements

Requirement	Design Target/Goal	Projected Results
Pedal Effort to local all four wheels w/ 150 lb driver.	72 lbf	58 lbf
Braking Torque (At 72 lb)	220 lbf*ft	277 lbf * ft

Dynamic Brakes Prototypes

Figure 1: Dynamic Torque Testing Done with Vandal Engine

Human Interface Manufacturing

Figure 2: Seat Manufacturing

Static Brake Prototype

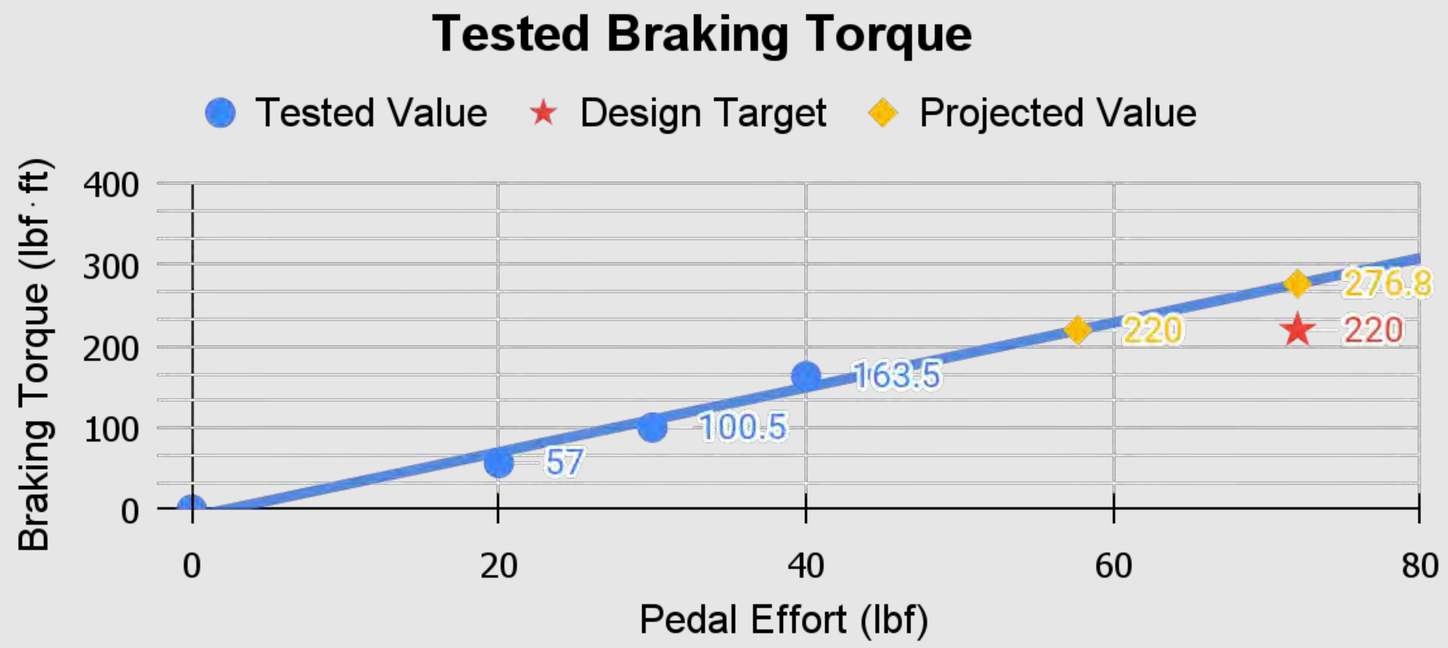

Figure 3: Static Torque Test Values. Projected test values exceed design target.

Figure 4 & 5: Static Torque Testing.
Pedal force is applied at at Point 1, and braking torque is measured at Point 2

Human Interface Prototype

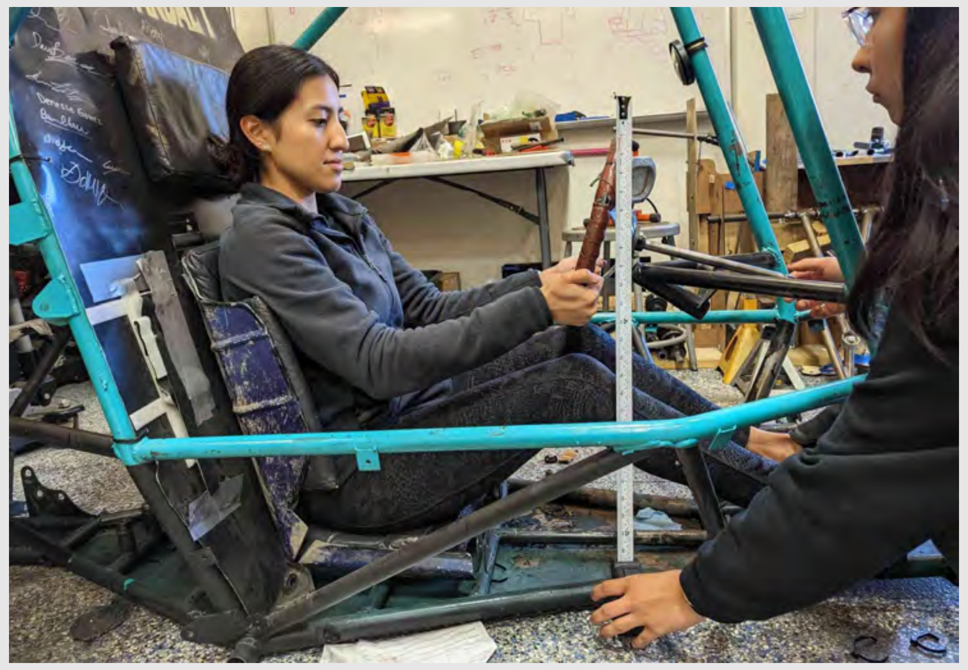

Figure 6: Steering Wheel Position

Figure 7: PVC Chassis

Brakes CAD Drawings

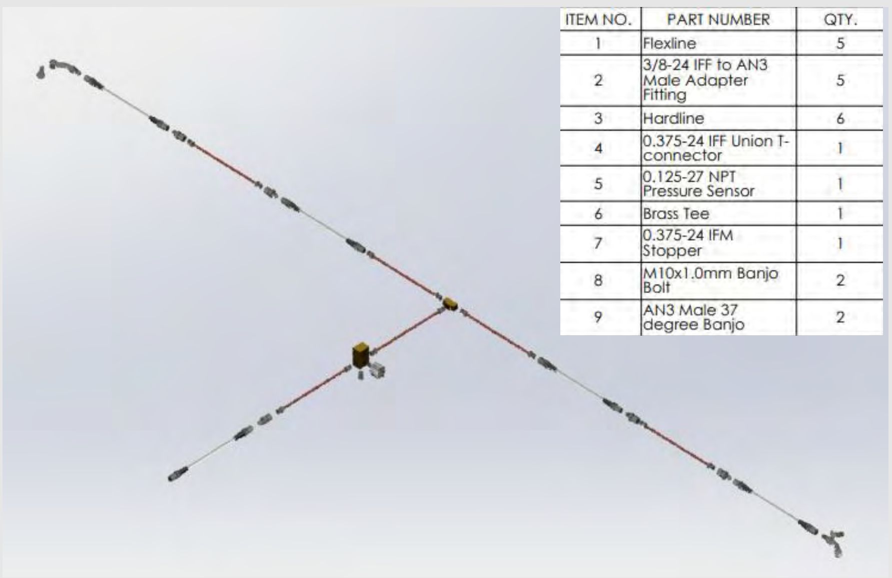

Figure 8: Flat Brake Line. Rogue consists of front and Rear independent brake lines.

Figure 9: Flexline to Hard line connection

Figure 10: Pressure Sensor

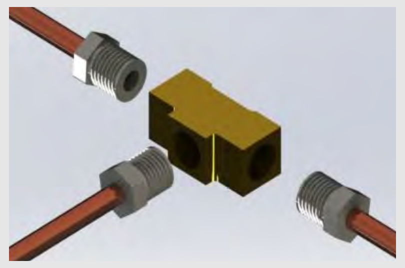

Figure 11: Brake Line Split

Figure 12: Connection to Caliper

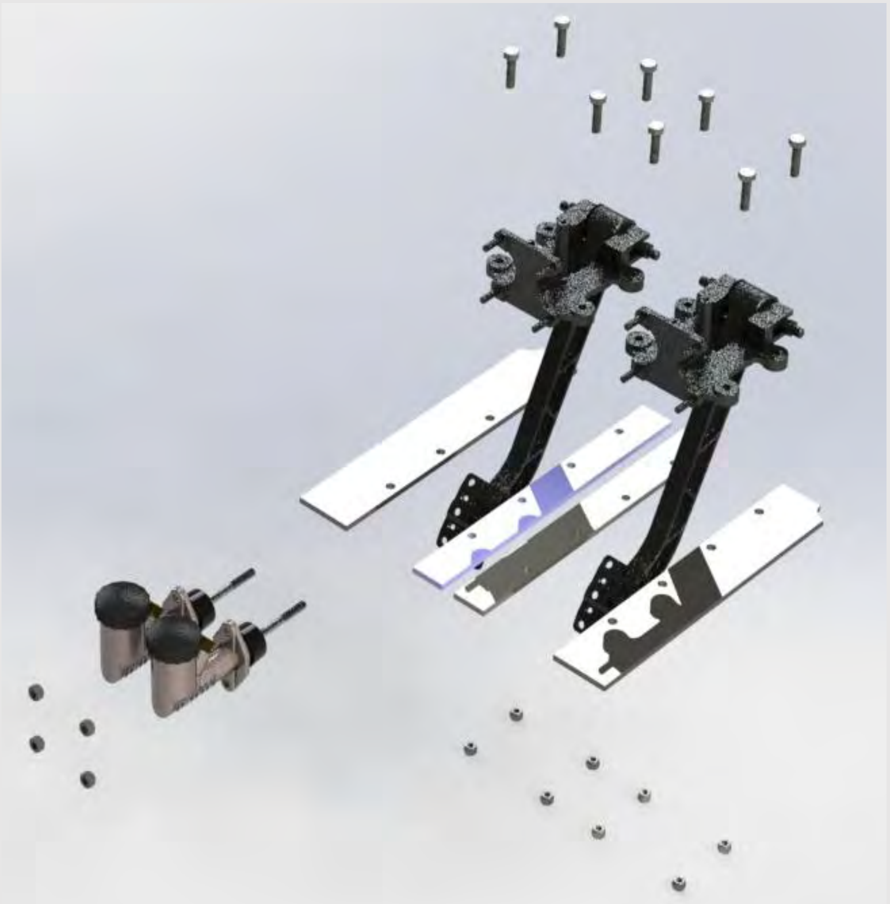

Figure 13: Pedal Box and Mounts. 6 inches of adjustability

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Chassis Subteam

Advisors: John Michael McCarthy, Quoc "QV" Viet Dang, Robert "Smitty" Smith, Phil Chipman, Ron Kessler
Subteam Members: Nathan Martinez, Noah Castillo, Andy Chen, Musab Al Kindy, Anthony Sardisco, Kassandra Vazquez

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Estimated Performance Requirements

Table 1: Chassis Design Goals

Requirement	Relative Speed (mph)	Load Location	Peak Load (lbf)	How is Success Defined?
Hard Impact	20 - 35	Front	7240 - 12,952 (6 to 11 Gs)	Avoid Critical Injury to the Driver
	10 - 15	Side/Rear	3,736 - 5,563	
Soft Impact	10 - 20	Front	3,736 - 7,240	Avoid critical injury to the driver AND vehicle shall be fully functional and operable after collision
	5 - 10	Side/Rear	1,826 - 3,736	
Rollover	14	Top	Maximum: 1,300	Avoid critical injury to the driver AND vehicle shall be fully functional and operable after collision

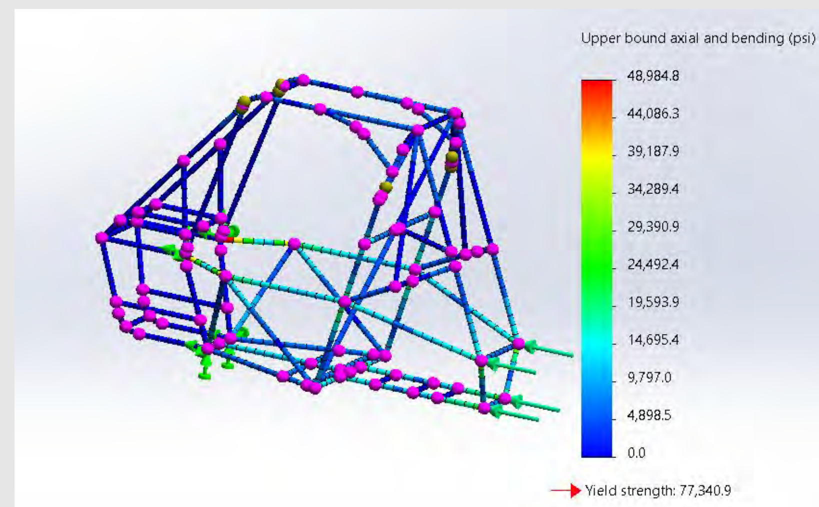

Fig 1: Soft Rear Impact Simulation

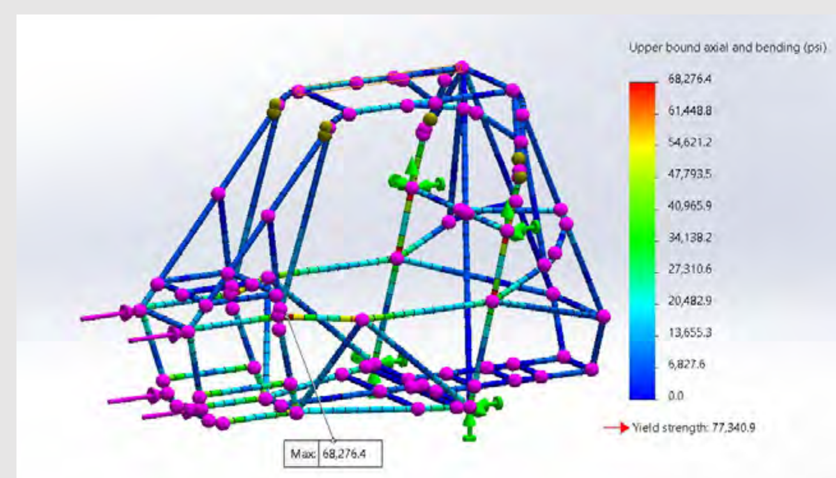

Fig 2: Soft Front Impact Simulation

Rules Verification

SECONDARY MEMBERS ONLY		
Bend Angle \ Length	≤1016mm (40in)	>1016mm (40in)
≤ 30°	No Supports Required	1 Support Member Required*
> 30°	1 Support Member Required**	2 Support Members Required**

* Required within 50mm (2in) of the midpoint of the overall tube length
** Required within the tangents of the bend

Table 2: Secondary Member Requirements

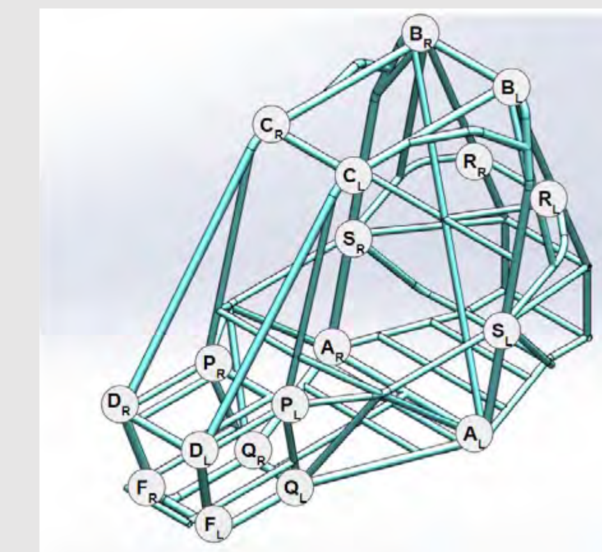

Figure 3: Named Point Locations

Primary Members			
Bend Angle \ Length	≤ 33in	≤ 40in	>40in
Straight	No supports	No Support	1 Support Member
0°<θ<30°	1 support member	1 support member	1 support member

Table 3: Primary Member Requirements

CAD Design

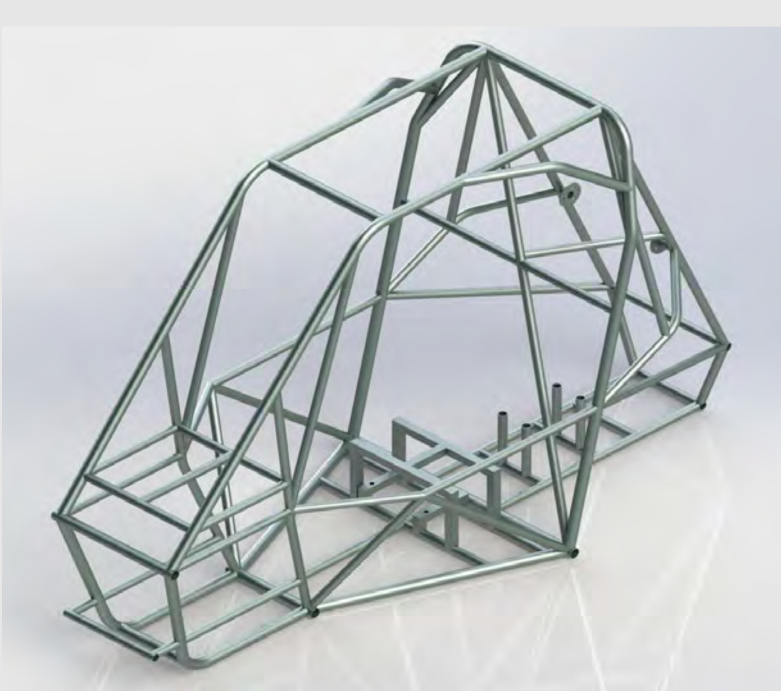

Fig 4: Chassis Front Isometric View

Fig 5: Chassis Rear Isometric View

Material: 1.25" OD x 0.065" primary and 1" OD x 0.065" secondary DOM 1020 steel tubing,

Weight: 95 lbs

Feature removable rear lateral member for quick engine access

Manufacturing

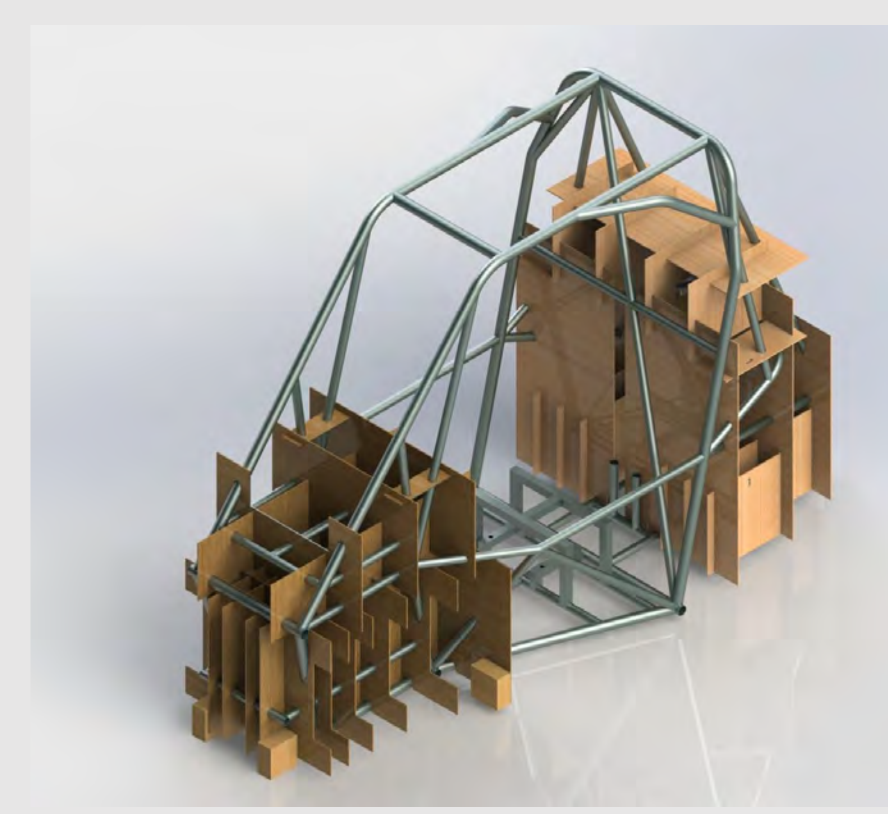

Figure 6: Laser Cut 3D Manufacturing Jig

Figure 7: Manufactured Rear Roll Hoop In 2D Jig