SAE BAJA Final Design Presentation

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UVU MECHANICAL ENGINEERING

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Presentation Overview

1. Baja SAE
2. Background
3. Problem Research
4. Requirements
5. Concept Generation
6. Concept Selection
7. Prototyping
8. Analysis
9. Development
10. Final Design
11. Conclusion

Baja SAE (Society of Automotive Engineers)

- Worldwide collegiate competition
- Entirely student-run effort
- Competition of off-road vehicles

Background

2019 UVU Baja Team

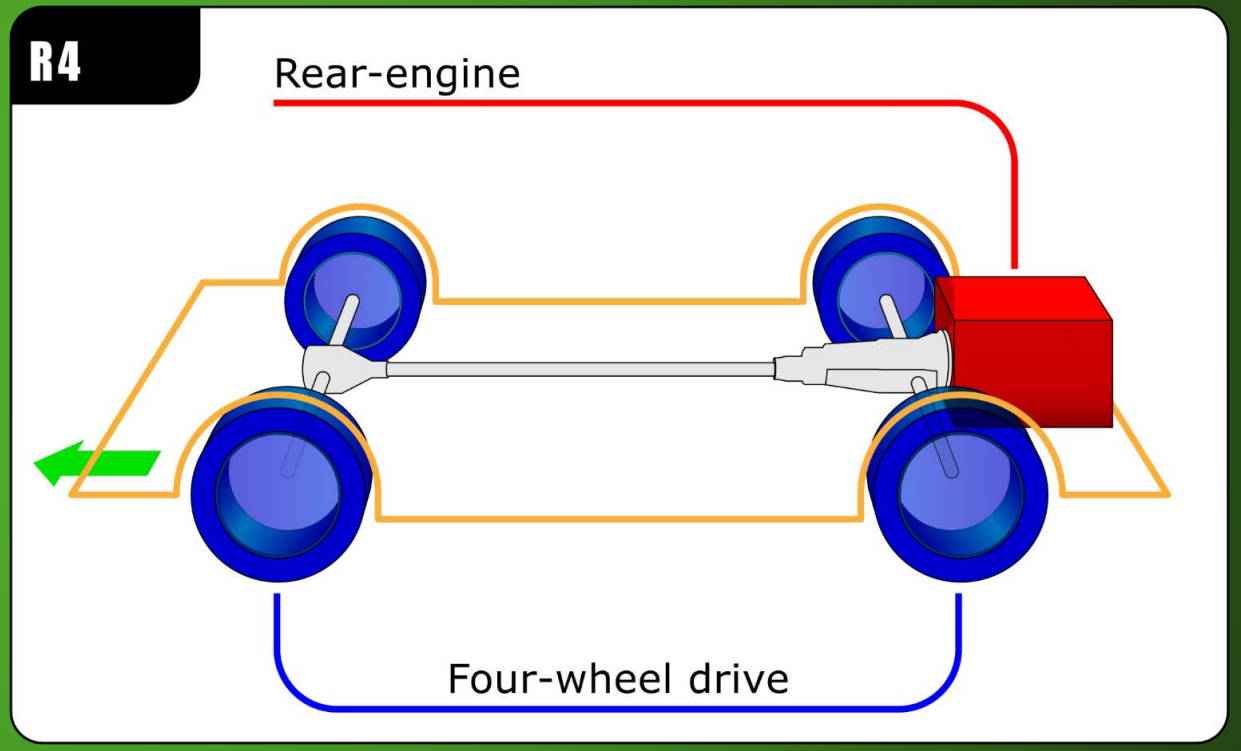
- Designed/Built rollcage and rims

2021 UVU Baja Team

- Integrated new designs and made a working 2WD vehicle
- Competed in Arizona Baja SAE

2022 UVU Baja Team Goals

- Design and build a robust functioning 4WD system
- Subframe design shielding 4WD components



Problem Research

Interviews

- Mechanics, ATV/UTV enthusiasts, and everyday drivers

Forum Searches

- Baja SAE forums provided insight from other competing teams

Competition Rules

- Set requirements which need to be met

Internet Searches

- Researched 4WD/Drivetrain methods

Requirements

BAJA SAE RULES

- Adequate ground clearance and traction
- Four or more wheels, not in a straight line
- All four wheels must have power delivered to them
- Universal joints in the steering system need to be

Requirements

APPLICABLE CODES AND STANDARDS

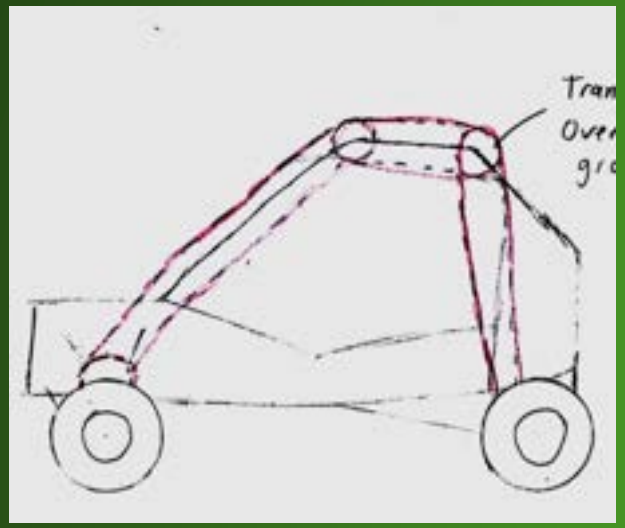
- Baja SAE requires that all fasteners be SAE grade 5 or Metric grade 8.8

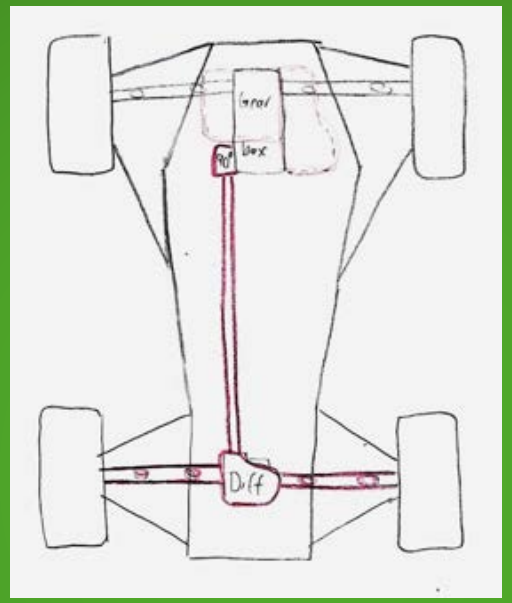
Requirements

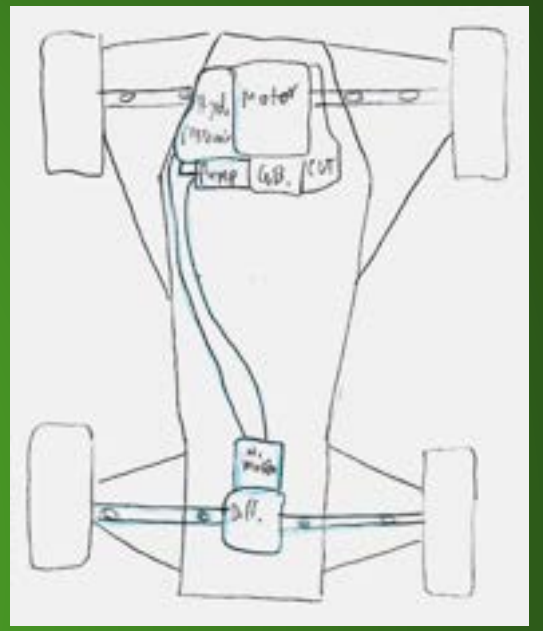
DESIGN REQUIREMENTS

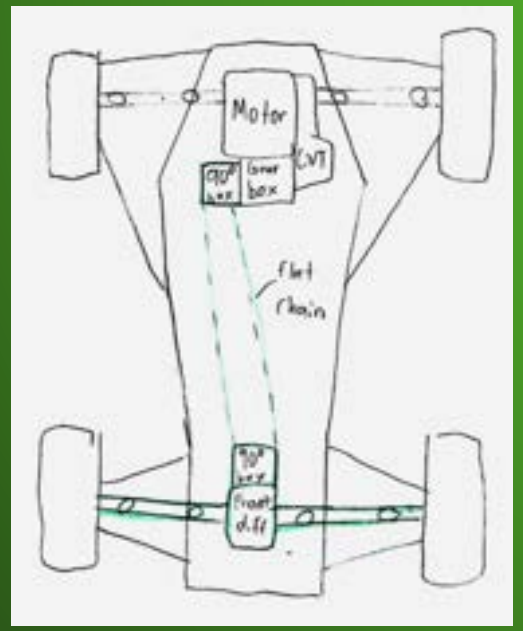
Metric	Importance	Units	Acceptable value
Number of wheels with power	1	# of wheels with power	4
4WD system last x hours without part failure	2	hours	> 300
Number of gear choices	3	Number of gear choices	infinite
4WD system can withstand quick acceleration	2	acceleration (m/s^2)	2
Ground clearance (unloaded)	4	inches	> 12
Time to assemble	3	hours	< 2
Time to dissassemble	5	hours	< 1
Adequate suspension travel	4	in	7
Low Cost (4WD upgrade)	5	USD	< 3000
Weight of 4WD system	5	pounds	< 200
Vehicle will withstand crashes up to x mph	6	miles per hour	30

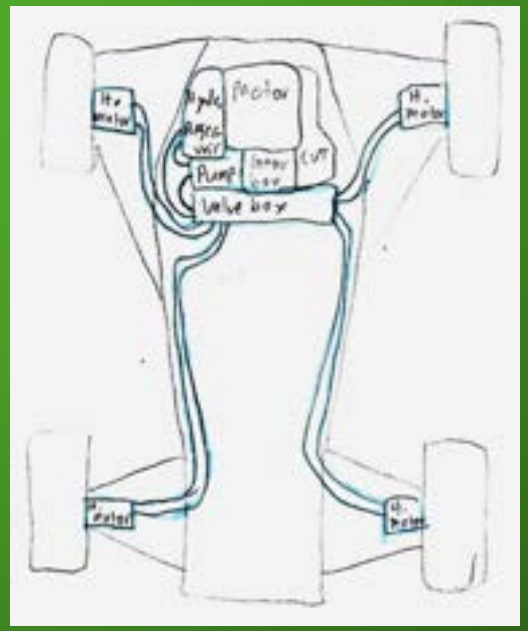
Concept Generation





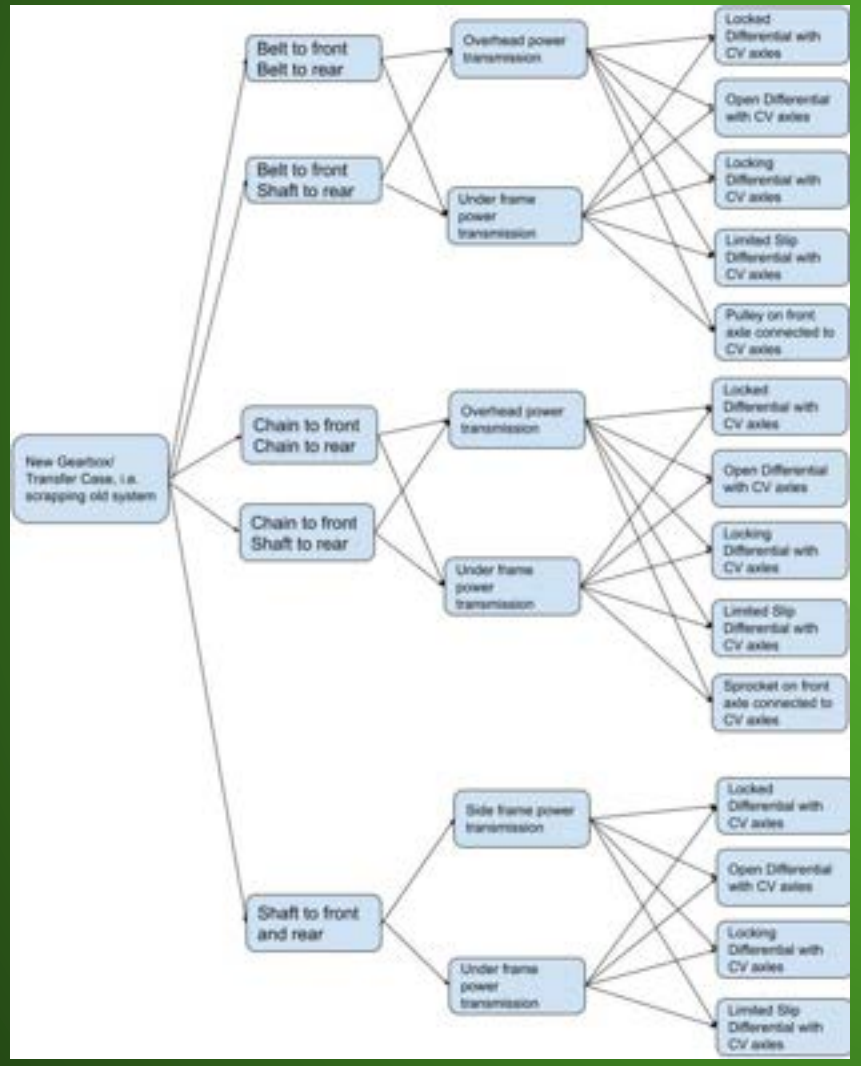


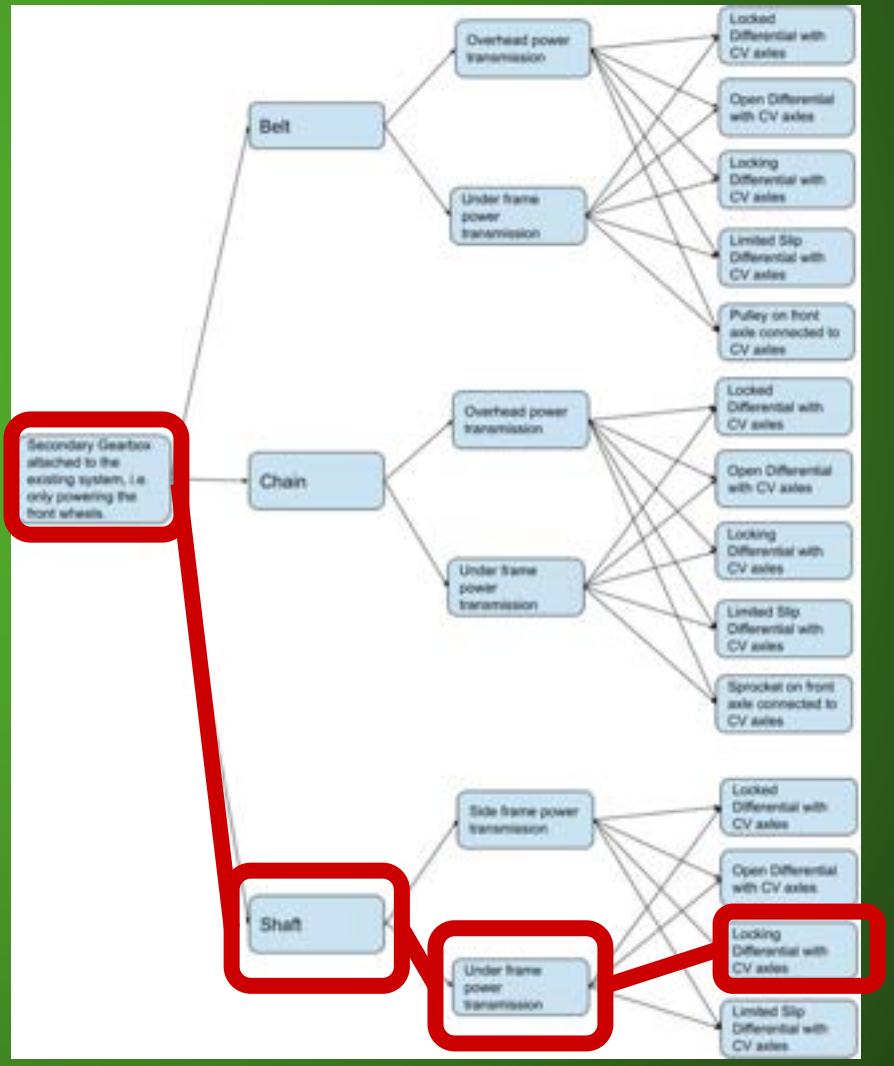




Concept Selection

CONCEPT TREE





Concept Selection

SCREENING MATRICES

	A	B	C	D	E	F	G	H
1		Concepts						
2	**Selection Criteria**	Localized Fluid	Centralized Fluid	Belt Drive (solid)	Belt Drive Differential	Chain Drive (solid)	Chain Drive Differential	Shaft Drive (Reference)
3	Necessary Frame modifications	+	-	-	0	-	0	0
4	Weight of added system	-	-	+	0	+	0	0
5	Durability	0	-	-	-	-	-	0
6	Ease of using 4WD	0	0	+	0	+	0	0
7	Ground Clearance	+	0	+	0	+	0	0
8	Acceleration	-	-	-	-	-	-	0
9	Simplicity	-	-	+	-	+	-	0
10	Power loss	-	-	+	0	+	0	0
11	Ease of repair	-	-	+	0	+	0	0
12	Plusses	2	0	6	0	6	0	0
13	Sames	2	2	0	6	0	6	0
14	Minuses	5	7	3	3	3	3	0
15	Net	-3	-7	3	-3	3	-3	0
16	Rank (1=best)	5	7	1	6	2	4	3
17	Continue?	N	N	Y	N	Y	Y	Y

Concept Selection

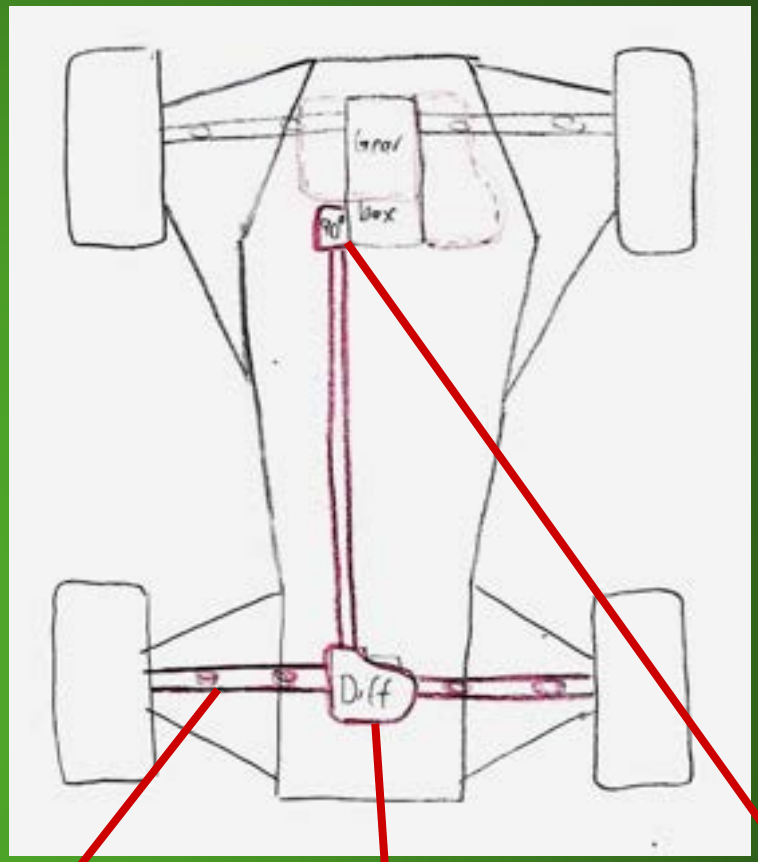
SCORING MATRICES

		Concepts							
		Chain Drive (Differential)		Belt Drive (Solid)		Chain Drive (Solid)		Shaft Drive	
Selection Criteria	**Weight**	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Necessary Frame modifications	25%	2	0.5	3	0.75	3	0.75	2	0.5
Weight of added system	5%	4	0.2	5	0.25	4	0.2	3	0.15
Durability	15%	2	0.3	2	0.3	3	0.45	5	0.75
Ease of engaging 4WD	10%	4	0.4	5	0.5	5	0.5	4	0.4
Ground Clearance	10%	3	0.3	3	0.3	3	0.3	2	0.2
Acceleration	10%	1	0.1	2	0.2	2	0.2	5	0.5
Simplicity	5%	1	0.05	4	0.2	3	0.15	3	0.15
Power loss	5%	2	0.1	2	0.1	2	0.1	4	0.2
Ease of repair	15%	4	0.6	4	0.6	4	0.6	3	0.45
Total Score (out of 5)		2.55		3.2		3.25		3.3	
Rank		4		3		2		1	
Continue?		NO		NO		NO		YES	

Concept Selection

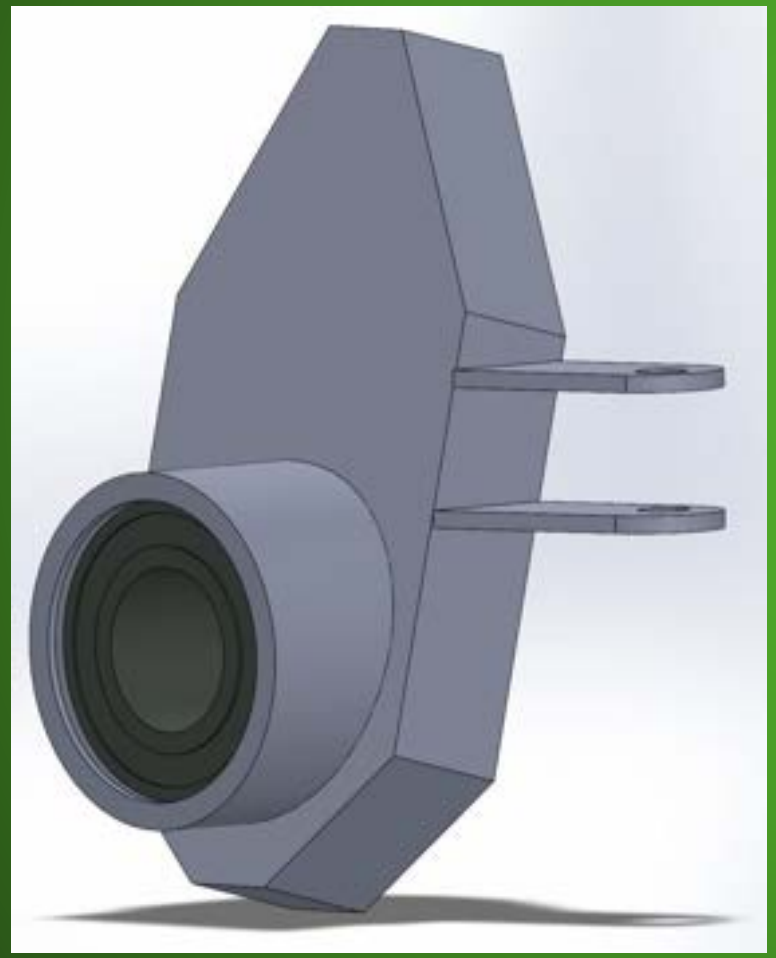
SELECTED CONCEPT

- Standard differential design
- Differential and CV axles from Yamaha ATV
- Custom rear gearbox, driveshaft, steering knuckle, hub adapters
- Requires subframe addition



Prototyping

3D MODELING

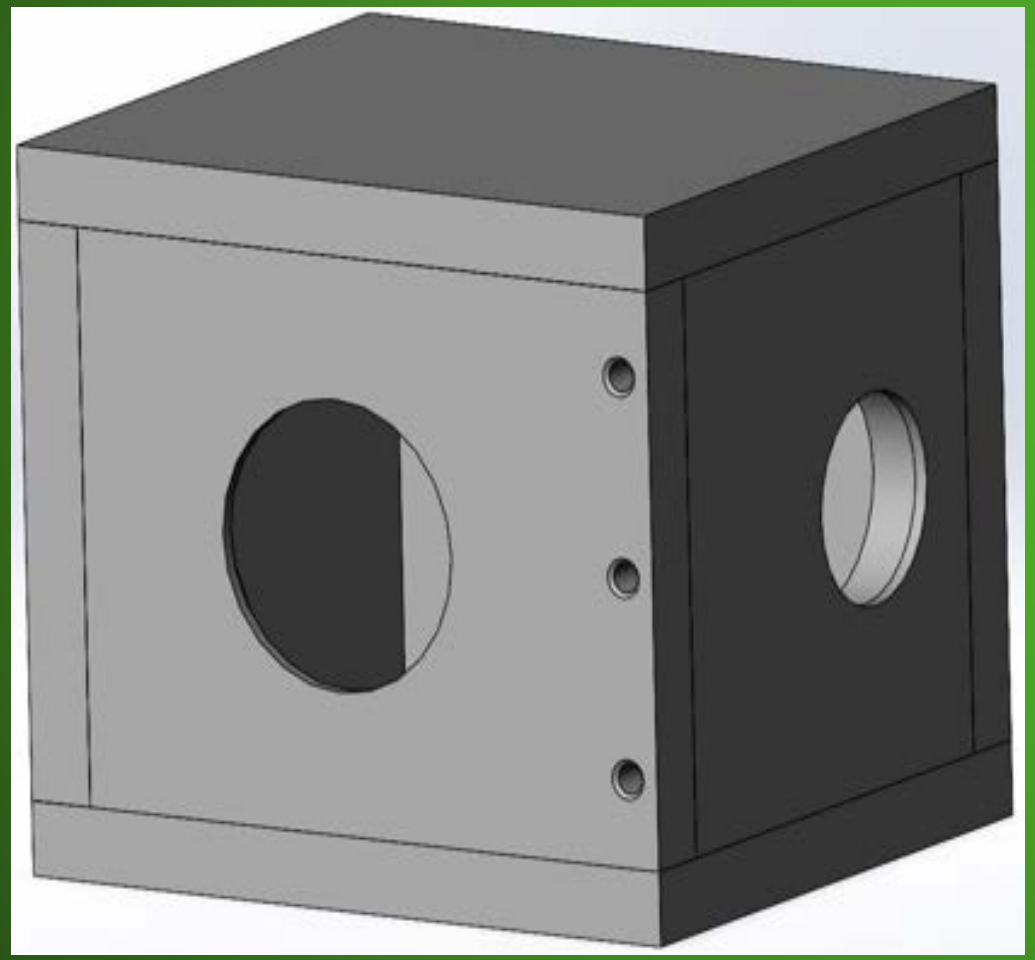


Steering Knuckle Model

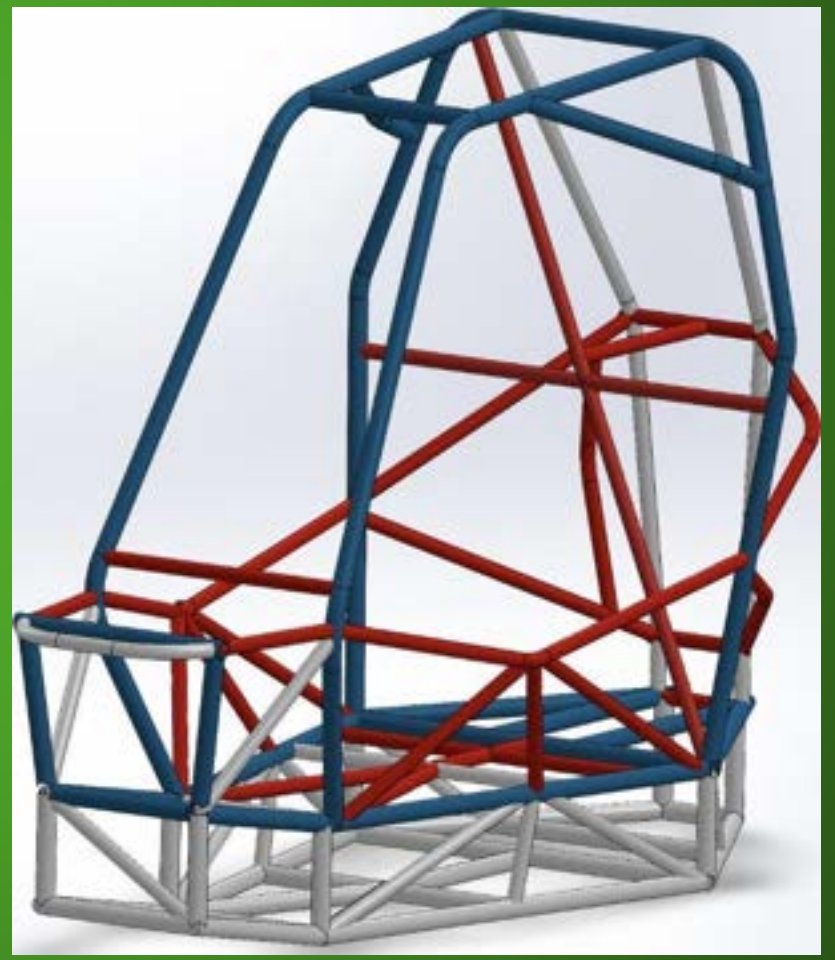
Hub Adapter

Prototyping

3D MODELING



Rear Gearbox Model



Chassis Subframe Model

Analysis

ATV HAND CALCULATIONS

- Dynamometer data from another Baja Team and an ATV user was used
- Maximum torque output for the Baja vehicle and the selected ATV was calculated
- Based on the maximum loading for the ATV motor the factor of safety is 2.21

Power Source	Measurement source		Torque (ft-lb)	HP	Output RPM
BAJA	Dyno'd Motor	max torque	15.85	8.2	2718
		max hp	13.85	9.1	3450
	Max gear ratio 36:1	max torque	570.6	8.2	75.50
		max hp	498.7	9.1	95.83
	Min gear ratio 5.6:1	max torque	88.76	8.2	485.4
		max hp	77.58	9.1	616.1
ATV	Dyno'd Motor	max torque (no data)			
		max hp	27.28	32.67	6290
	Max gear ratio 46.18:1	max torque (no data)			
		max hp	1260	32.67	136.2
	Min gear ratio 25.73:1	max torque (no data)			
		max hp	701.9	32.67	244.5

Analysis

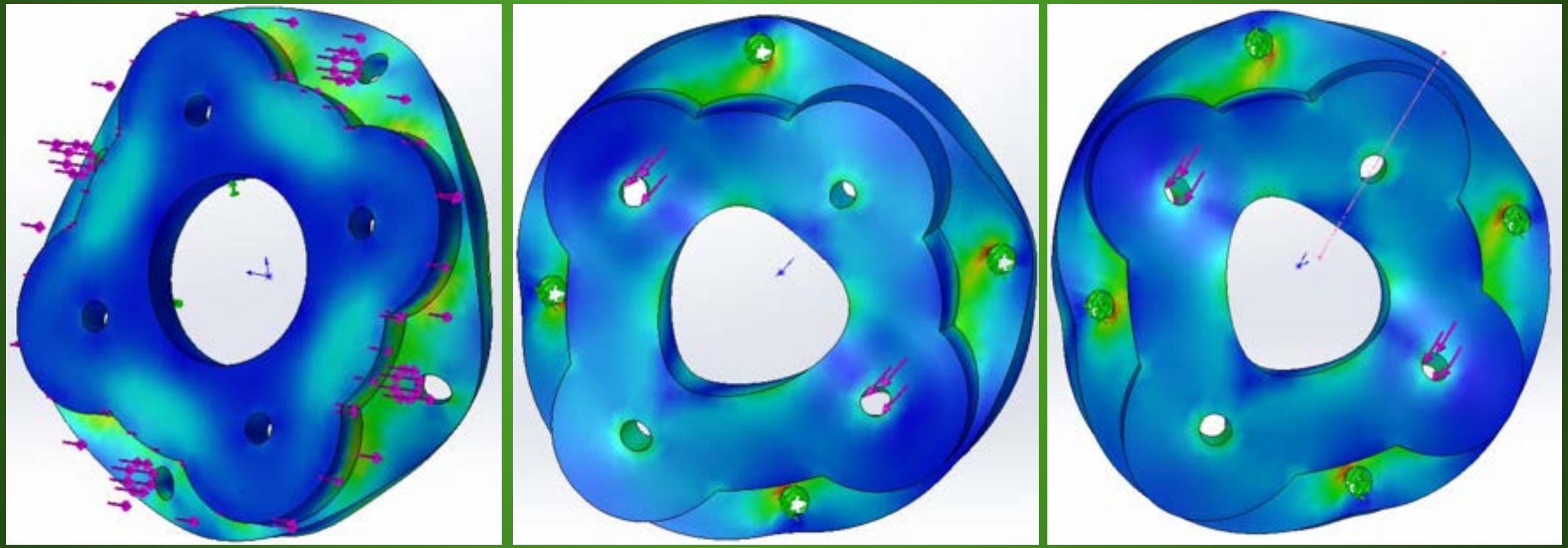
DRIVE SHAFT HAND CALCULATIONS

- Internal stresses were calculated using:
  - the maximum torque from Baja vehicle
  - static torsional shear stress equations
  - static transverse shear stress equations.
- Axial loading was ignored because there should be none.
- Selected shaft with the lightest weight with an acceptable safety factor (>1).

Tube Size (in)	.75 S80	1.25x.125 DOM	1.25x.25 DOM	1 S40
Material	A500	1020	1020	A500
ID (in)	0.74	1	0.75	0.96
OD (in)	1.05	1.25	1.25	1.32
TtorMax (psi)	39990	25880	20513	21052
TtorMax (ksi)	39.99	25.88	20.51	21.05
TshearMax (psi)	58690	49193	26804	31664
TshearMax (ksi)	58.69	49.19	26.80	31.66
Weight (lbs)	5.90	6.02	10.71	8.73
Degree of twist	9.5	6.8	5.4	5.0
Safety Factor (T)	0.66	1.02	1.43	1.25
Safety Factor (S)	198	211	433	366

Analysis

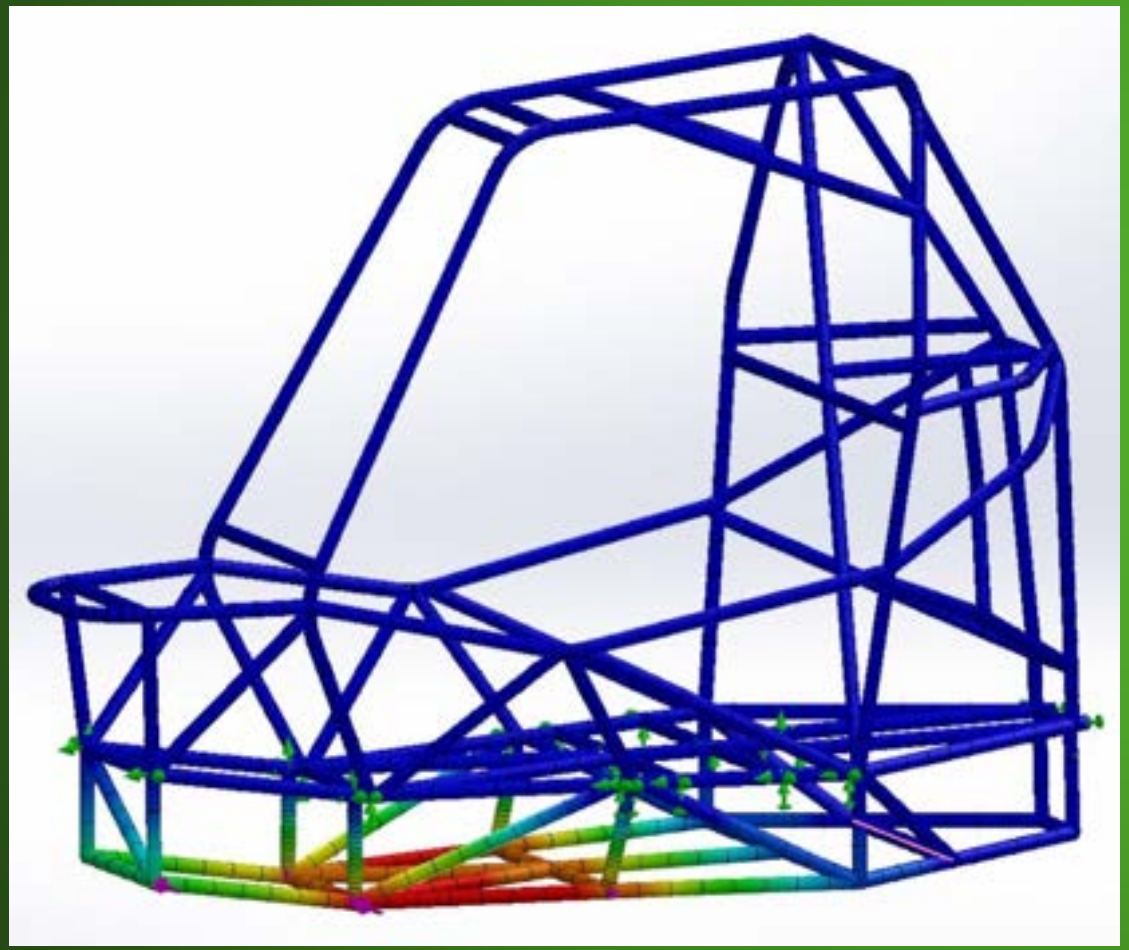
FINITE ELEMENT ANALYSIS

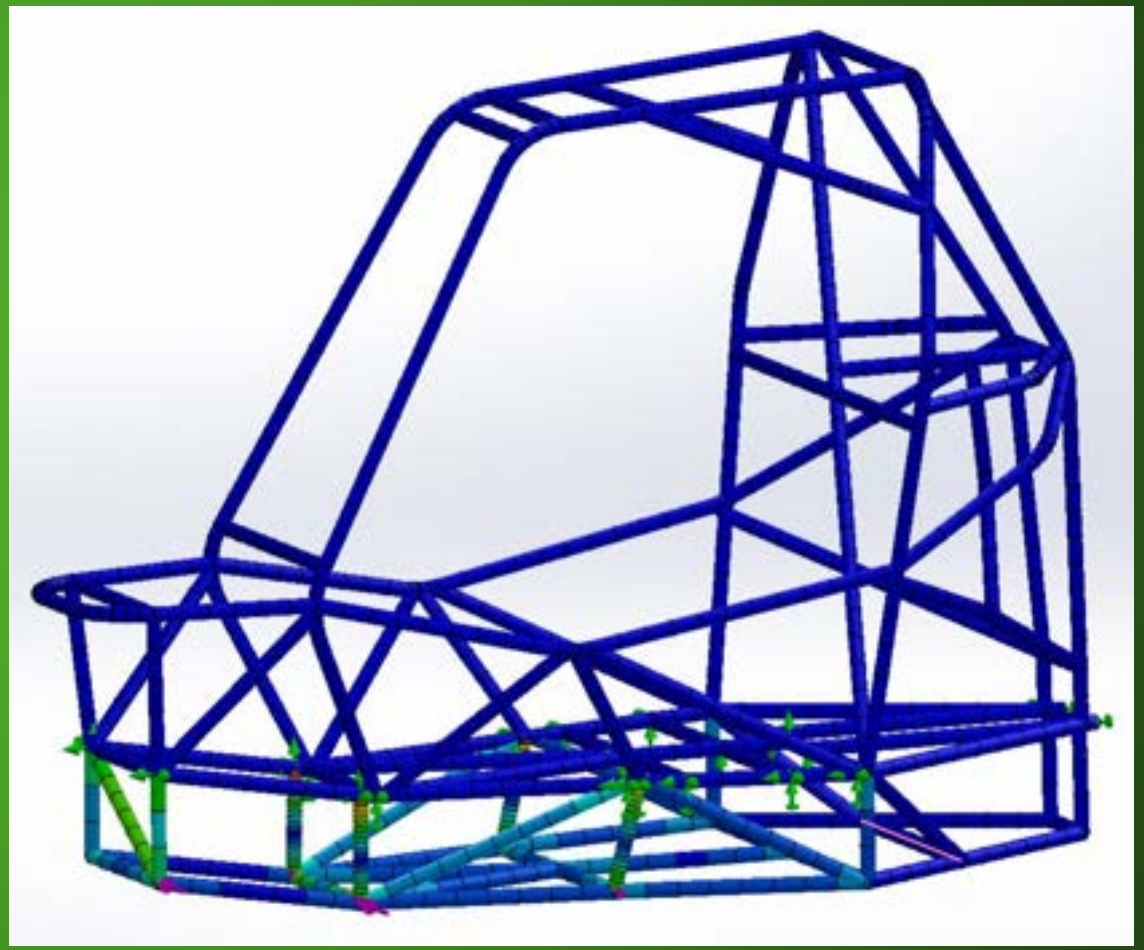


Stress Plots Results of FEA on Hub Adapters

Analysis

FINITE ELEMENT ANALYSIS



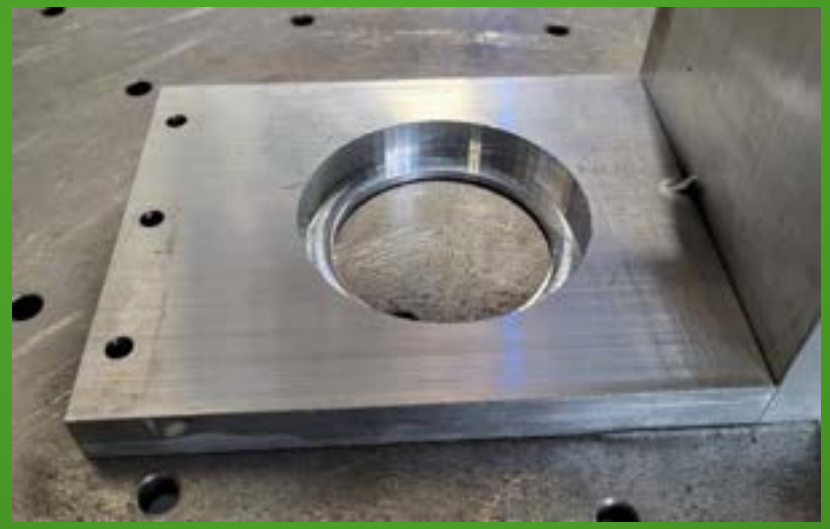


Stress Analysis Plots of Subframe

Development

MACHINED COMPONENTS

Steering Knuckles



Big Gear Plate

Small Gear Plate

Development

FABRICATED COMPONENTS

Rollcage with Subframe

Rear Gear Box

Development

FABRICATED COMPONENTS

Steering Knuckle with Bearing holder

Drive Shaft

Spline Adapter for Drive Shaft

Final Design

Steering Knuckle - CV Axle

CV Axle - Differential

Final Design

Drive Shaft - Rear Gear Box

Drive Shaft - Differential

Final Design

Final Design

Conclusion

- Researched the Problem
- Set Design Requirements
- Generated Concepts
- Final Concept Selected
- Modeled Machined & Fabricated Parts
- Analyzed Components
- Built

Questions?

SOURCES

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