SAE MINI BAJA
Front & Rear End

Front End: **Will Preston**

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Rear End: **Jacob Ruiz**

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SAE INTERNATIONAL

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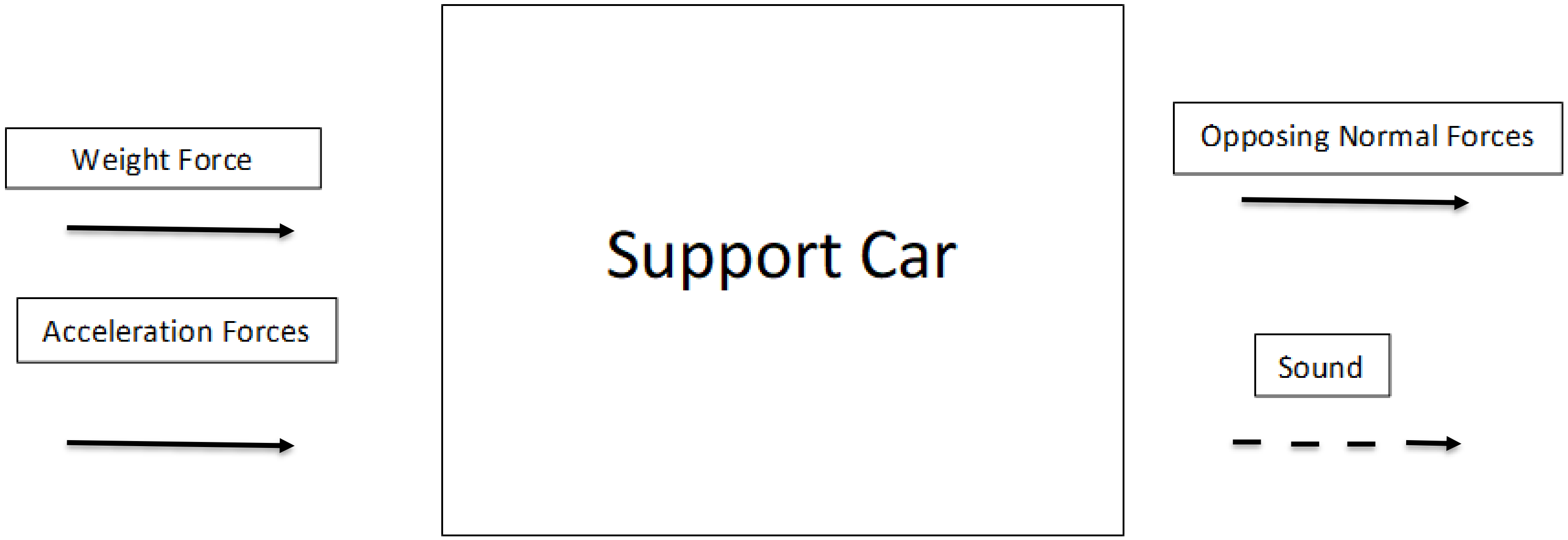
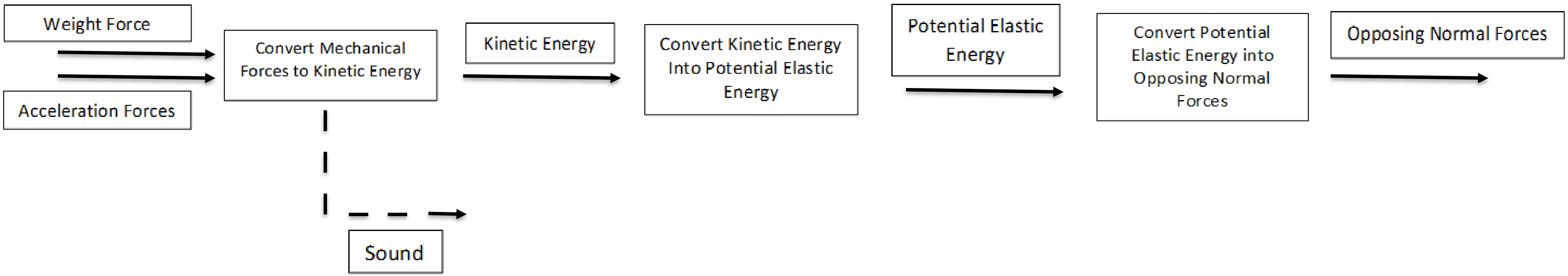
Project Description

- SAE Baja is a collegiate competition in which teams design, build, and test off-roading vehicles
- Vehicles are presented in competition to a fictitious firm for possible manufacturing
- Designs must abide by Baja SAE competition rules in order to compete
- Must be able to perform well in Dynamic and Static events
  - Acceleration Test
  - Braking Test
  - Hillclimb
  - Endurance
- Sponsors include W.L. Gore, NAU and SAE International

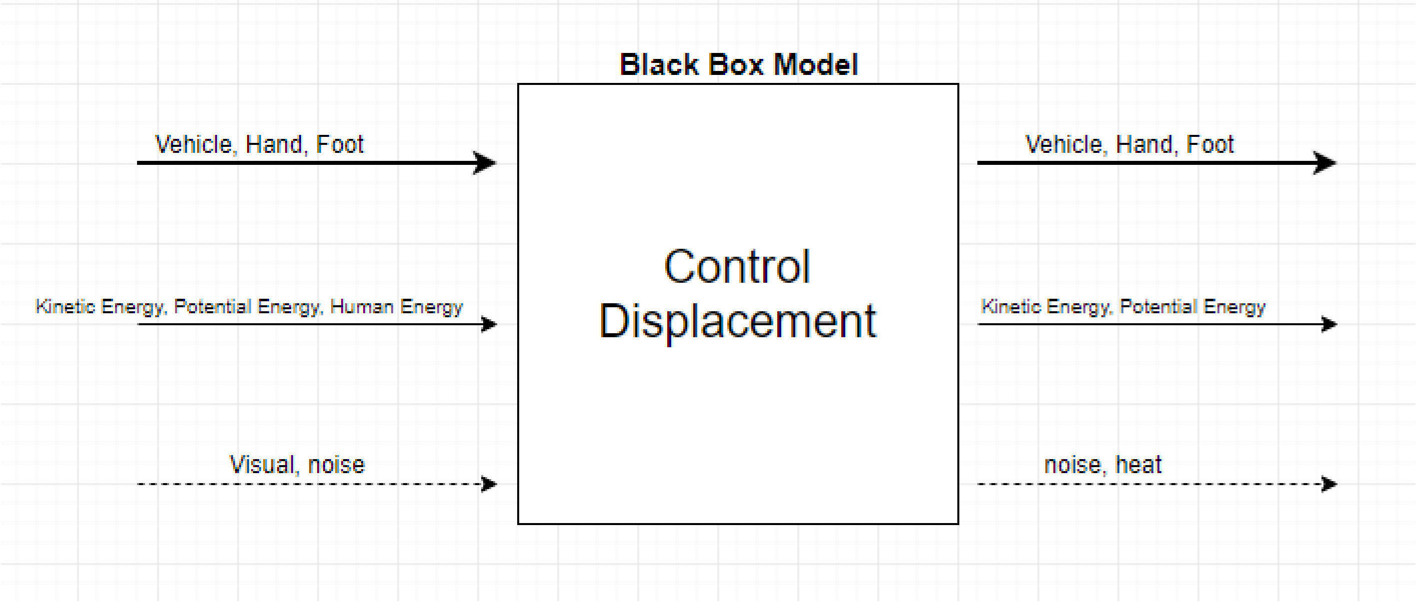
Black Box Model - Rear End



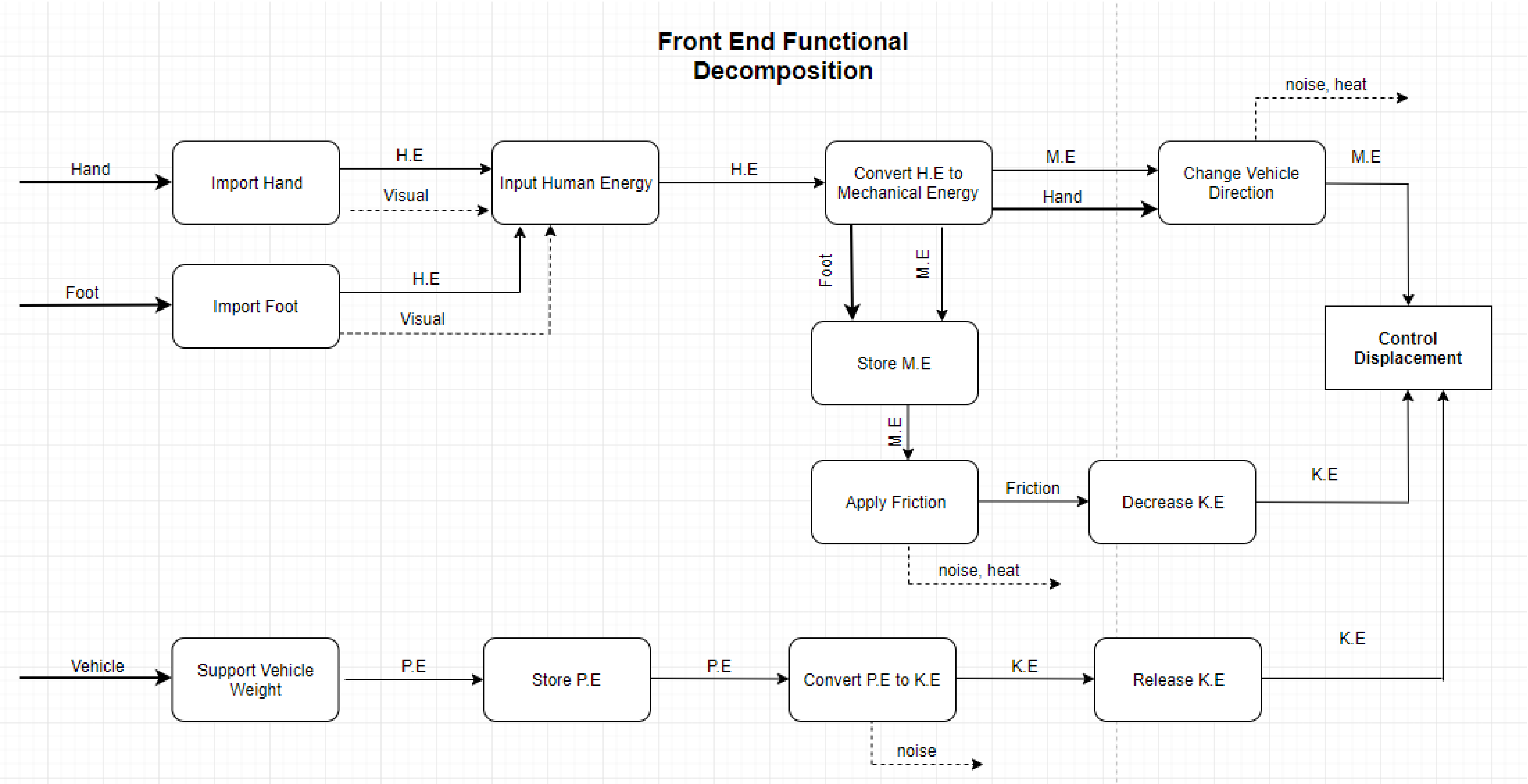
Detailed Decomposition Model (Rear End)



Black Box Model - Front End



Detailed Decomposition Model (Front End)



Concept Generation – Rear End

Advantages:
- Increases travel
- Lower unsprung weight
- Better ride quality
- Independent suspension

Disadvantages:
- Long rear links
- Hard to manufacture

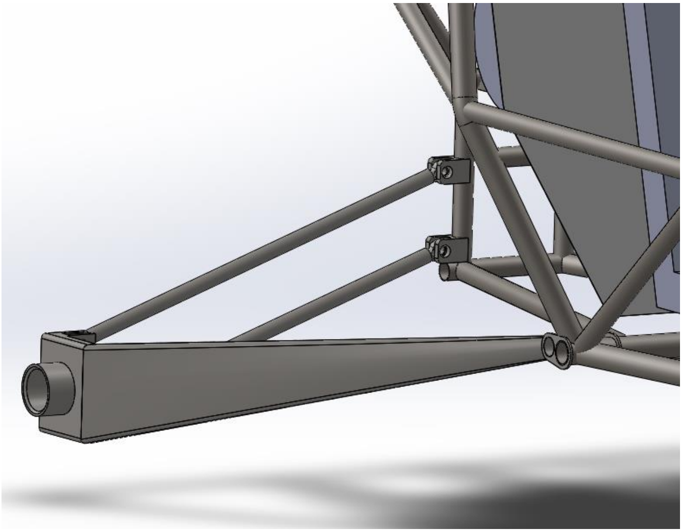


Figure 1: Tailing Arm with Links

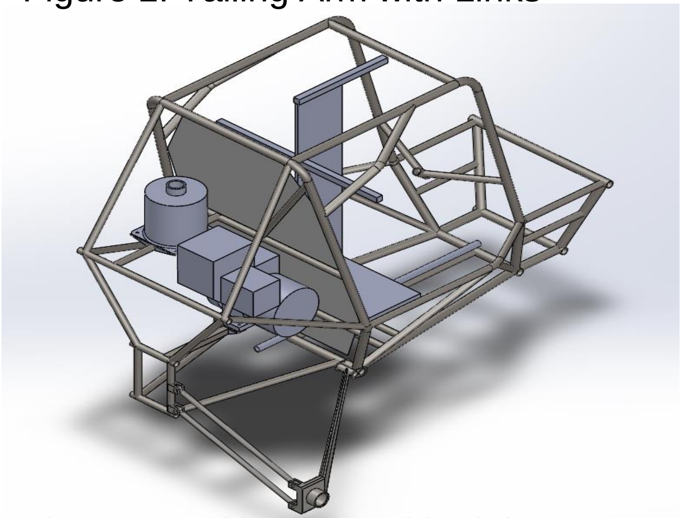


Figure 2: Tailing Arm with Links from Rear

Concept Generation (Double Wishbone) - Rear End

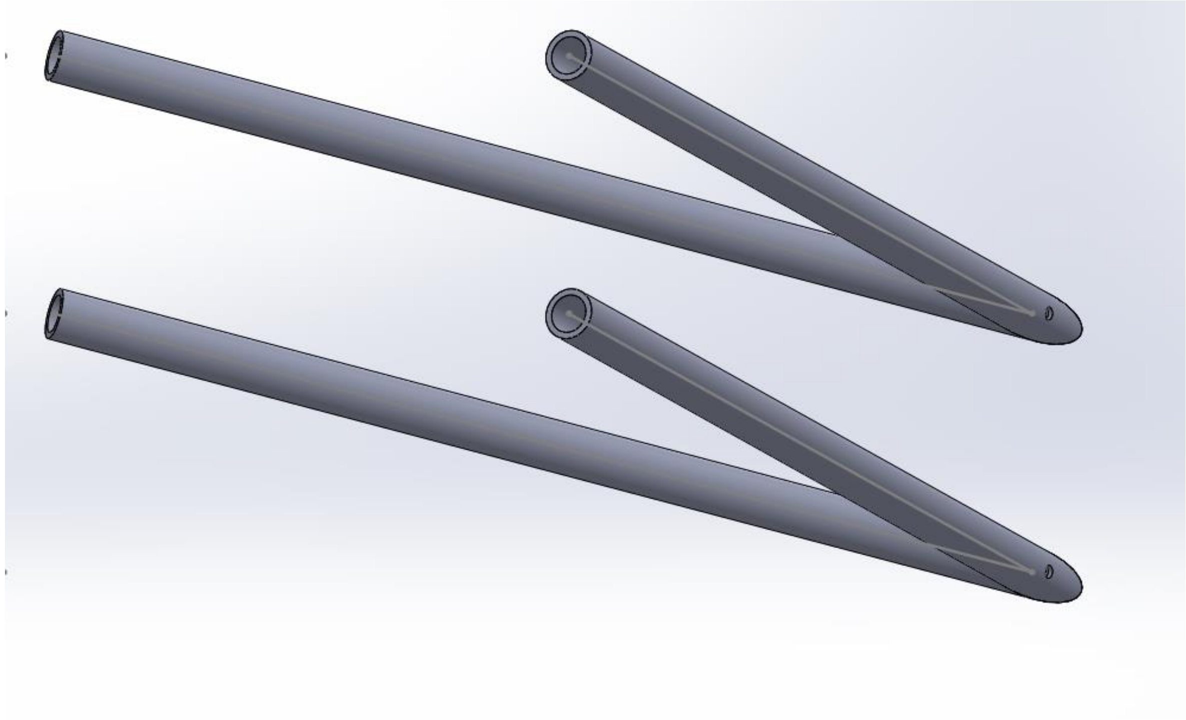


Figure 3: Double Wishbone

Advantages:

- Allows movement only in vertical direction to fix the toe Angle

Disadvantages:

- Requires a change to the frame
- Heavy

Concept Generation (Single Part Trailing Arm) - Rear End

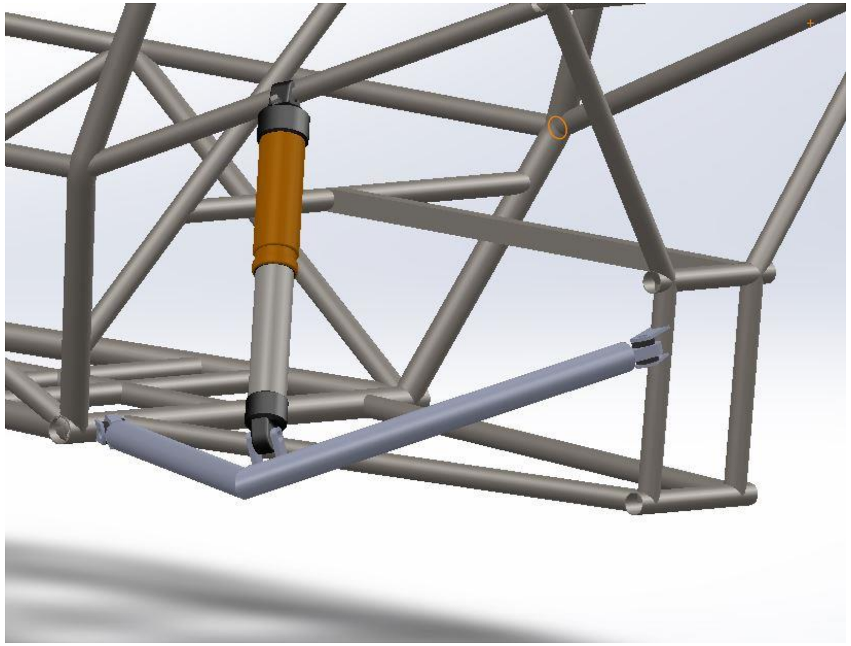


Figure 4: Tailing Arm Single Part

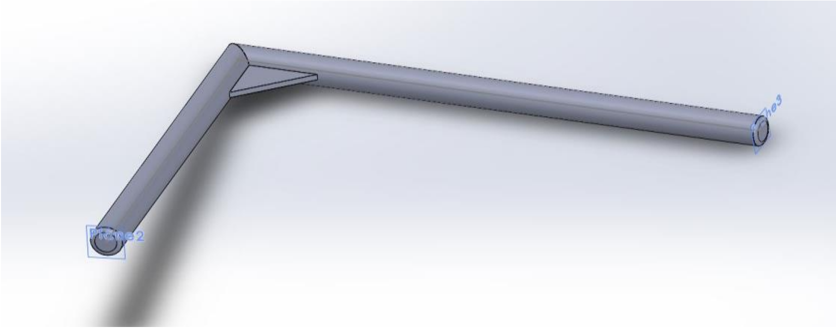


Figure 5: Tailing Arm Single Part Only

Advantages:
- Lightweight
- Easy Mounting
- Durable

Disadvantages:
- Any failure leads to full system failure
- Difficult hub/axle connections (manufacturing)

Decision Matrix – Rear End

Decision Matrix							
CN's	Weight	Double Wishbone		Single Piece Trailing Arm		Trailing Arm Two Lateral Links	
		Score(1-5)	Weighted	Score(1-5)	Weighted	Score(1-5)	Weighted
Safe	15%	5	0.75	2	0.3	4	0.6
Durable	15%	3	0.45	2	0.3	4	0.6
Lightweight	20%	1	0.2	5	1	3	0.6
Ease of Production	10%	2	0.2	3	0.3	3	0.3
Cost	15%	2	0.3	5	0.75	3	0.45
Performance	25%	4	1	3	0.75	5	1.25
Totals:	100%		2.9		3.4		3.8

Table 1: Decision Matrix (Rear End)

Concept Generation – MacPherson Strut

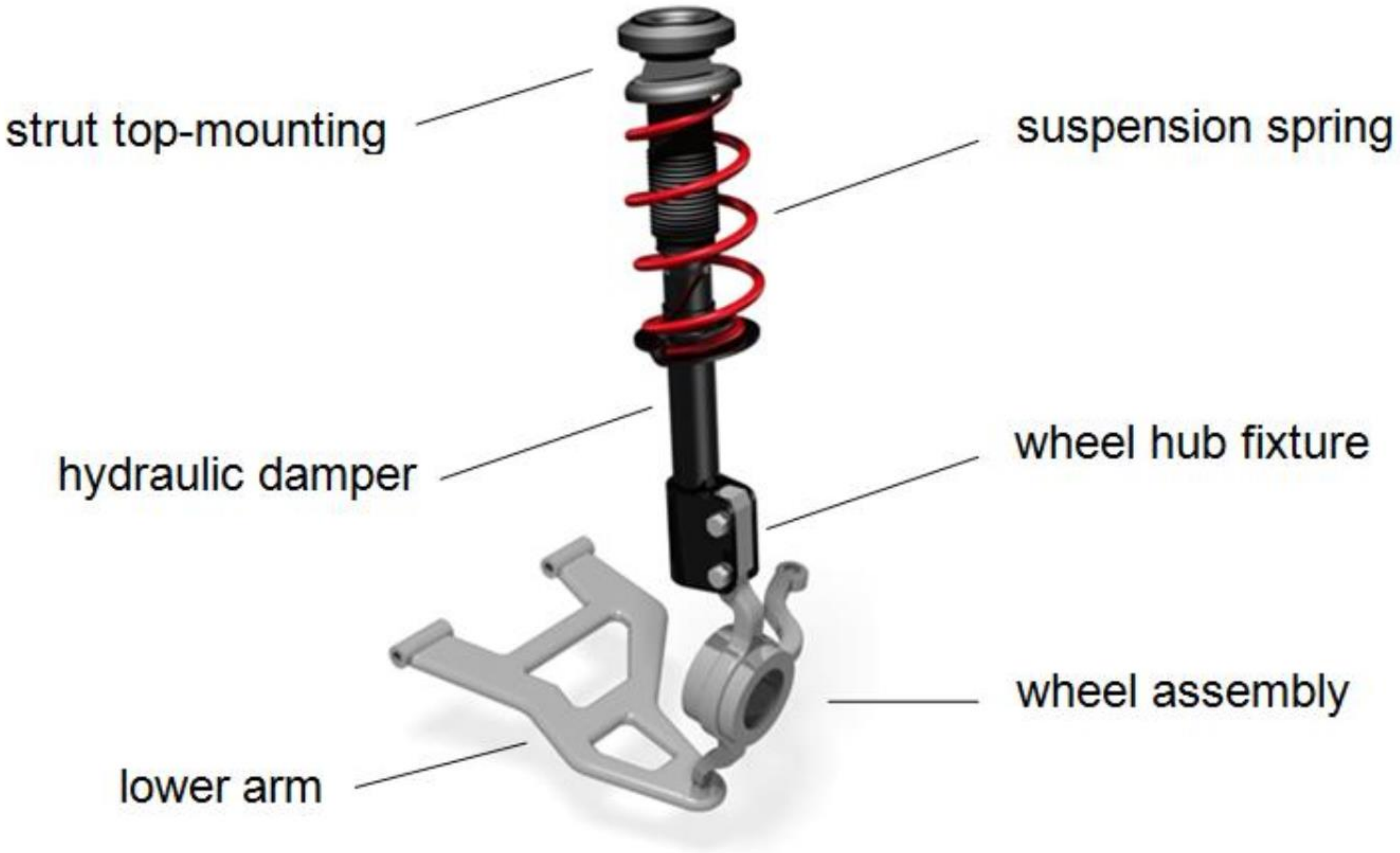
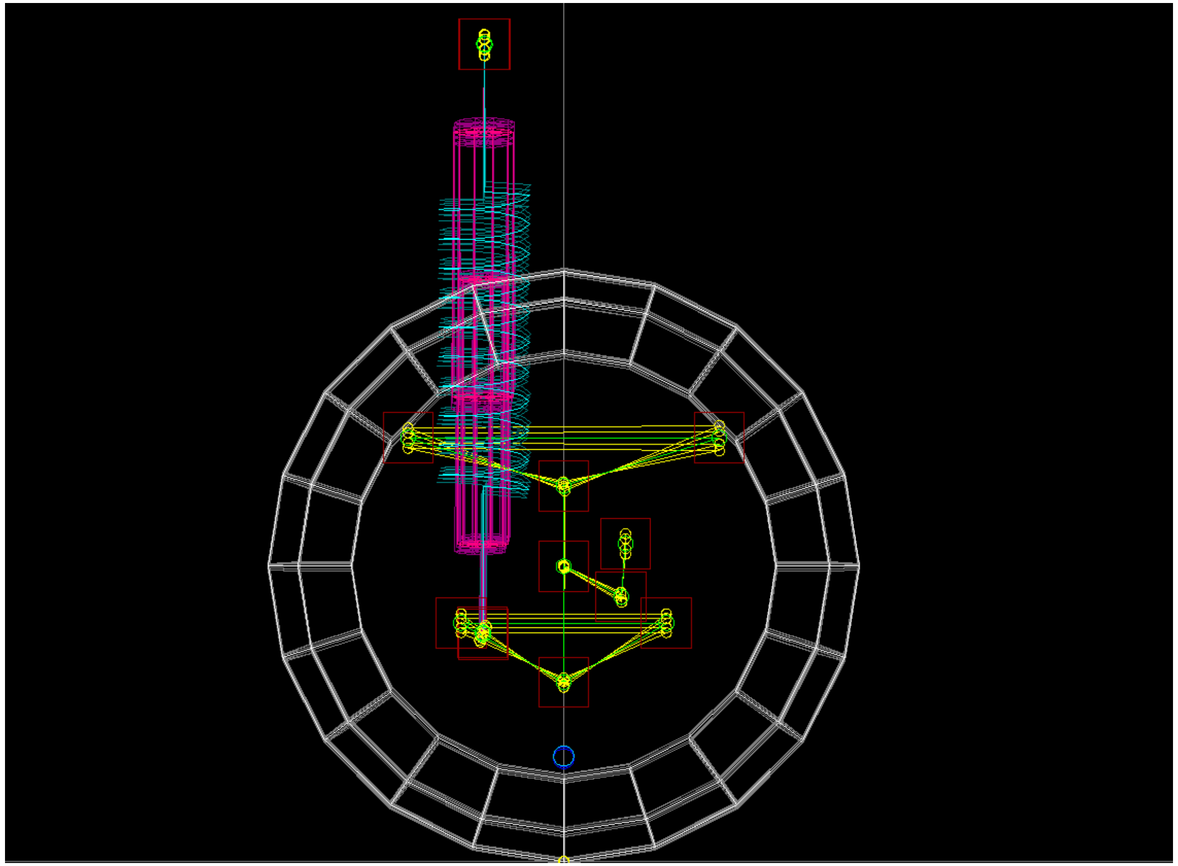


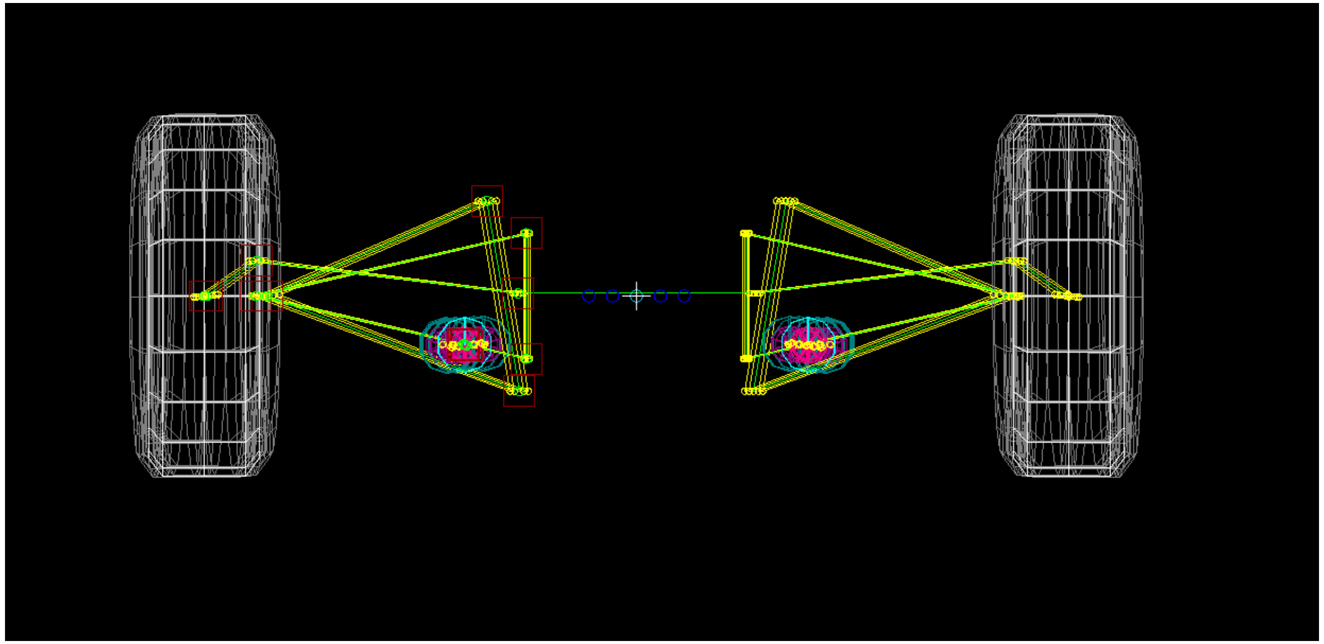
Figure 6: MacPherson Strut model [1]

Advantages:
- fewer number of parts

Disadvantages:
- not used for off-road platforms
- not easily mounted to tube frames

Concept Generation - Double Wishbone A



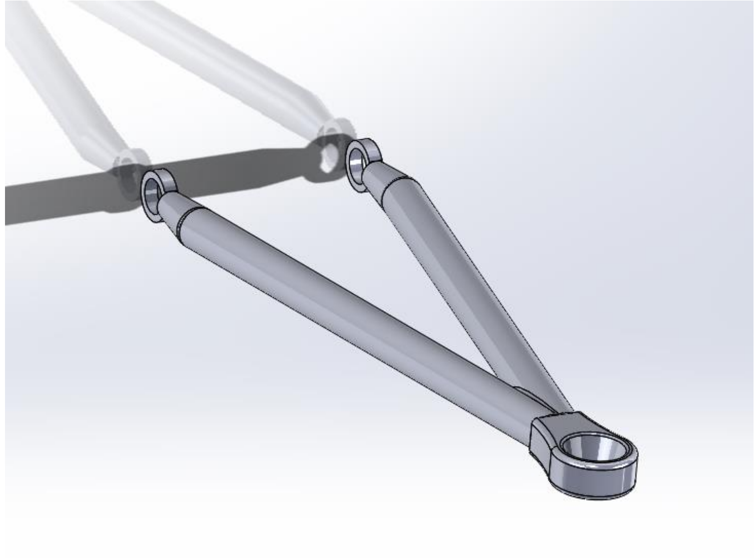


Advantages:
- Maintains desired alignment specifications

Disadvantages:
- Limited space between components, restricts maneuverability
- Difficult to repair

Figure 7: Double Wishbone A

Concept Generation – Double Wishbone B



Advantages:
- Consistent alignment
- Allows space for steering, drivetrain components

Disadvantages:
- Requires high upper shock mounting point

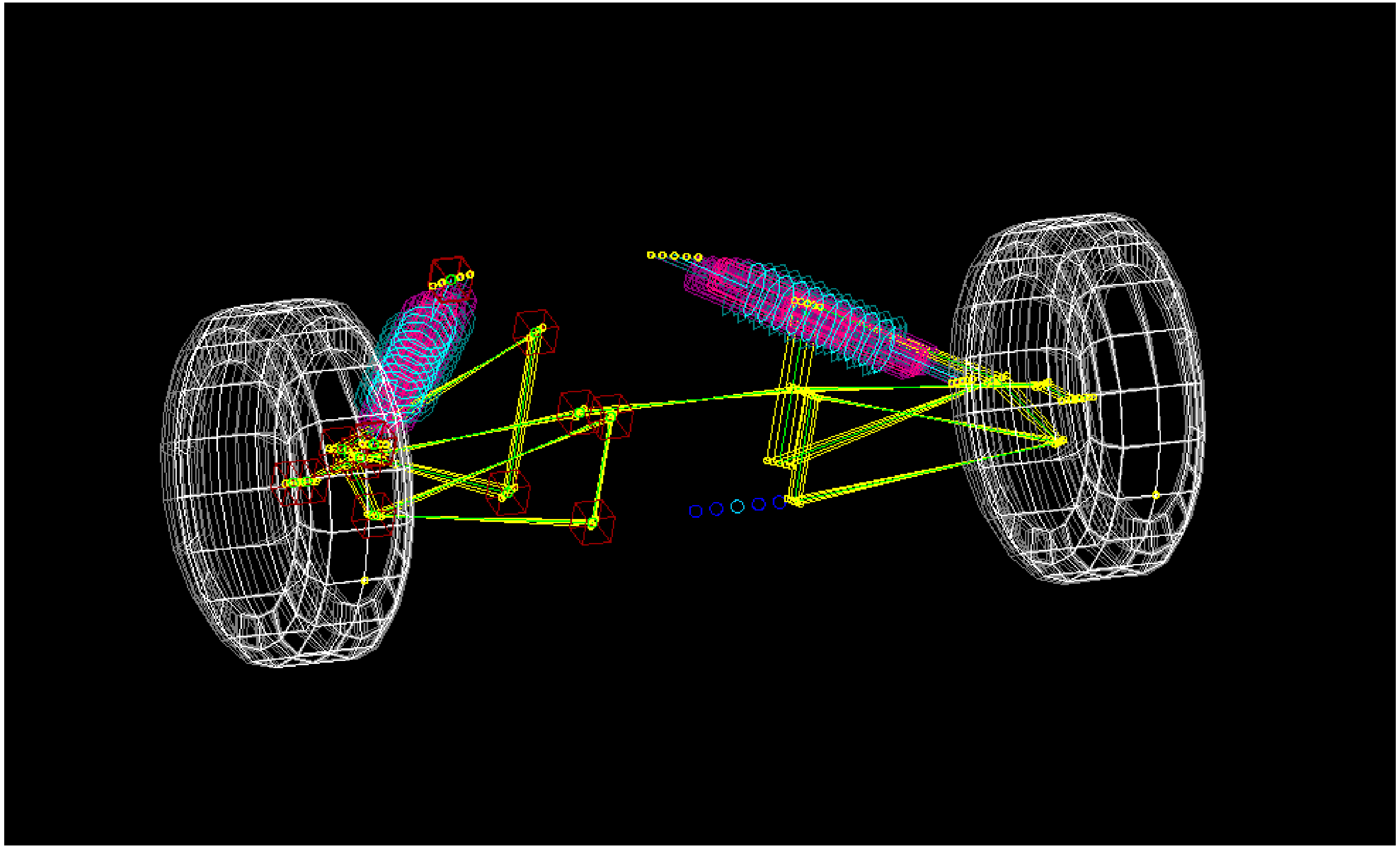


Figure 8: Double Wishbone B

Decision Matrix – Front End

Table 2: Decision Matrix (Front End)

	(1-5)			
Criteria	**Customer Weight**	**Double Wishbone B (top A-arm shock mount)**	**Double Wishbone A (bottom A-arm shock mount)**	**MacPherson Strut**
Reliable	5	4	5	3
Durable	5	4	4	3
Lightweight	4	3	3	4
Maneuverable	4	5	2	3
Low Cost	5	3	3	4
Easy Field Repair	3	3	2	4
Short Stopping Distance	4	4	4	3
Short Wheel Base	4	3	3	3
Ride Height	4	3	3	3
Track Width	4	4	4	2
Safe to Operate	5	4	2	4
Total		**40**	35	36
Relative Ranking		**172**	152	154

CAD – Rear End

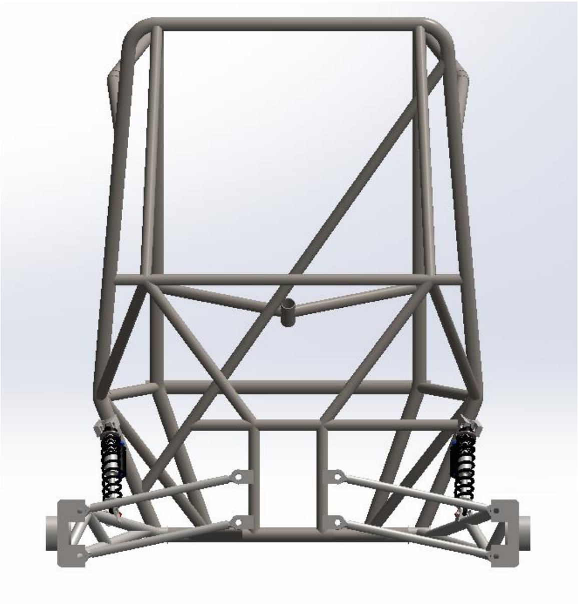


Figure 8: Rear End Back View [2,3]

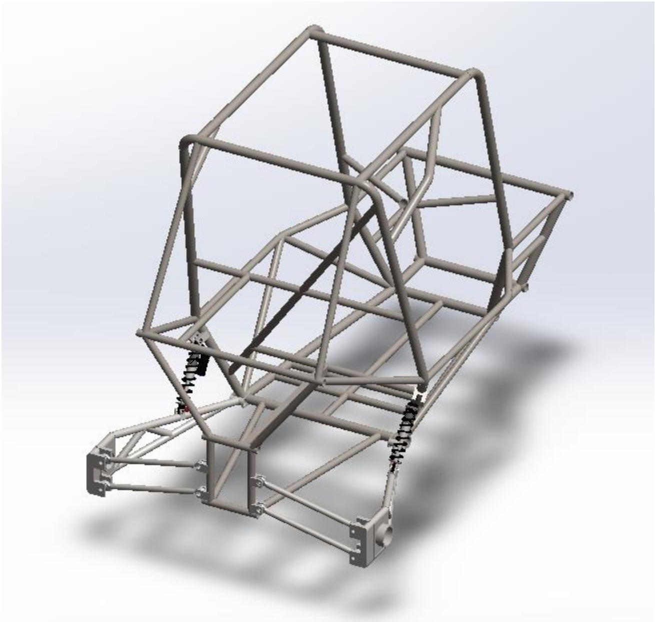


Figure 9: Rear End Isometric View [2,3]

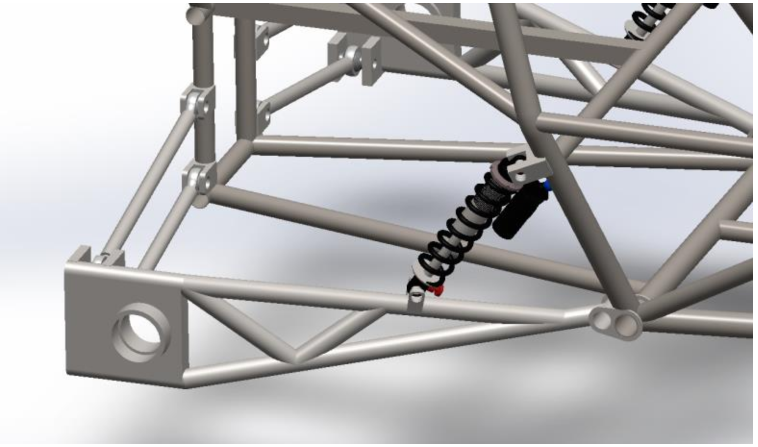


Figure 10: Rear End without Tire [2,3]

CAD – Front End

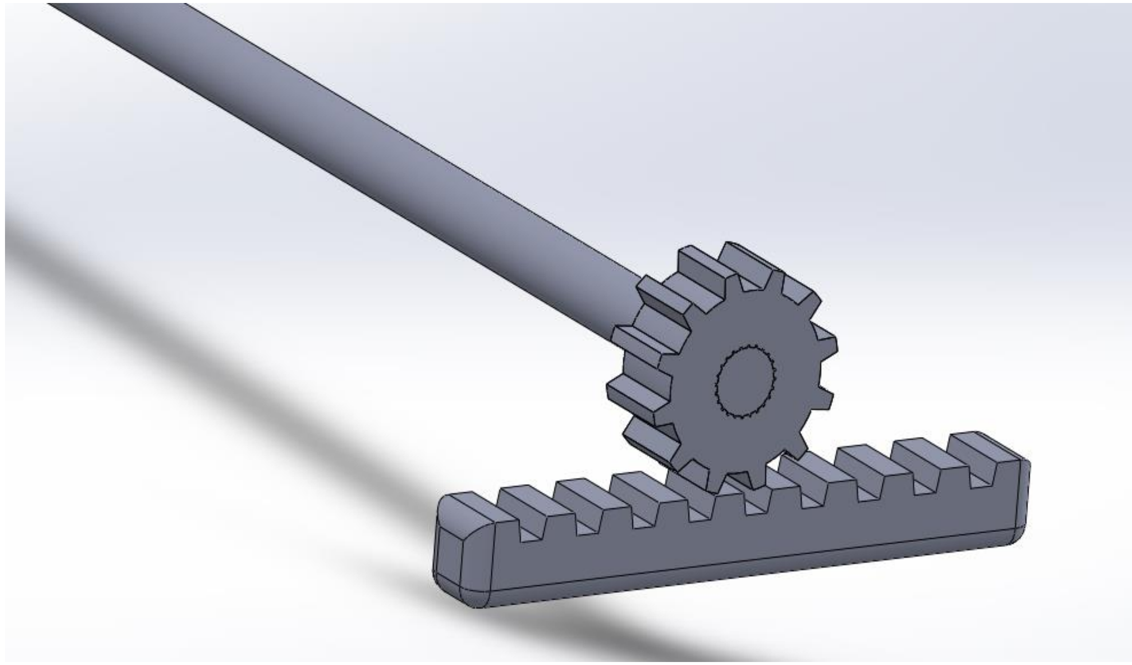


Figure 11: Rack and Pinion Steering

- Rack and Pinion Steering System
- Aluminum components.
- Expecting Aluminum Steering Column.

- **Track Width**
- FE – 55 in
- RE – 58 in

- **Wheelbase –** 60 in

- **Ackermann angles**
- L – 48.72 degrees
- R – 28.28 degrees

- **Mounting angle**
- 24.62 degrees

CAD – Front End

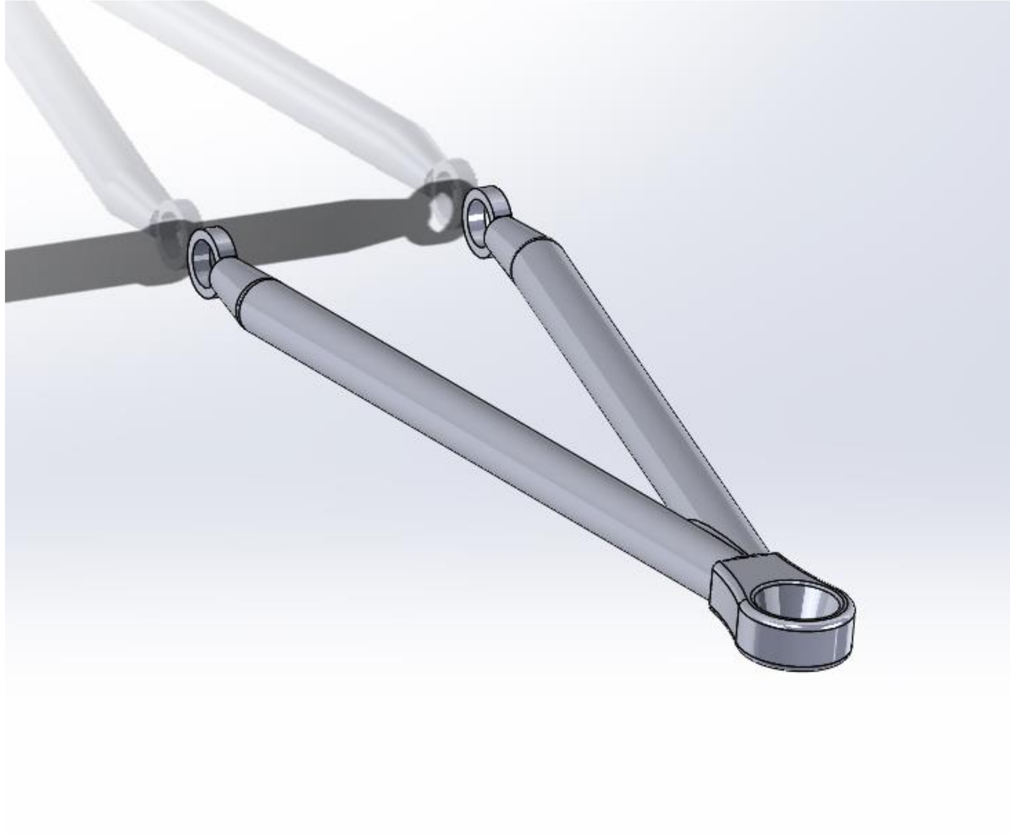


Figure 12: Front End CAD Isometric View

Figure 13: Front End CAD Top View

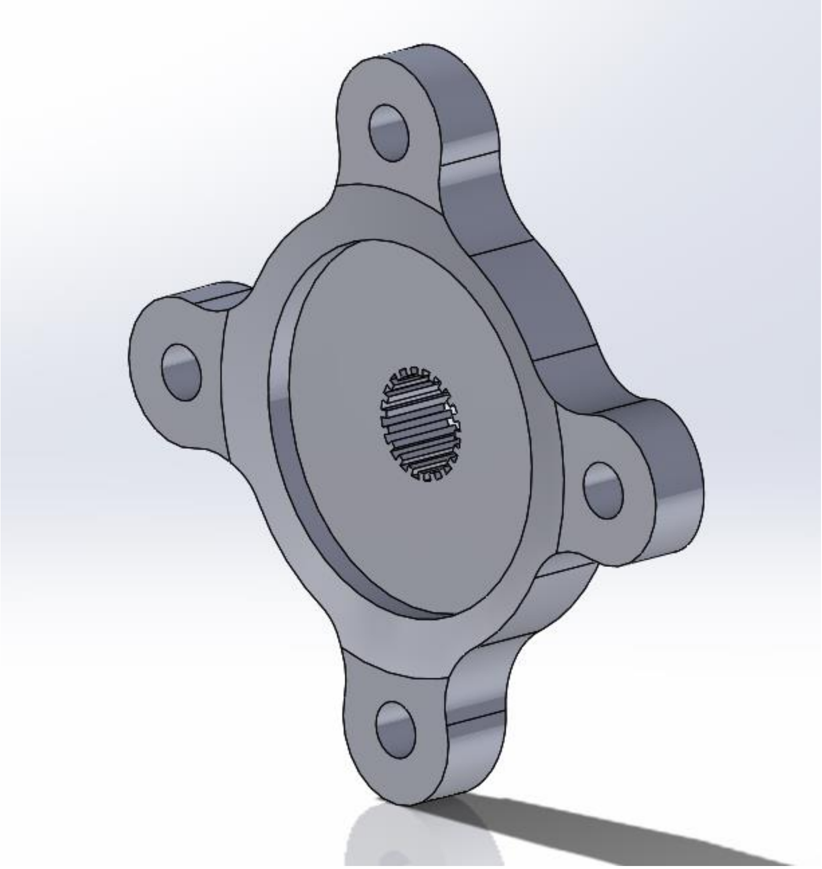


Figure 14: Front End CAD Hub

CAD – Front End

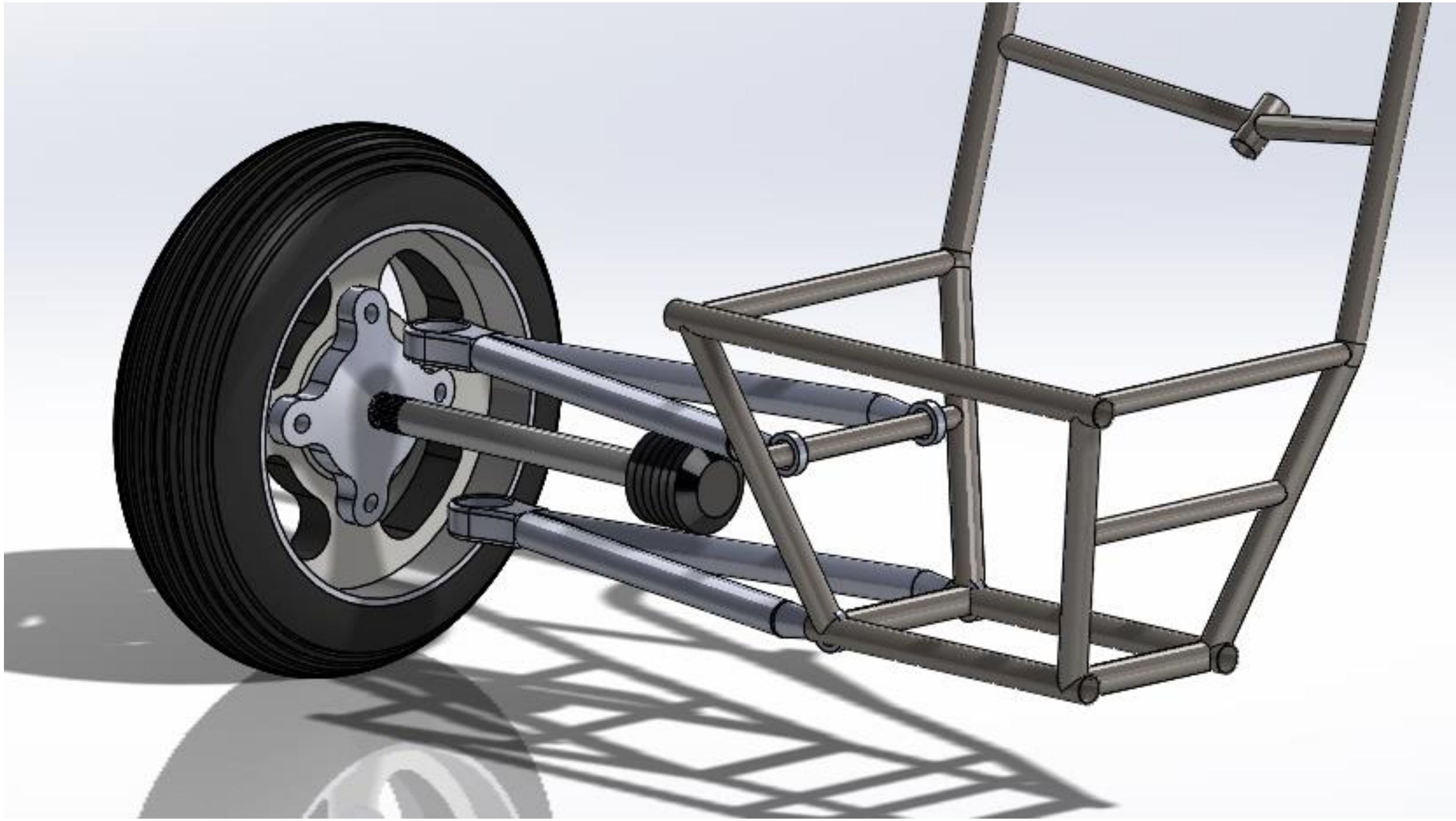


Figure 15: Front End CAD

Bill of Materials – Rear End

Table 3: Rear End Bill of Materials [3,4,5,6]

Qty	Description	Cost	Total Cost
8	Super-Swivel Ball Joint Rod Ends	$ 21.94	$175.52
1	Steel Sheet	$ 47.53	$47.53
1	Steel Bar Stock	$ 57.94	$57.94
4	Polaris Rear Hub	$ 75.99	$303.96
4	Steel Tubing	$ 77.59	$310.36
2	Aluminum Rod	$ 40.63	$81.26
1	Fox Factory Series Float 3 Evol RC2	$ 1,595.00	$1,595.00
8	1/2" Ball Joint Rod Ends	$ 7.08	$56.64
2	Rim, Flat Black	$ 92.80	$185.60
2	Rear Tire	$ 205.99	$411.98
Total			$3,225.79

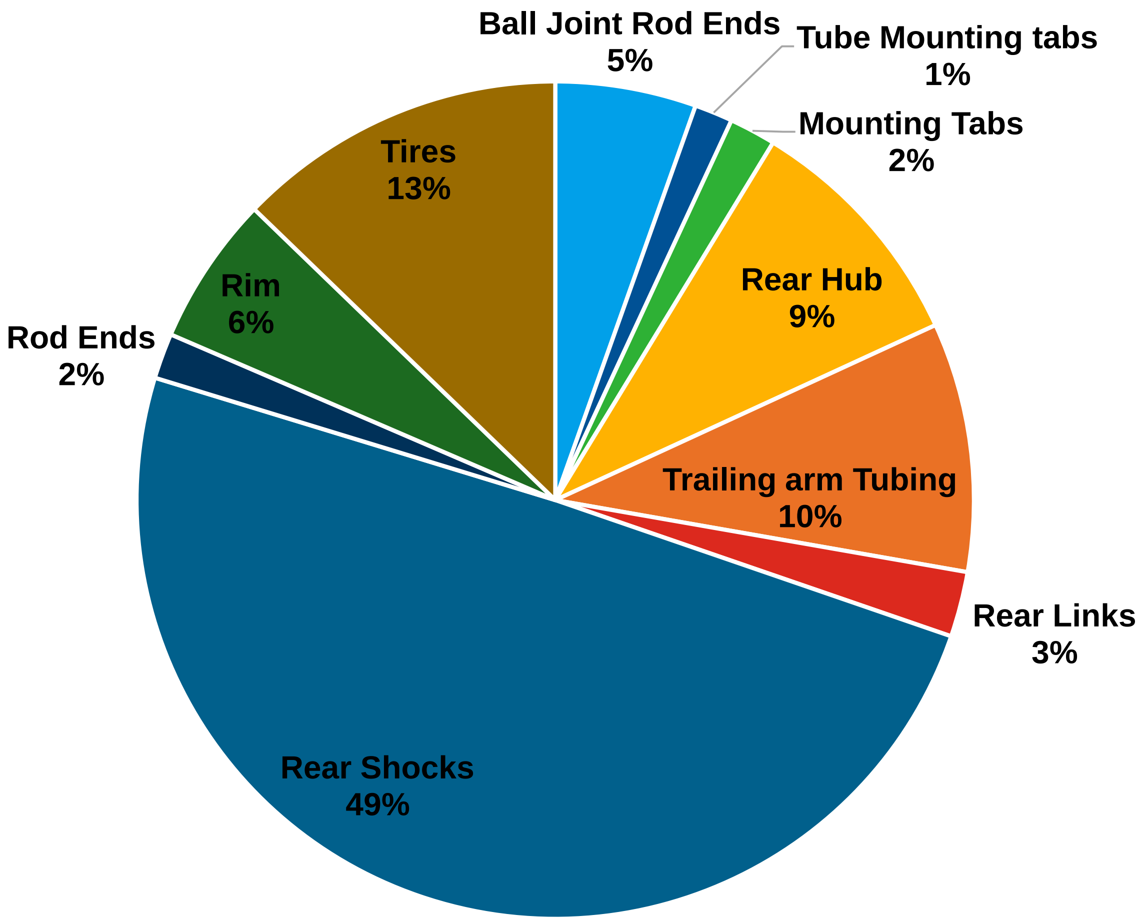


Figure 16: Rear End Budget Breakdown

Bill of Materials – Front End

Table 4: Front End Bill of Materials

Bill of Materials - Initial							
	Team		Baja Front End				
Part #	**Part Name**	**Qty**	**Functions**	**Material**	**Estimated Unit Cost**	**Estimated Total Cost**	**Links**
1	A- Arms	4	Suspension System	4130 Chromoly Tubing	50.00	200.00	
2	Hubs	2	Turning Wheels	Aluminium	102.00	204.00	https://www.polarispartshouse.com/oemparts/a/pol/5c38140f87a866171473b29a/suspension-front-carrier
3	Knuckles	2	Mounting A-Arms and steering	Steel	164.00	328.00	https://www.polarispartshouse.com/oemparts/a/pol/5c38140f87a866171473b29a/suspension-front-carrier
4	Shocks	2	Dampning impacts		474.05	948.10	https://www.summitracing.com/parts/kss-20001-111?seid=srese1&gclid=CjwKCAjwxOvsBRAjEiwAuY7L8h0YbcTliDPkO50dnYWvXvqRKZLkY-cs8R_nVpVYrPOJ3mz0H124HhoC66EQAvD_BwE
5	Wheels	2	Moving Baja	Steel	78.97	157.94	https://www.bbwheelsonline.com/remington-utv-buckshot-atv-wheels-rims-satin-black-12x7-4x110-0mm-offset-BS1270430SB/
6	Rotors	2	Braking System	Steel	20.00	40.00	
7	Brake lines	2	Distributing brake fluid to system		100.00	200.00	http://lsracing.com/honda-trx250r-atc250r-stainless-steel-front-brake-lines-universal.372.2.atv-utv-racing
8	Brake Callipers	2	Mounting Braking system	Aluminium	74.99	149.98	
9	Brake Fluid	4	Hydraulic Pressure		2.97	11.88	Walmart
10	Master Brake Cylinder	1					
11	Brake pads	4	Stop wheels rotation	Ceramic	45.00	90.00	O'Reillys
12	Steering rack and pinion	1	Steering	Aluminium	299.95	299.95	https://www.superatv.com/polaris-rzr-xp-1000-rackboss-heavy-duty-rack-and-pinion-group?gclid=CjwKCAjwxOvsBRAjEiwAuY7L8lZLpjxlxoszF0Iw89uPBo1qwBsT72lVUS4tpT07tjxqG8r1_AXXnBoCZIMQAvD_BwE
13	Steering Column	1	Steering	Aluminium	220.00	220.00	cl01ah?seid=srese1&gclid=CjwKCAjwxOvsBRAjEiwAuY7L8v6QdkR2pdO-O9pfQJx-DW1stWYKLrUmiXYVdBCH5O-GlqQOKGz2cRoCESMQAvD_BwE
14	Tie Rods	2	Mount steering rack to knuckle	Aluminium	34.95	69.90	https://www.amazon.com/Empi-Ball-Joint-Left-Buggy/dp/B003LJ0Y8U/ref=asc_df_B003LJ0Y8U/?tag=hyprod-20&linkCode=df0&hvadid=331942329025&hvpos=1o1&hvnetw=g&hvrand=2580168634257857066&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1013406&hvtargid=aud-799728744414:pla-635982283416&psc=1
15	Ball joints	8	Mounting	4130 Chromoly	18.99	151.92	https://www.summitracing.com/parts/qdb-41-3558?seid=srese1&gclid=CjwKCAjwxOvsBRAjEiwAuY7L8uelqf4WXsz-wo3YFhFPPZtoJirNRqBsOTRonVwGu3kZaoBDuQRJNhoCQgkQAvD_BwE
16	Nuts & Bolts	20	Attachments and mounting	Steel	0.00	0.00	Easily accessible
17	Tires	2	Traction	Rubber	60.99	121.98	
		Total Cost Estimate:			3193.65		
			Allocating Budget	4000.00			

Questions?

References

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[7] Dixon, *Suspension geometry and computation*, 1st ed. Chichester: John Wiley, 2009.

SAE MINI BAJA
FRAME & DRIVETRAIN

Frame: Jacob Kelley
Riley Karg

Drivetrain: Tye Jorgenson
Jacob Najmy
Kaleb Brunmeier

SAE INTERNATIONAL®

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Project Description

General:

- Design and build a single-seat, all-terrain vehicle to compete in the SAE Baja Collegiate Competition
- Entire vehicle built within the limits of the official rulebook
- Performance measured by success in the static and dynamic events at competition in April

Figure 1: 2018-19 NAU Baja [1]

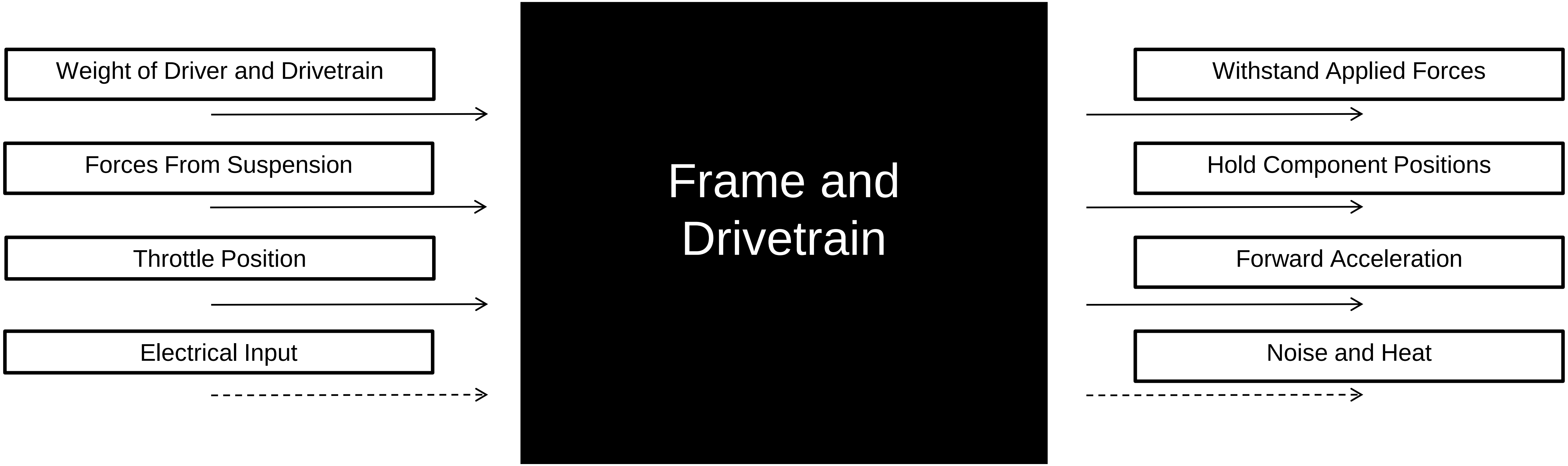
Frame:

- Cage designed and fabricated to withstand critical failure during normal operation, collision, or roll over
- Interfaces with all other sub-teams
- All welding done in-house

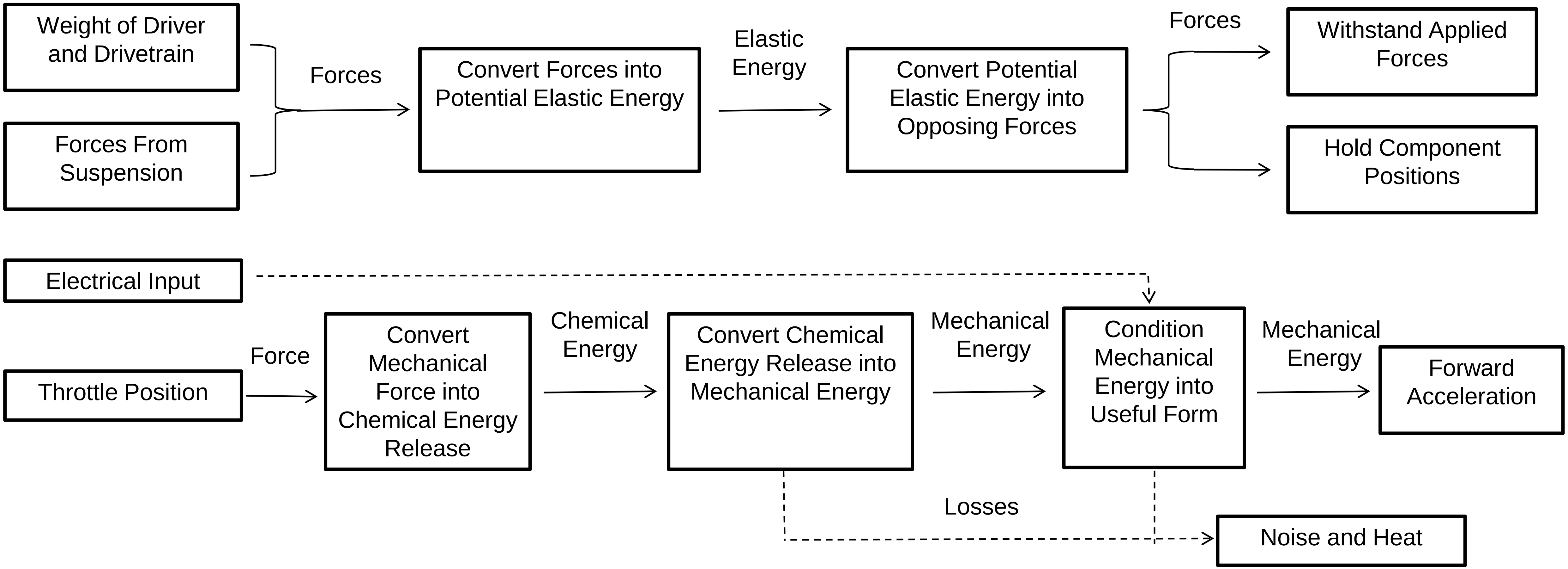
Drivetrain:

- Responsible for transmitting engine power to vehicle propulsion
- Up to 150 bonus points for operational 4WD/AWD system

Black Box Model



Detailed Decomposition Model



Drivetrain Concept Generation (ECVT)

Generation Type: Gallery Method, Directed Search

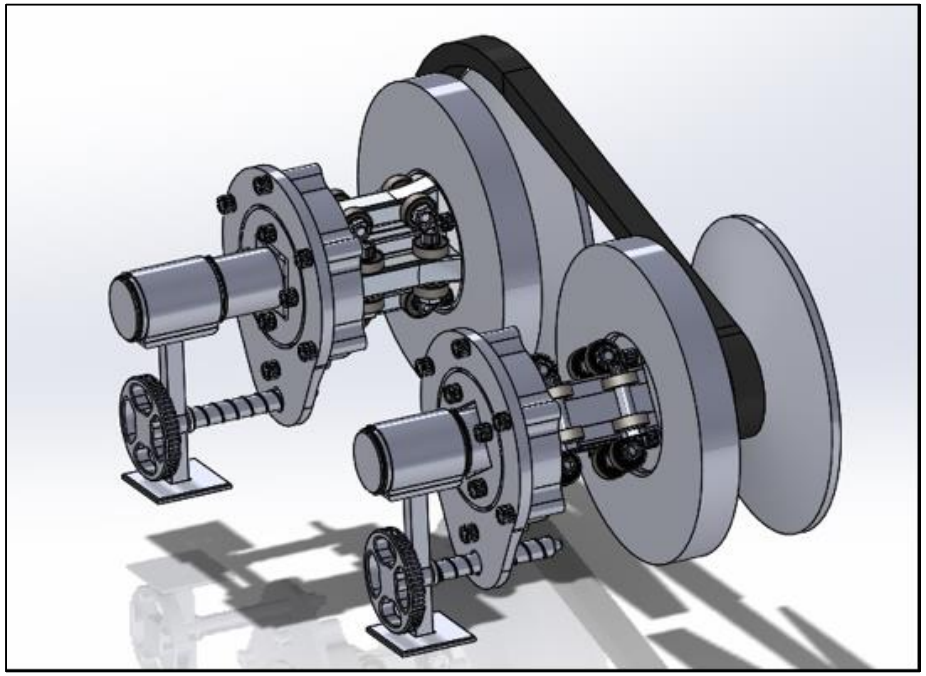


Figure 2: Spring 2019 Linear Design [1]

Advantages:
- ✓ Lower initial cost
- ✓ Robust Design

Disadvantages:
- × Hard to Manufacture
- × Large Moment on Stepper Motor Bracket
- × Heavy Design with Solid Shafts

Generation Type: Gallery Method, C-sketch

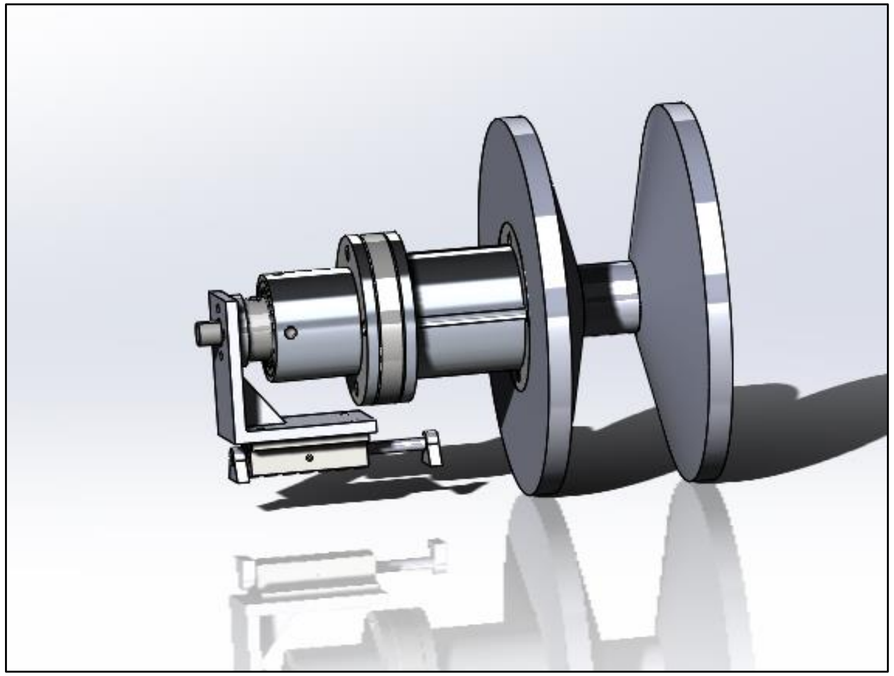


Figure 3: Fall 2019 Design Iteration

Advantages:
- ✓ User Input or automatic mode
- ✓ Different modes based on terrain
- ✓ Centralized Design (No moment on stepper motor)

Disadvantages:
- × Battery reliant
- × Possible stepper motor overheating

Drivetrain Concept Generation (Transfer Case)

Generation Type: Gallery Method, Directed Search

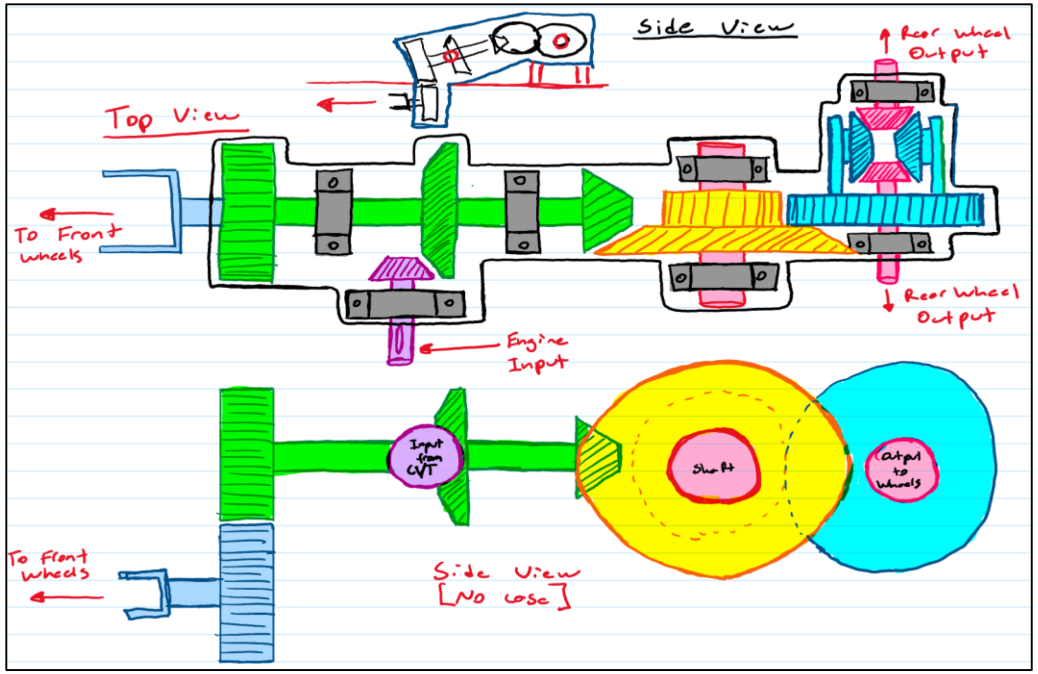


Figure 4: Concept 1

Advantages:
- ✓ Allows motion to be transmitted perpendicular to the engine
- ✓ Simple Gear geometry that allows for easy of manufacturing

Disadvantages:
- × Larger Housing requiring more lubricant (Heavy Design)
- × Complex Machining
- × Does not allow for placement of CVT within the frame

Generation Type: Gallery Method, Directed Search

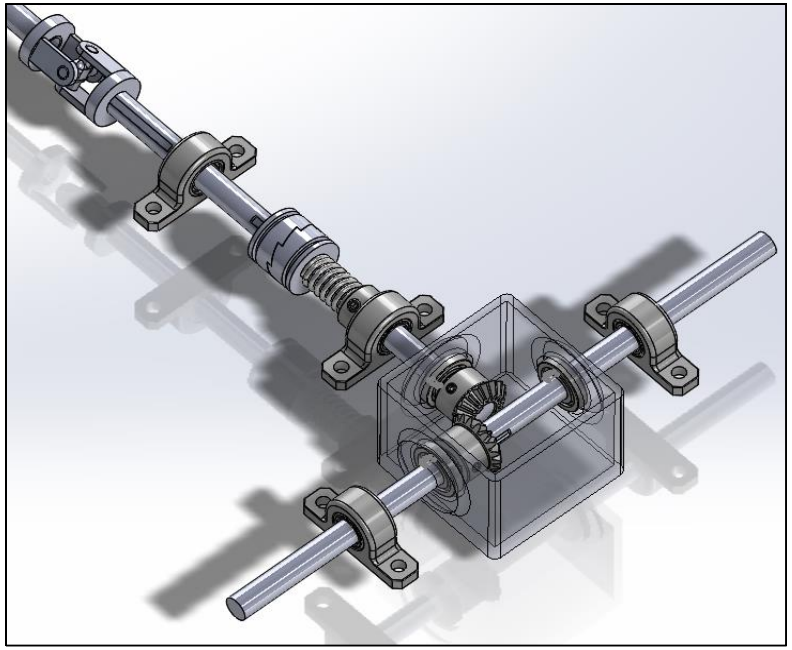


Figure 5: Bevel Gear Concept 2

Advantages:
- ✓ Allows motion to be transmitted perpendicular to the engine
- ✓ Disengaged front driveline for less driveline resistance

Disadvantages:
- × Complex design
- × Complex machining
- × Geometry restriction (Mounting at an angle for the CVT)

Drivetrain Concept Generation (Gear Reduction)

Generation Type: Gallery Method, Directed Search

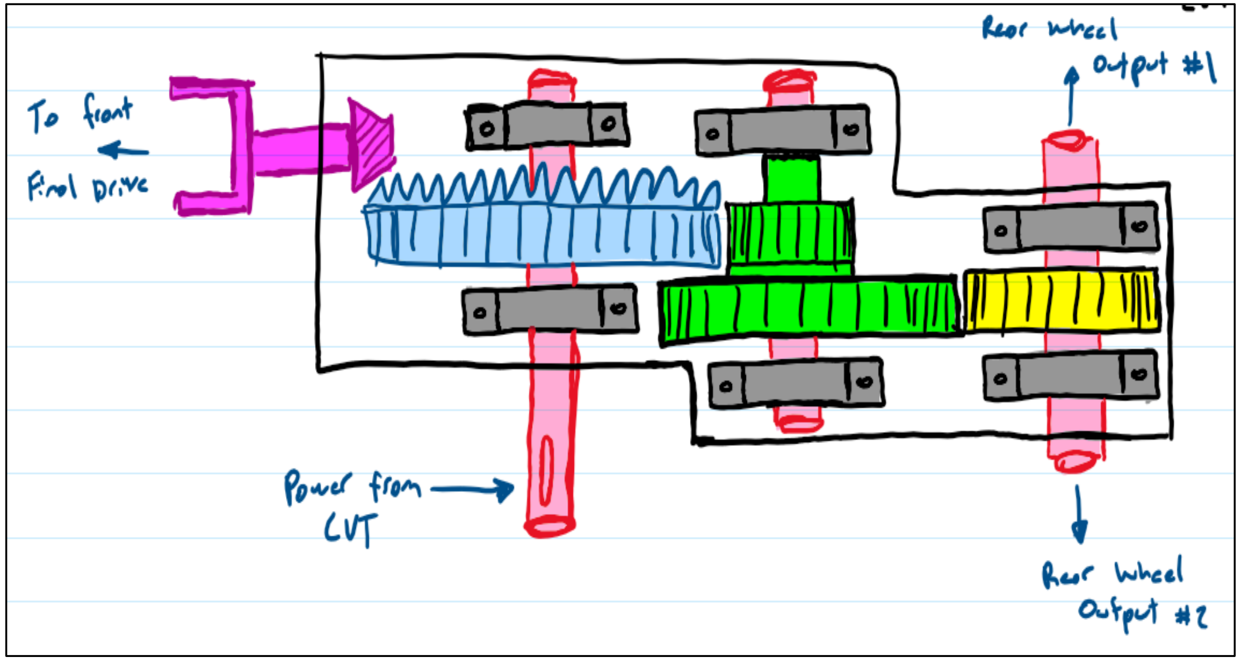


Figure 6: Spur Gear Reduction [##]

Advantages:

- ✓ Built-in transmission guard
- ✓ Environment Proof

Disadvantages:

- × Heavy 'Wet' System needs lubricant
- × High Machining Cost and Schedule Critical
- × High Tolerance Gear Mating

Generation Type: Gallery Method, Directed Search

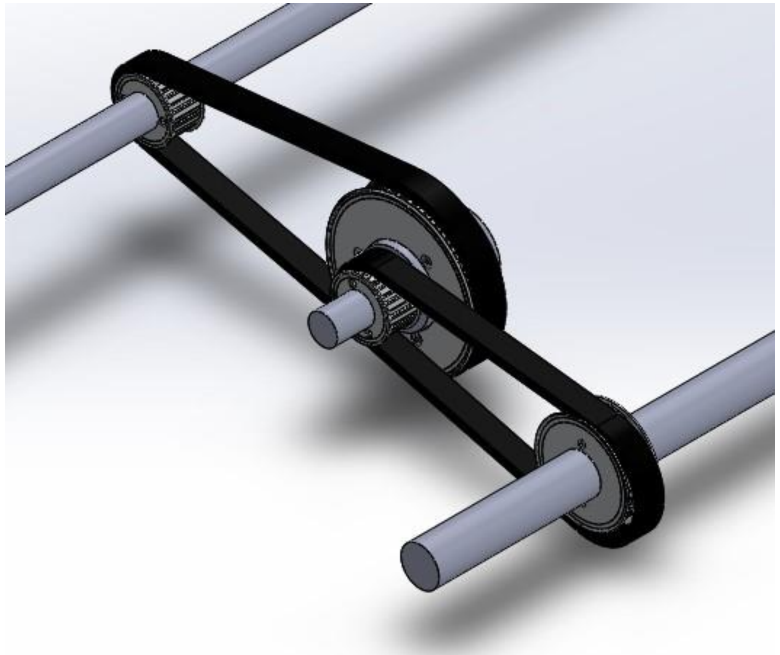


Figure 7: Pulley Gear Reduction

Advantages:

- ✓ Efficient Power Transmission (98%)
- ✓ Lightweight 'Dry' System does not need lubricant
- ✓ Little drivetrain noise at high speeds

Disadvantages:

- × Tensioning require
- × Maintenance intensive (belt replacements)

Drivetrain Concept Selection: Pugh Charts

Speed Reducer Pugh Chart

Criteria	Spur Gear	Timing Belt	Helical Gear	Chain Drive	Direct Drive
Weight	0	+	0	+	+
Approximate Width	0	-	0	+	+
Approximate Height	0	0	0	+	+
Approximate Length	0	-	0	-	+
Efficiency	0	+	-	-	-
2-stage reduction capable	0	+	0	-	-
Thermal E. Generation	0	+	-	+	-
Audible Volume	0	+	+	-	-
Maintenance	0	+	0	-	-
TOTALS					
Positives	0	6	1	4	0
Negatives	0	2	2	5	5
Final:	0	44%	-11%	-11%	-56%

Figure 8:Speed Reducer Pugh Chart

Transfer Case Pugh Chart

Criteria	Classic Transfer Case	Classic Differential	Simplified Bevel	Diff. Concept 1	Diff. Concept 2	Diff. Concept 3
Weight	0	-	0	+	-	-
Approximate Width	0	-	+	+	0	0
Approximate Height	0	-	+	+	0	0
Approximate Length	0	-	+	+	0	0
Efficiency	0	+	+	-	-	-
Reduction Capable	0	+	+	+	+	+
Thermal E. Generation	0	0	0	-	-	-
Audible Volume	0	0	0	-	-	-
Maintenance	0	-	0	0	0	0
TOTALS						
Positives	0	2	5	5	1	1
Negatives	0	5	0	3	4	4
Final:	0%	-33%	56%	22%	-33%	-33%

Figure 9: Transfer Case Pugh Chart

- Criteria derived from House of Quality criteria
- Speed Reducer Designs to Consider: Spur Gear Reduction, Timing Belt Reduction
- Transfer Case Designs to Consider: Differential Concept 1, Simplified Bevel

Drivetrain Concept Selection: Decision Matrices

Speed Reducer Decision Matrix					
Criteria	Weight	Concept			
		Spur Gear		Timing Belt	
		score	total	score	total
Weight	33	3	90	5	150
Approximate Width	6	3	21	2	14
Approximate Height	3	3	15	2	10
Approximate Length	10	4	40	3	30
Efficiency	20	3	75	4	100
2-stage reduction capable	15	4	40	4	40
Thermal E. Generation	7	3	21	2	14
Audible Volume	1	1	1	3	3
Maintenance	5	2	10	2	10
TOTALS	100		313		371

Figure 10: Speed Reducer Decision Matrix

Transfer Case Decision Matrix					
Criteria	Weight	Concept			
		Simplified Bevel		Diff.Concept 1	
		score	total	score	total
Weight	30	3	90	4	120
Approximate Width	7	2	14	2	14
Approximate Height	5	3	15	2	10
Approximate Length	10	5	50	3	30
Efficiency	25	5	125	3	75
Reduction Capable	10	3	30	4	40
Thermal E. Generation	7	4	28	1	7
Audible Volume	1	3	3	2	2
Maintenance	5	4	20	3	15
TOTALS	100		375		313

Figure 11: Transfer Case Decision Matrix

- Major Criteria: Weight, Efficiency, 2-Stage Reduction
- Minor Criteria: Audible Volume, Approximate Height, Maintenance
- Final Speed Reducer: Timing Belt Drive
  - Reduced Weight, Slight Volume Increase
- Final Transfer Case: Simplified Bevel System
  - Least Weight, Highest Efficiency (least components)

Frame Concept Generation

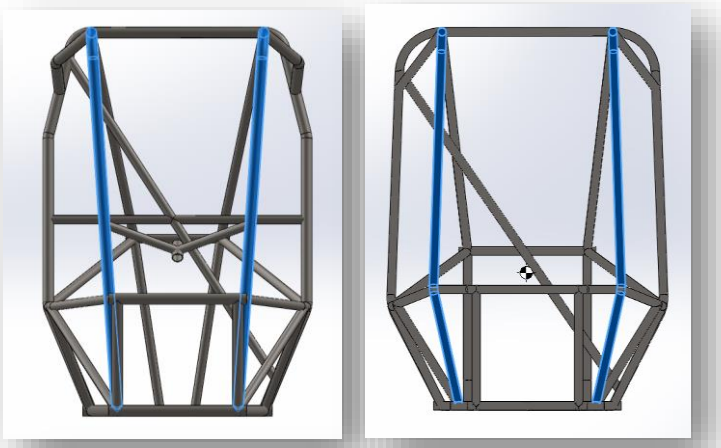


Figure 12: Read View

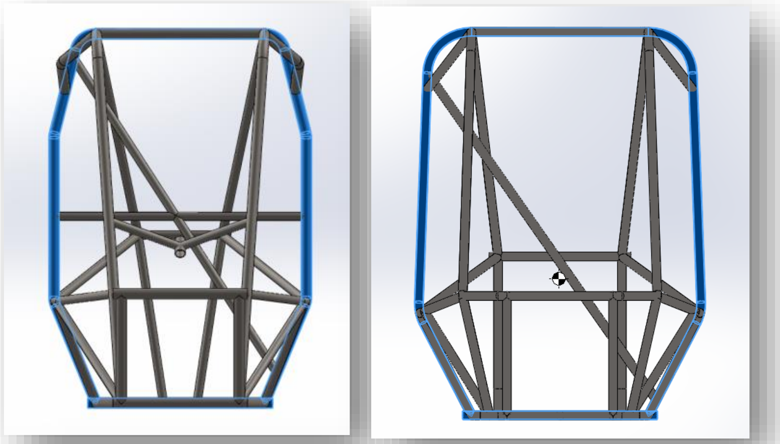


Figure 13: Front View

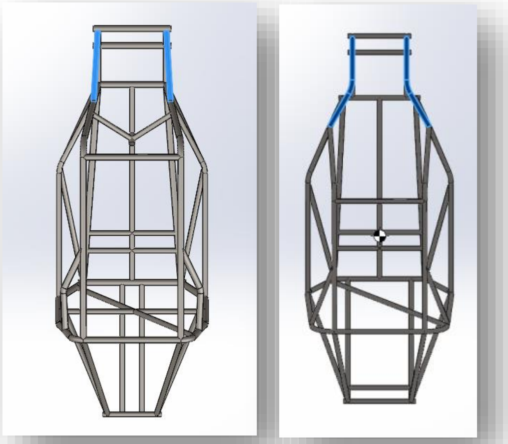


Figure 14: Top View

Straight Front Bracing Members
- Higher top impact resistance

Bent Front Bracing Members
- Allows wider cockpit area

Additional Bend in Roll Hoop
- Distributes impact loading evenly

No Additional Bend in Roll Hoop
- Bigger driver clearances

Strait Upper Nose Members
- Higher front impact resistance

Bent Upper Nose Members
- Narrows nose for front end

Frame Decision Matrix

Criteria	Weight (%)	Concept Score											
		Straight FBMs		Bent FBMs		Additional RRH bend		Minimal RRH bends		Straight Nose		Bent Nose	
		Raw	Weighted	Raw	Weighted	Raw	Weighted	Raw	Weighted	Raw	Weighted	Raw	Weighted
Low weight	35	3	105	2	70	2	70	3	105	3	105	3	105
Ease of manufacturing	15	3	45	1	15	1	15	3	45	3	45	1	15
Ease of maintinence	15	2	30	1	15	1	15	2	30	2	30	1	15
Design flexibility	10	1	10	3	30	1	10	1	10	3	30	1	10
Aesthetics	5	1	5	2	10	3	15	2	10	1	5	2	10
Structual integrity	20	3	60	2	40	3	60	2	40	3	60	2	40
Totals	100	13	255	11	180	11	185	13	240	15	275	10	195

Figure 15: Frame Decision Matrix

- Few factors are decided upon.
- Most of frame geometry is predetermined.
- Even material selection lacks diversity of options.

Frame Decision Making

Design Necessities

- Must be compatible with front and rear suspension.
- Must allow space for all other subsystems.
- Must ensure certain subsystems are fully enclosed by the frame.
- Must comply with all rules.
- Must be able to easily adapt while in design phase.

Accounting for Design Necessities

- Multiple meetings/briefing with other sub-teams.
- Understanding how the frame affects other sub-teams.
- Understanding how other sub-teams affects the frame.
- Constant design updates being created and shared with the entire team.
- Checking each change with the rules to ensure compliance.

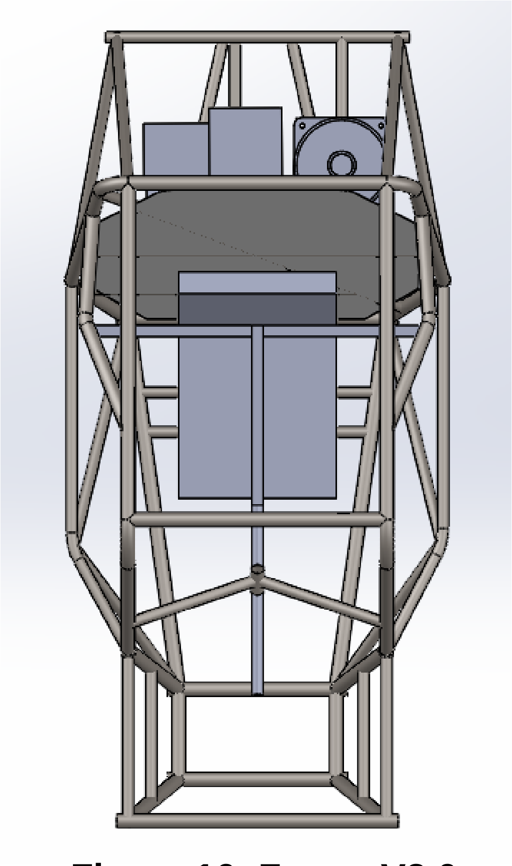


Figure 16: Frame V2.0

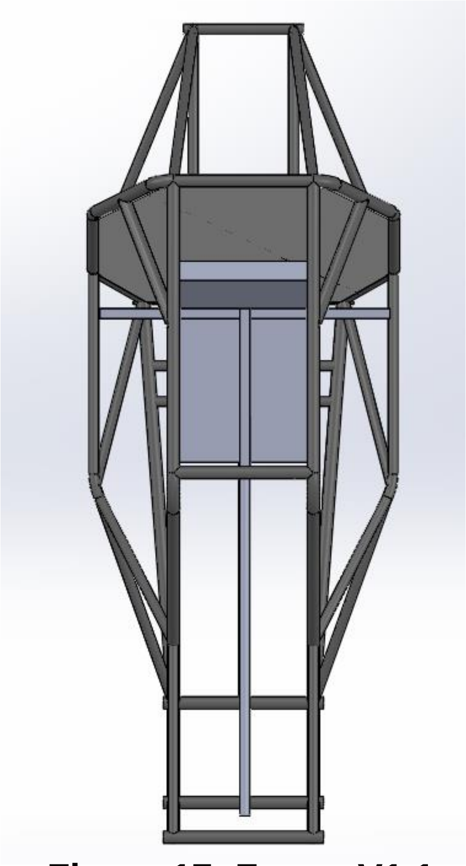


Figure 17: Frame V1.1

Frame Material Calculations

	Minimum Tubing	Primary Tubing		Secondary Tubing
material	1018 steel	4130 steel		4130 steel
OD (in)	1	1.25		1
Wall thickness (in)	0.12	0.065		0.035
carbon content (%)	0.18	0.3		0.3
E (kpsi)	29700	29700		29700
I (in^4)	0.032710765	0.042602298		0.012367468
k_b (klb * in^2)	971.5097313	1265.288253	293.7785	367.3138007
S_y (kpsi)	52.9388	63.1		63.1
c (in)	0.5	0.625		0.5
S_b (klb*in)	3.463337331	4.301128015	0.837791	1.560774466
density (lb/in^3)	0.284	0.284		0.284
weight per foot (lb)	1.130611444	0.824671841	-0.30594	0.361613651

Figure 18: Frame Material Calculations

- Used excel sheet to calculate various materials and sizes.
- Objective is to find the lightest weight material that meets the minimum requirement.
- For primary tubing, a 1.25" OD and 0.065" wall thickness yielded the lowest weight.
- For secondary tubing, a 1.00" OD and 0.058" wall thickness was chosen.
- For tertiary tubing, a 1.00" OD and 0.035" wall thickness was chosen.

Frame Final CAD

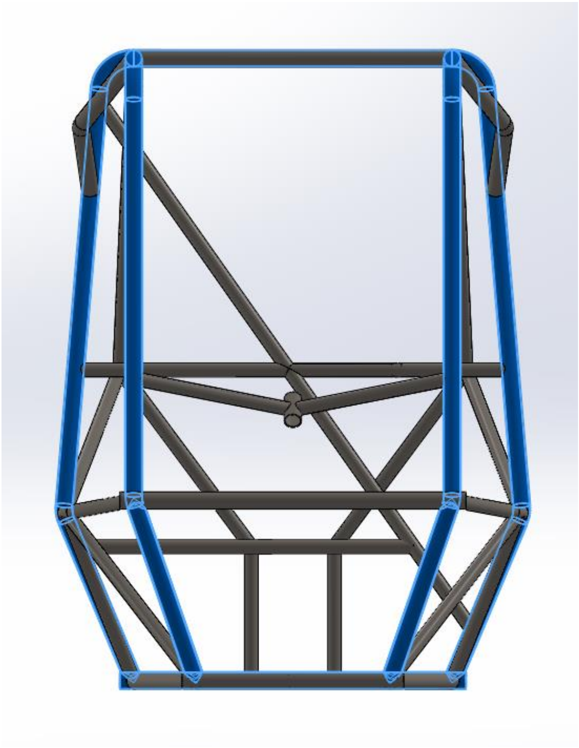


Figure 19: Rear View

No Additional Bend in the Roll Hoop

Adhering to rules on bent member lengths

Easier to fabricate

Bent Front Bracing Members

Strong enough in FEA

Larger cockpit

Strait Upper Nose Members

More compact nose

Easier to fabricate

Better interface for front end to work with

Higher front impact resistance

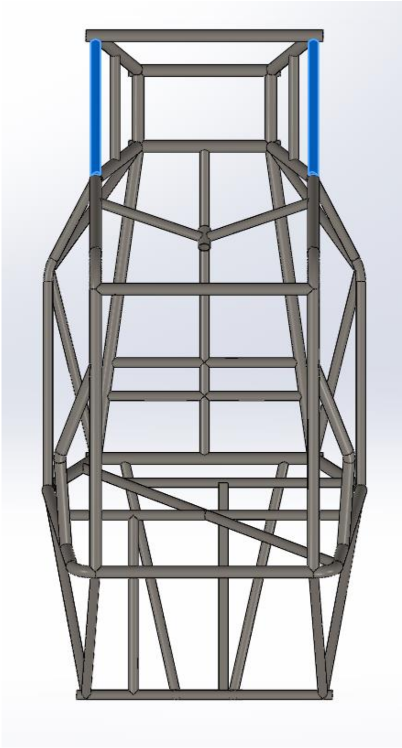
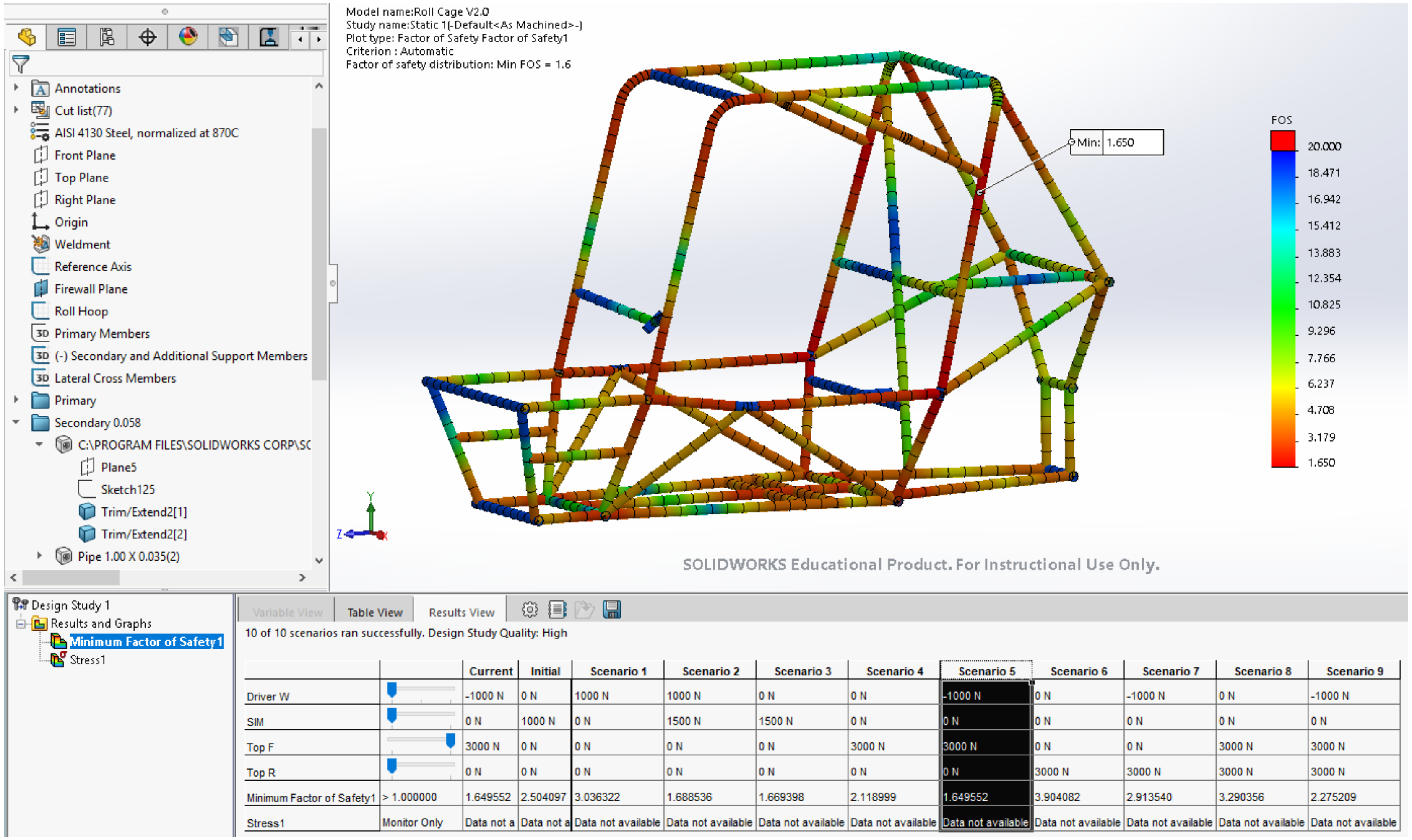


Figure 20: Top View

Frame FEA



		Current	Initial	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8	Scenario 9
Driver W		-1000 N	0 N	1000 N	1000 N	0 N	0 N	-1000 N	0 N	-1000 N	0 N	-1000 N
SIM		0 N	1000 N	0 N	1500 N	1500 N	0 N	0 N	0 N	0 N	0 N	0 N
Top F		3000 N	0 N	0 N	0 N	0 N	3000 N	3000 N	0 N	0 N	3000 N	3000 N
Top R		0 N	0 N	0 N	0 N	0 N	0 N	0 N	3000 N	3000 N	3000 N	3000 N
Minimum Factor of Safety1	> 1.000000	1.649552	2.504097	3.036322	1.688536	1.669398	2.118999	1.649552	3.904082	2.913540	3.290356	2.275209
Stress1	Monitor Only	Data not a	Data not a	Data not available	Data not available	Data not available	Data not available	Data not available	Data not available	Data not available	Data not available	Data not available

Figure 21: Frame FEA Analysis

Nine Scenarios simulated for multiple impact conditions

- Used overestimates for impacts and weights
- Lowest FOS of 1.65 was the top front impact with driver
- This is lower than we would like but this scenario highly unlikely

Bill of Materials

Initial Bill of Materials: Drivetrain						
Item	**Qty.**	**Vendor**	**Cost Range**		**Link**	**Notes**
B&S 10 HP Vanguard Engine	1	Briggs & Stratton	$546.30	$546.30	Briggs & Stratton	Price subject to change based on availability
Fuel Tank	1	Pyrotect	$225.00	$225.00	Fuel Tank	New aluminum fuel tank required for all competing teams
Fuel Line	1	Napa Auto	$0.00	$0.00	1.5 ft of Fuel Line	Donated by Napa/Excess from last year
Kill Switches	2	Parker SportsCenter	$51.00	$51.00	ParkerYamaha	2 kill switches per rulebook requirements
Primary ECVT Pulley	1	In-house	$0.00	$400.00	N/A	Price dependent on 6061-T6 Aluminum donations
Linear Bearing for Splined Shaft	1	McMaster-Carr	$278.89	$278.89	ECVT Main Bearing	ECVT component that allows linear and rotational movement
Gaged Secondary CVT Pulley	1	Gaged Engineering	$0.00	$0.00	Gaged CVT Specifications	Secondary from previous capstone teams
Nema 23 2.8A Stepper Motor	1	StepperOnline	$26.00	$26.00	Stepper Motor	Arduino controlled stepper motor for ECVT primary
US5881 Hall Effect Sensor	2	SainSmart	$7.98	$7.98	Arduino Sensor	Used to detect engine output RPM
Arduino Components	TBD	Arduino	$0.00	$40.00	Arduino	Prototyping may effect cost
Bevel Gears	2	TBD	$100.00	$400.00	Bevel Gear Sets	Ongoing bevel gearbox design iterations
Case Material	1	SpeedyMetals	$0.00	$500.00	6x10 6061-T6	Case material may be donated
Case Manufacturing	2	Ping	$0.00	$0.00	N/A	Investment Cast
5/8 Hollow Steel Tube	1	SpeedyMetals	$27.36	$27.36	5/8 OD Steel Tube	4 ft hollow steel tubing for custom driveshaft
Closed Cell High Density Foam	1	USAFoam	$22.36	$22.36	1/2 x 23 x 108	Composite floorboard
Safety Covers	2	SpeedyMetals	$54.32	$54.32	1/8 in. Aluminum Sheets	1/8" 6061 aluminum covers required for exposed components
Misc. Hardware	TBD	Copper State	$20.00	$150.00	Copper State Bolt & Nut	Hardware for assembly
Unforseen Expenses	N/A	Any	$0.00	$200.00	N/A	Accounting for potential unforseen expenses
		Drivetrain Total:	**$1,359.21**	**$2,929.21**		
Initial Bill of Materials: Frame						
4130 Steel Tubing 1.25''x0.065''	56ft	Advanced Metals Sales	$0	$660.00	Primary Tubing	Tubing donations for frame are pending
4130 Steel Tubing 1.00''x0.058''	30ft	Advanced Metals Sales	$0	$300.00	Secondary Tubing	
4130 Steel Tubing 1.00''x0.035''	40ft	Advanced Metals Sales	$0	$416.00	Tertiary Tubing	
4130 Steel Sqaure Tubing 1.00''x0.035	10f	Advanced Metals Sales	$0	$128.00	Square Tubing	
4130 Steel Plate 0.125''	3ft^2	Advanced Metals Sales	$75.00	$75.00	0.125 Steel Plate	Firewall material
4130 Steel Plate 0.250''	2ft^2	Advanced Metals Sales	$125.00	$125.00	0.25 Steel Plate	
Dzus Fasteners	50	TBD	$87	$87	Fasteners	5/16" fasteners
		Frame Total:	**$287**	**$1,791.00**		

Figure : Drivetrain/Frame BOM

Questions?

References

[1] (Najmy, Janshah, ElShamsi, Jorgenson, & Smith, 2019) Final Proposal for SAE Baja ECVT, 2019

[2] Grainger. Power Drive Pulleys. https://www.grainger.com/category/power-transmission/sheaves-and-pulleys/timing-belt-pulleys