EBaja Presentation 3

Team Members:

Octavio Duran - financial Manager

Brendon Jameson - CAD/ Manufacturing Engineer

Benjamin Plis - Test Engineer

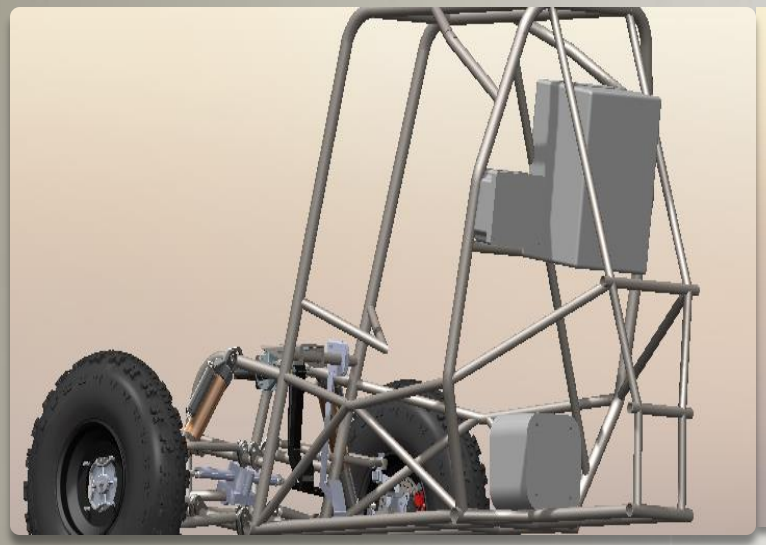
Abriana Romero - Project Manager

Jared Walker - Logistics Manager

Project Description

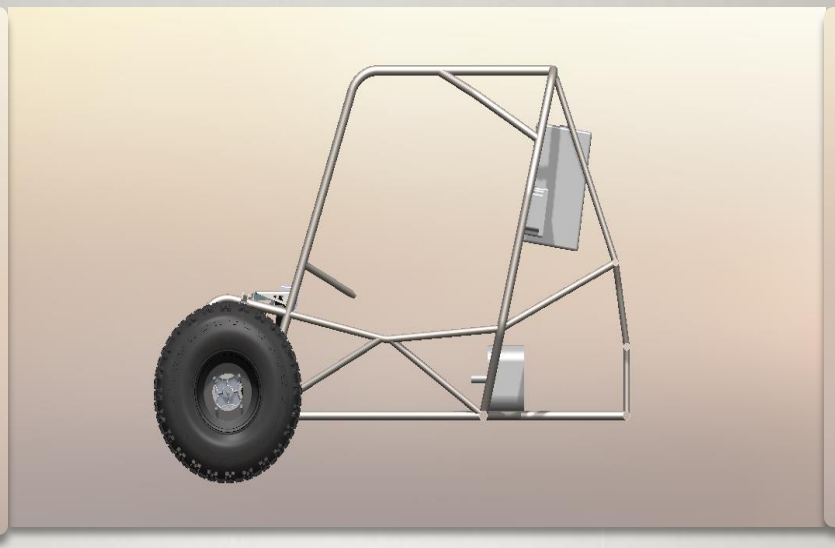
- Goal: To mechanically restore and convert a previous SAE Baja design into an electric powered vehicle
  - Must restore mechanical systems (suspension, braking, and steering)
  - Replace all internal combustion engine (ICE) components with electric components
  - Must design spatial solutions for electrical components
- Multidisciplinary engineering with EE sub team to normalize SAE eBaja project in the United States

CAD Model



Rear View

- Shows battery and motor controller mounted on firewall above motor
- Missing RE suspension, differential, and firewall



Right View

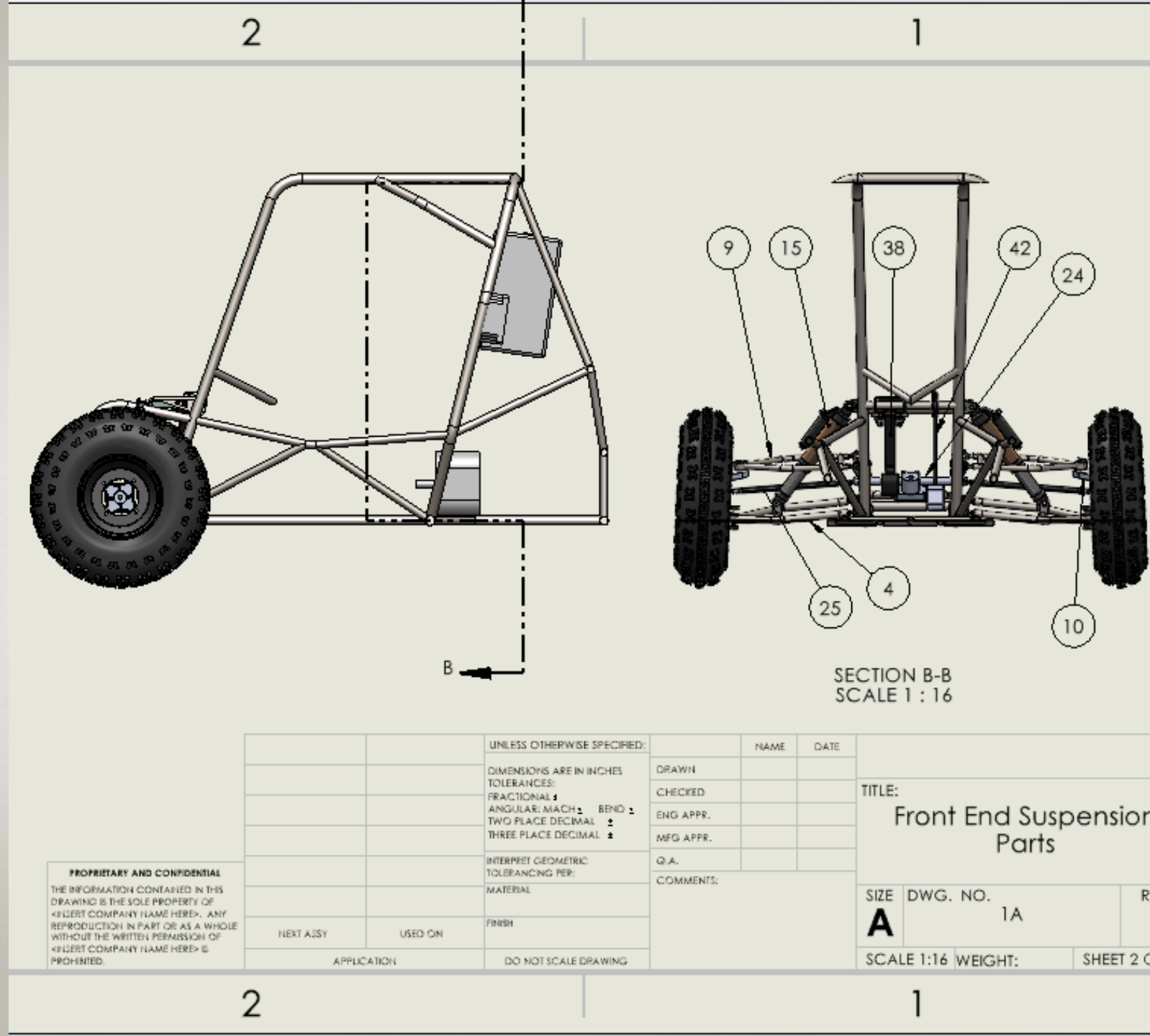
- Highlights frame and drivetrain components
- Spatial prototyping of electric drivetrain

Front View

- Complete FE suspension with braking and throttling placement
- Braking and throttling systems not complete

Subsystems

- FE Suspension with brake and pedal placement
- Section View B-B
  - 9: Upper Control Arm
  - 15: Shock Absorber
  - 10: Front Knuckle
  - 4: Lower Control Arm
  - 24: Mock Steering Rack
  - 38: Brake Pedal
  - 25: Steering Drag Link
  - 42: Throttle Shaft



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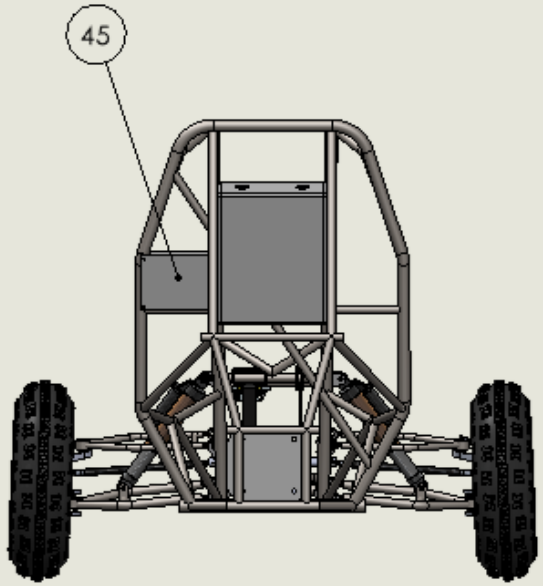
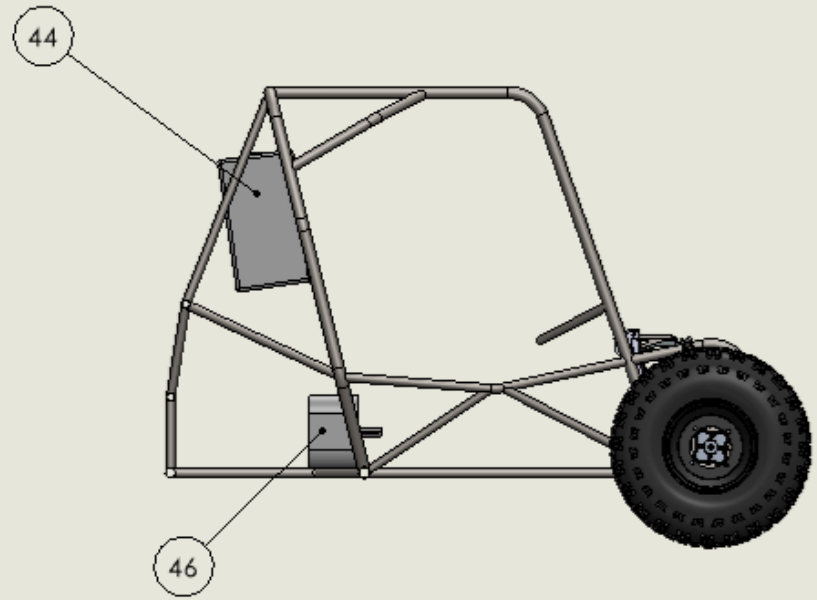
Subsystems

- Electric drive train component placement
- Rear View
  - 45: Motor Controller
- Left View
  - 44: Battery Pack
  - 46: Motor





2 1

		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

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TITLE:
Rear Drive Train Part

SIZE	DWG. NO.	RE
A	2A	1

SCALE: 1:48 WEIGHT: SHEET 3 O

2 1

Design Function

- Battery stores energy used by electrical components
  - Motor, controller, and auxiliaries consume power from battery
  - Motor provides torque to gearbox
  - Gearbox transmits torque to differential
  - Differential transmits torque to axle
  - Axel transmits torque to tire
- Steering controls direction of travel
  - Steering column provides torque to steering rack
  - Steering rack translates tie rods, pivoting tires
- Braking stops the vehicle
  - Brake pedal applies force to master cylinder
  - Master cylinder increases pressure in brake lines
  - Line pressure actuates calipers
  - Calipers apply brake pads to rotor
  - Friction from rotor slows tire, slowing vehicle
- Suspension connects tires to frame
  - Shocks absorb impulse forces from the road

Right-side RE Suspension

Left-side RE Suspension

Current Design

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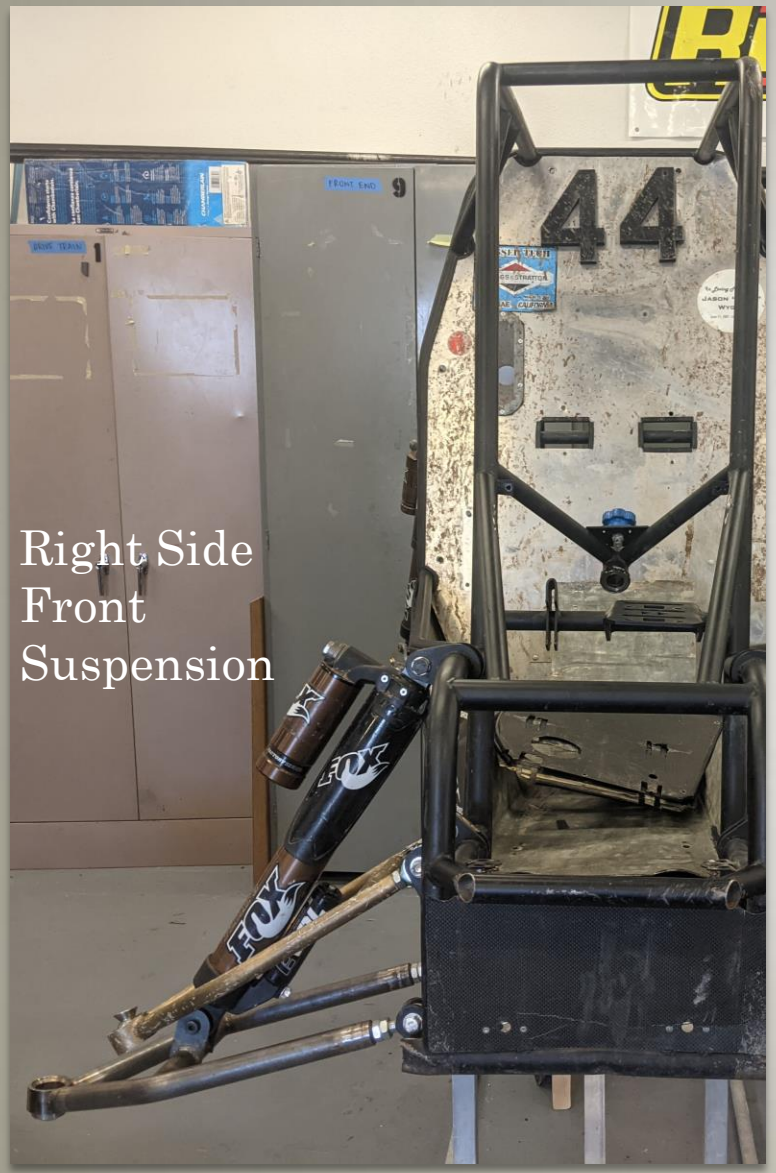
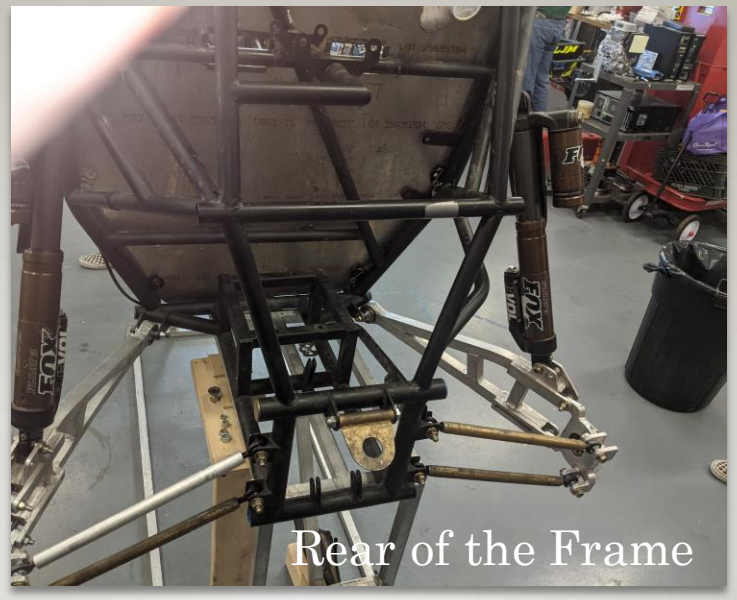
Current Design



Right Side Front Suspension



Rear of the Frame

Side View (Right)

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Braking Subsystem Calculations

- This is the current iteration of the braking system excel sheet.
- Most of the numbers here are subject to change as the design evolves over the development process.
- The final iterations of this sheet will be compared to the Baja teams brake calculations for safety purposes.

Inputs				Calculations		
Pedal Ratio	5	-		a(retardation)	7.993790464	m/s^2
Master Cylinder Diameter	0.028575	m		Fmc	2500	N
Brake Rotor Diameter	0.2	m		Pbf	3898321.464	Pa
Weight Distribution	0.4	0.6		Fr	1530.36	N
Vehicle Weight	200	kg		Ff	1020.24	N
Driver weight	60	kg		DFf	1700.4	N
Total Weight	260	kg		DFf(mass)	173.3333333	kg
Wheel Base	1.5	m		DFr	850.2	N
Track Width	1	m		DFr(mass)	86.66666667	kg
C.G. Height	0.4	m		Fbf	692.7951735	N
Weight Distribution (Front)	104	kg		Fbr	346.3975868	N
Weight Distribution (Back)	156	kg		Tbf	207.8385521	Nm
From front tire to C.G.	0.9	m		Tbr	103.919276	Nm
from Back tire to C.G.	0.6	m		Fbrf	2078.385521	N
Top speed	8.9408	m/s		Fbrr	2078.385521	N
Radius of Tire	0.3	m		Fpf	2597.981901	N
Stopping distance	5	m		Fpr	2597.981901	N
Pedal Pressure	500	N		df	0.029129585	m
MC Area	0.0006413	m^2		dr	0.029129585	m
Brake Rotor Radius	0.1	m				
coefficient of friction	0.4	-				

Gearbox Calculations

- Rough calculation of gearbox with given motor specifications from Electrical capstone team
  - Continuous power: 13kW
  - Max rotor speed: 8000 RPM
- Goal speed: 35 mph

Quantity	Symbol	Pinion Value	Gear Value	Units
Bending factor of safety	SF	2.43	2.40	
	(SH)^n	0.90	0.92	
Wear factor of safety	SH	0.95	0.96	
Power	H	17.43	17.43	hp
Pitch diameter	d	3.2	10.4	in
Torque	T	231	752	in-lbf

Quantity	Symbol	Pinion Value	Gear Value	Units
Number of teeth	N	16	52	teeth
Diametral pitch	P	5	5	teeth/in
Speed	n	4750	1461.54	rpm
Transmitted load	Wt	144.54	144.54	lbf
Face width	F	0.8	0.8	in
Quality number	Qv	5	5	
Overload power/driven		Light-moderate	Light-moderate	
Centered?		TRUE	TRUE	
Crowned?		FALSE	FALSE	
Adjusted?		FALSE	FALSE	

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Gearbox Calculations Continued

- These calculations may change as we go through the design process
- Output speed from gearbox is 34.10 mph with the assumption of using a 22 in wheel diameter

Quantity	Symbol	Pinion Value	Gear Value	Units
Number of teeth	N	20	56	teeth
Diametral pitch	P	5	5	teeth/in
Speed	n	1461.54	521.98	rpm
Transmitted load	Wt	375.81	375.81	lbf
Face width	F	1	1	in
Quality number	Qv	5	5	
Overload power/driven		Light-moderate	Light-moderate	
Centered?		TRUE	TRUE	
Crowned?		FALSE	FALSE	
Adjusted?		FALSE	FALSE	

Quantity	Symbol	Pinion Value	Gear Value	Units
Bending factor of safety	SF	1.73	2.07	
	(SH)^n	0.63	0.64	
Wear factor of safety	SH	0.80	0.80	
Power	H	17.43	17.43	hp
Pitch diameter	d	4	11.2	in
Torque	T	752	2105	in-lbf

FMEA

Product Name	eBaja 44	Development Team				Page No of			
System Name						FMEA Number			
Subsystem Name						Date			
Component Name									
Part # and Functions	Potential Failure Mode	Potential Effect(s) of Failure	Severity (S)	Potential Causes and Mechanisms of Failure	Occurance (O)	Current Design Controls Test	Detection (D)	RPN	Recommended Action
Frame	Yielding	Damage to other parts, debris, driver injury	10	Direct impact, higher than intended load	2	Visual Inspection/ Deformation Checks	3	60	Reduce total weight of car
Fasteners	Brittle Fracture	Shrapnel, subsystem failure, damage to connected parts	7	Excessive acceleration, higher than intended load	4	Assembly Test	2	56	Use material with higher ultimate strength
Firewall	Ductile Rupture	Driver Injury	7	Shrapnel, excessive heat from powertrain	3	Firewall Integrity, Quick-touch test	1	21	None
Suspension Arms	Yielding	Damage other parts, suspension system failure	7	Excessive force	2	Visual Inspection/ Deformation Checks	2	28	None
Shocks	Brittle Fracture	Shrapnel, suspension system failure	7	Shrapnel, excessive acceleration	2	Sound Confirmation, Compression Test	1	14	None
Suspension Knuckles	Yielding	Shrapnel, suspension system failure	6	Higher than intended load, shrapnel	3	Visual Inspection/ Deformation Checks	2	36	Use material with higher ultimate strength
Spindles	Brittle Fracture	Wheel assembly unable to turn	7	Excessive force	3	Allignment Check, Tire Rotation Observation	5	105	Use material with higher ultimate strength
Wheels	Ductile Rupture	Reduced driving capability, increased part wear	4	Road conditions, change in atmospheric condition	5	Tire Pressure, Hub Deformation	1	20	None
Hubs	Brittle Fracture	Loss of wheels, shrapnel	7	Excessive force	2	Hub Deformation, Tire Rotation Observation, Assembly Test	4	56	Line Curvability Indication
Brake Pads	Abrasive Wear	Loss of brake force	4	Use of braking system	7	Sound Confirmation, Stopping Distance, Visual Inspection	1	28	None
Brake Discs	Abrasive Wear	Loss of brake force	5	Use of braking system	4	Sound Confirmation, Stopping Distance, Visual Inspection	1	20	None
Brake Clamps	Brittle Fracture	Loss of braking action, shrapnel	7	Excessive braking force, shrapnel	2	Sound Confirmation, Stopping Distance, Visual Inspection	2	28	None
Brake Lines	Ductile Rupture	Loss of braking action, loss of brake fluid	7	Shrapnel, Excessive braking force	3	Fluid Level, Stopping Distance, Visual Inspection	1	21	None
Master Cylinder	Ductile Rupture	Loss of braking action, loss of brake fluid, shrapnel	7	Excessive braking force, shrapnel	4	Fluid Level, Stopping Distance, Visual Inspection	1	28	None
Brake Pedal	Brittle Fracture	Loss of braking action	7	Excessive braking force	1	Visual Inspection	1	7	None
Steering Wheel	Yielding	Loss of steering ability	7	Excessive steering force	1	Visual Inspection	1	7	None
Steering Column	Yielding	Loss of steering ability	9	Excessive steering force	1	Visual Inspection, Range of Motion	1	9	None
Steering Gearbox	Brittle Fracture	Loss of steering ability, shrapnel	8	Excessive steering force, shrapnel	2	Range of Motion	1	16	None
Steering Arms	Yielding	Loss of steering ability, debris interfering with other systems	7	Shrapnel	2	Visual Inspection, Range of Motion, Ackerman Assessment	1	14	None
Throttle Pedal	Yielding	Loss of powertrain control	7	Excessive applied force	1	Visual Inspection	1	7	None
Powertrain Wires	Ductile Fracture	Loss of powertrain control, loss of power transmission, electrical hazar	7	Shrapnel	4	Voltmeter Test, Visual Inspection	3	84	Wire Drag; Consult EE Team for better testing methods
Battery Pack	Ductile Rupture	Loss of power transmission, chemical hazard, electrical hazard	10	Shrapnel, excessive acceleration	3	Visual Inspection, Battery Tester	1	30	None
Motor Controller	Ductile Rupture	Loss of powertrain control, loss of power transmission, electrical hazar	7	Shrapnel	4	Visual Inspection, Powertrain Operation Test	4	112	Protective Casing
Motor	Brittle Fracture	Shrapnel, loss of power transmission	10	Improper vibration reduction, shrapnel	3	Powertrain Operation Test, Torque Measurement, Sound Test	2	60	Protect Structurally (Frame)
Gearbox	Brittle Fracture	Shrapnel, loss of power transmission	8	Improper vibration reduction, shrapnel	5	Sound Test, Visual Inspection, Powertrain Operation	2	80	Increase Tooth Number Size (Design)
Differential	Brittle Fracture	Shrapnel, loss of power transmission	7	Improper vibration reduction, shrapnel	4	Powertraint Operation, Visual Inspection, Sound Test	3	84	Improve Component Selection Process
Driving Axles	Yielding	Shrapnel, loss of power transmission	7	Excessive force	2	Deformation Test, Drive Test, Visual Inspection	1	14	None
Indicator Lights	Brittle Fracture	Electrical hazard	4	Shrapnel	3	Visual Inspection, Electrical Test	0		None

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Part # and Functions	Potential Causes and Mechanisms of Failure
Frame	Direct impact, higher than intended load
Fasteners	Excessive acceleration, higher than intended load
Firewall	Shrapnel, excessive heat from powertrain
Suspension Arms	Excessive force
Shocks	Shrapnel, excessive acceleration
Suspension Knuckles	Higher than intended load, shrapnel
Spindles	Excessive force
Wheels	Road conditions, change in atmospheric condition
Hubs	Excessive force
Brake Pads	Use of braking system
Brake Discs	Use of braking system
Brake Clamps	Excessive braking force, shrapnel
Brake Lines	Shrapnel, Excessive braking force
Master Cylinder	Excessive braking force, shrapnel
Brake Pedal	Excessive braking force
Steering Wheel	Excessive steering force
Steering Column	Excessive steering force
Steering Gearbox	Excessive steering force, shrapnel
Steering Arms	Shrapnel
Throttle Pedal	Excessive applied force
Powertrain Wires	Shrapnel
Battery Pack	Shrapnel, excessive acceleration
Motor Controller	Shrapnel
Motor	Improper vibration reduction, shrapnel
Gearbox	Improper vibration reduction, shrapnel
Differential	Improper vibration reduction, shrapnel
Driving Axles	Excessive force
Indicator Lights	Shrapnel

FMEA: Potential Failures

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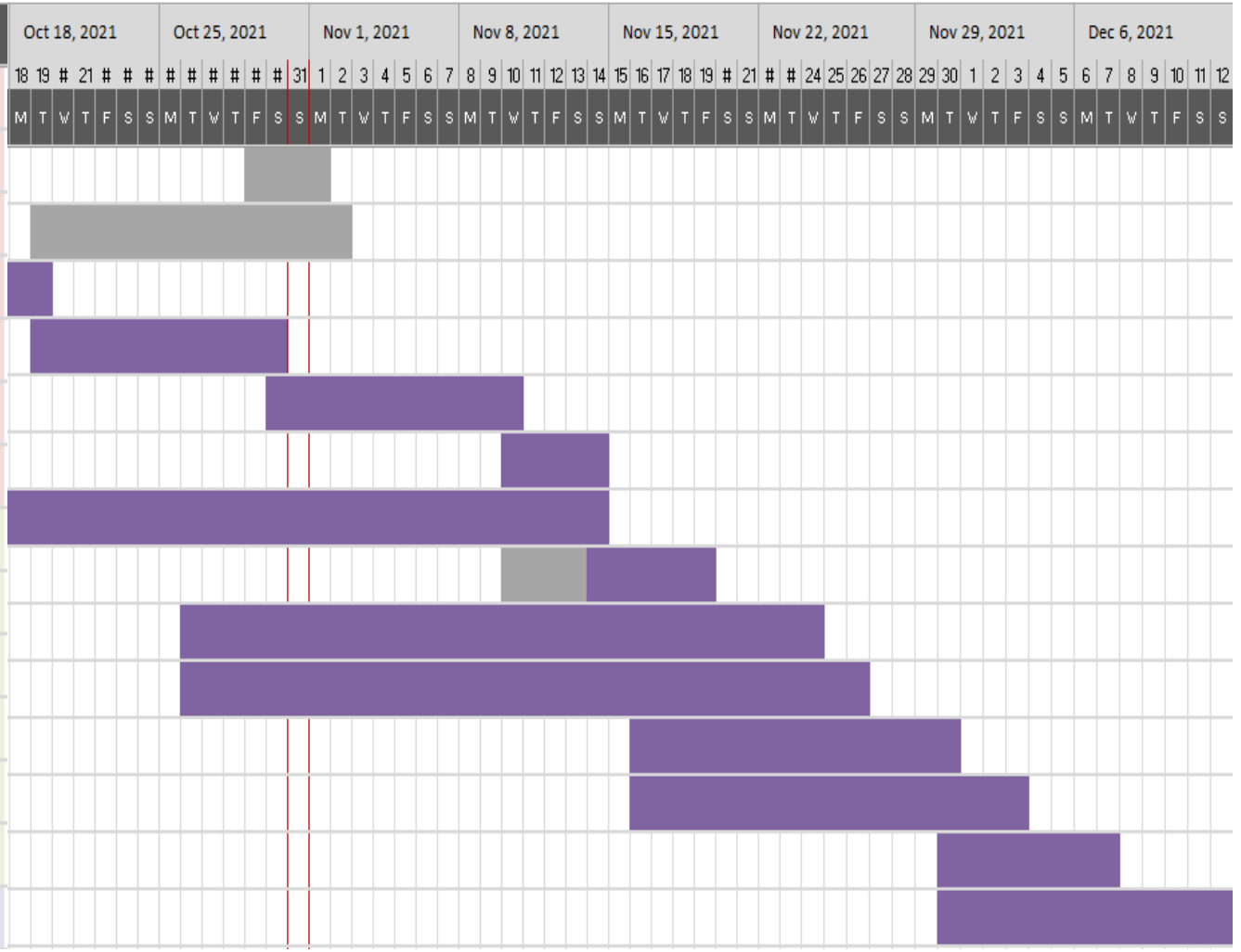
FMEA Results

- Component RPN scores above 30 were prescribed recommended actions

Part # and Functions	RPN	Recommended Action
Frame	60	Reduce total weight of car
Fasteners	56	Use material with higher ultimate strength
Firewall	21	None
Suspension Arms	28	None
Shocks	14	None
Suspension Knuckles	36	Use material with higher ultimate strength
Spindles	105	Use material with higher ultimate strength
Wheels	20	None
Hubs	56	Line Curvability Indication
Brake Pads	28	None
Brake Discs	20	None
Brake Clamps	28	None
Brake Lines	21	None
Master Cylinder	28	None
Brake Pedal	7	None
Steering Wheel	7	None
Steering Column	9	None
Steering Gearbox	16	None
Steering Arms	14	None
Throttle Pedal	7	None
Powertrain Wires	84	Wire Drag; Consult EE Team for better testing methods
Battery Pack	30	None
Motor Controller	112	Protective Casing
Motor	60	Protect Structurally (Frame)
Gearbox	80	Increase Tooth Number Size (Design)
Differential	84	Improve Component Selection Process
Driving Axles	14	None
Indicator Lights		None

Schedule

TASK	ASSIGNED TO	PROGRESS	START	END
Schedule & Budget	Everyone	100%	10/29/21	11/1/21
Presentation 3	Everyone	100%	10/19/21	11/2/21
Testing procedures	Everyone	0%	10/8/21	10/19/21
Risk Analysis & Mitigation	Everyone	100%	10/19/21	10/30/21
Conclusion	Everyone	0%	10/30/21	11/10/21
Review and Edit Report	Everyone	0%	11/10/21	11/14/21
FInal Report	Everyone	0%	10/8/21	11/14/21
Final CAD/BOM	Everyone	40%	11/10/21	11/19/21
Begin Mechanical Tests	Everyone	0%	10/26/21	11/24/21
Individual Analytical Report	Individual	0%	10/26/21	11/26/21
Prototype Demo	Everyone	0%	11/16/21	11/30/21
Final Prototype	Everyone	0%	11/16/21	12/3/21
Website Check	Everyone	0%	11/30/21	12/7/21
Begin Conversion Efforts	Everyone	0%	11/30/21	date



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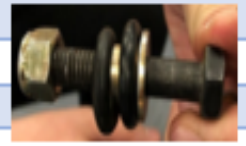
Budget

Budget		$3,000				
Money Left		$2,883				
Part Name	Picture		Dimensions	Website	Count (need)	Price ($)
Lock nuts			Outer diameter = 14mm	https://www.fastenal.com/product/fasteners/nuts/	5	1.65
Socket cap screw			diameter = 9.5mm, length = 59.5mm	https://www.fastenal.com/product/fasteners/socke	1	1.06
Bushings			large outer diameter = 22mm, small inner diameter = 10.15mm, total leng	Team machining part	4	0
O-rings			inner diameter = 17mm, outer diameter = 26mm	https://www.mcmaster.com/o-rings/cross-section-s	4	7.61
Hex head screw			bolt length = 66.5mm, bolt diameter = 10mm, hex diameter = 16.7mm,	https://www.mcmaster.com/screws/hex-head-screv	1	14.35
Lock nut			outer diameter = 16mm, inner diameter = 9mm	https://www.fastenal.com/product/fasteners/nuts/	1	0.33
Flat washers			outer diameter = 20mm, inner diameter = 11mm, thickness 1.5mm	https://www.fastenal.com/product/fasteners/washe	8	1.04
Hex head screws			length = 50.5mm, diameter = 9.5mm	https://www.mcmaster.com/screws/hex-head-screv	4	7.26
Bushings			outer diameter = 19.3mm, inner diameter = 13mm, flared outer diameter	Team Machining part	6	0
HAB 7T Bearing			length = 16mm, outer diameter = 35mm, ball diameter = 22.2mm	https://www.amazon.com/Aurora-Bearing-Compan	2	77.96
Socket cap screw			total length = 93.4mm, threaded diameter = 9.5mm, unthreaded diameter	https://www.fastenal.com/product/fasteners/socke	1	4.31
Flat washers			outer diameter = 26.4mm, inner diameter = 14.2mm, thickness = 2.7mm	https://www.fastenal.com/product/fasteners/washe	3	0.57
Hex nuts			outer diameter = 14.1mm, inner diameter = 8mm, length = 8.5mm	https://www.fastenal.com/product/fasteners/nuts/	3	0.63
Spindle			length = 105.5mm, head length = 3.0mm, minimum diameter = 13.6mm, v	Team machining part	1	0
				Total		116.77

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Reference(s)

- [1] "SAE Baja 2018-2019 Shared Drive", *Drive.google.com*, 2021. [Online]. Available: https://drive.google.com/drive/folders/1G100gEIlHtoXj_N8L44qE0VRtSuOrLfA. [Accessed: 31- Oct- 2021].

Thank You For Your Time

Are There Any Questions?